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UNIVERSITÀ DI PAVIA

ISYDE2024

Italian Symposium on
DIGITAL EDUCATION

University of Pavia 19 - 21 June 2024

Lifelong Digital Learning and Education: promoting flexibility, inclusion, critical thinking and international exchange

Annamaria DE SANTIS, Elena CALDIROLA e Pietro CARRETTA

Conference PROCEEDINGS

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Preface

ISYDE 2024, the *Italian SYmposium on Digital Education,* has been jointly organized by the *Italian e-Learning Society* (SIe-L, https://www.sie-l.it/) and *Italian Society for Media Education Research* (SIREM, https://sirem.org/).

The 2024 edition focused on "Lifelong Digital Learning and Education: promoting flexibility, inclusion, critical thinking and international exchange" and aimed to promote innovative teaching and learning experiences enabled by technologies in the national and international scenario, able to transform educational paths into flexible and inclusive ecosystems.

Good teaching practices are the starting point for removing barriers and promoting inclusion, intercultural, and international exchange; favoring wellbeing and professional upskilling and reskilling throughout life through education and appropriate communication strategies; critically analyzing digital messages and environments.

The conference, which serves as a meeting point for sharing research, experiences, and technological applications, was held at the University of Pavia (Italy) from June 19 to 21, 2024.

Nearly 200 participants presented more than 60 contributions merged into eight Sections in the proceedings:

- Blended and Distance Learning (8)
- Teaching innovations, Communicating Science and emerging technologies in Education (10)
- Digital UpSkill and ReSkill for Adult Learners, Career Development and Training (5)
- Experiences in Education (11)
- Digital Citizenship and Media Literacy (4)
- Diversity, Equity, and Inclusion (6)
- AI in Education (13)
- Collaboration Projects and Networks (5).

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· Section 1 ·
Blended and Distance Learning

Micro-credentials and Lifelong Learning in Higher Education: European and International Perspectives

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Abstract

Micro-credentials have gained attention in public policies over the last few years. This paper, the scope of which is on micro-credentials in higher education with a particular focus on the European perspective, will explore the key policy documents in the European context and analyse how the higher education sector is working on an overall framework for designing, delivering and recognising micro-credentials. The paper also analyses micro-credentials from the three perspectives of qualifications frameworks, recognition and quality assurance, with a reference to digitalisation.

Keywords: Micro-credentials, Higher Education, Recognition, Quality Assurance, Qualifications Framework.

1. Introduction

In the last few years micro-credentials have gained attention in public policies in higher education. This paper focuses in particular on the European perspective, looking at approaches developed in the European Higher Education Area (EHEA) and in the European Union (EU), with a brief reference also to a global perspective.

Policy documents at European and international level identify the flexibilisation of higher education and micro-credentials as a way to support skills development, lifelong learning and inclusion in higher education. But a coherent regulatory and transparency framework in higher education in Europe and beyond is seen as key for their uptake, development, recognition, and also to assess their impact (OECD, 2021; Lantero et al., 2021). This paper explores how national authorities and the higher education sector in the European Region are seeking to define and formalise micro-credentials, from the different perspectives of qualifications frameworks, recognition and quality assurance, with a focus also on digitalisation. In the 'Results' section the emerging patterns are analysed against the existing evidence of the impact of public policies on micro-credentials.

2. Materials and method

This section analyses the key policy documents in Europe covering micro-credentials, identifying the concept, and how public authorities look at their definition, regulation and standardisation in the higher education sector, with a focus on digitalisation.

2.1 Micro-credentials in European policy documents

In the Rome Ministerial communiqué, the joint declaration signed by the Ministers in charge of Higher Education in the EHEA in 2020, micro-credentials as seen as a way to develop or update skills and competences at various stages of life, and to make the EHEA more innovative (EHEA, 2020). The same approach is reconfirmed in the Tirana communiqué in 2024 (EHEA, 2024). The EU Skills Agenda identifies micro-credentials as a way to up-skill and re-skill professionals, to value learning outcomes and to increase permeability and flexibility between different education sectors and pathways (European Commission, 2020d). The same value of upskilling and reskilling is referred to in the EU Digital Education Action Plan for 2021-2027 (European Commission,

2020b). The importance of adult learning is reflected in one of 3 targets defined by the European Pillar of Social Rights Action Plan, establishing that at least 60% of all adults should participate in training every year (European Commission, 2021).

In 2022, the share of people aged 25 to 64 in the EU who had participated in education or training in the previous 12 months was 46.6% [Eurostat, Participation rate in education and training by age, https://ec.europa.eu/eurostat/databrowser/view/trng_aes_101/default/bar?lang=en&category =educ.educ_part.trn g.trng_aes_12m0].

In the European Education Area micro-credentials are seen as a way to diversify the student population and to make higher education more inclusive by 2025 by supporting lifelong learning and providing more flexible and modular learning opportunities (European Commission, 2020c).

In 2020 and 2021 the European Commission were working on defining the European Approach to micro-credentials, with a common definition of micro-credentials, presentation of building blocks, and a roadmap of actions for their development and adoption in Europe (European Commission, 2020a). In June 2022 the Council Recommendation on a European approach to micro-credentials for lifelong learning and employability was adopted, containing the definition and the standard elements to describe a micro-credential, the conditions to support development of an ecosystem for them, and indications on how to deliver on their potential (Council of the European Union, 2022). The Recommendation also contains the European principles for the design and issuance of micro-credentials (Annex II). The role of universities in developing micro-credentials to obtain skills for the green transition is also referred to in the European Commission Communication on a European strategy for universities. The same approach can be found in the Council recommendation "Europe on the Move' – learning mobility opportunities for everyone", where micro-credentials are one of the instruments to support learning mobility (Council of the European Union, 2024a). Micro-credentials are also present in the policy documents published in March 2024 by the European Commission on higher education. In the Proposal for a Council Recommendation on attractive and sustainable careers in higher education, they are referred to on one side as an instrument to support continuous professional development for academic staff in innovative approaches to learning and teaching, with specific reference to green and digital transition. On the other side, they are considered a way to develop deeper transnational cooperation activities (Council of the European Union, 2024c). In the other document released in the same period, the Proposal for a Council Recommendation on a European Quality Assurance and Recognition System in Higher Education, it is recommended that quality assurance systems also cover micro-credentials (Council of the European Union, 2024b).

On a global scale, there was the effort to offer a policy analysis of the phenomenon and to find a common definition of micro-credentials by UNESCO (UNESCO, 2022b). The lifelong learning approach, aimed at serving the diverse education needs of youth and adults, is one of the six major challenges that need to be overcome in "reinventing Higher Education". Short courses and micro-credentials are seen as a vital way to tackle the educational needs of adults at different stages of their personal and professional lives. Flexible learning pathways, recognition, mobility, and internationalisation are one of the 9 ways to navigate towards 2030 (UNESCO, 2022a).

2.2 What is a micro-credential? Definition and characteristics

Since 2020, the European Commission has been working on a European Approach to micro-credentials, also through the establishment of a European group of experts that could look into the topic and support the definition of a common perspective. One of the rationales was that the lack of a commonly agreed definition of micro-credentials and their diversity was perceived as a limit to their value and impact, and an obstacle to their wider acceptance and uptake. The outcome was a report with a common definition of micro-credentials, presentation of building blocks, and a roadmap of actions for their development and adoption in Europe (European Commission, 2020a). The definition of a common approach served as a basis for consultation and dialogue at policy level on the topic, leading in 2022 to the Council Recommendation on a European approach to micro-credentials for lifelong learning and employability, that defines the key elements of micro-credentials. The Recommendation defines a micro-credential as "the record of the learning outcomes that a learner has acquired following a small volume of learning.

These learning outcomes will have been assessed against transparent and clearly defined criteria. Learning experiences leading to micro-credentials are designed to provide the learner with specific knowledge, skills and competences that respond to societal, personal, cultural or labour market needs. Micro-credentials are owned by the learner, can be shared and are portable. They may be stand-alone or combined into larger credentials. They are underpinned by quality assurance following agreed standards in the relevant sector or area of activity" (Council of the EU, 2022).

In the same years, a parallel discussion on flexibilisation of higher education and micro-credentials was ongoing in the European Higher Education Area, thanks also to a number of projects supported by the Erasmus+ programme of the EU, such as MICROBOL - Micro-credentials linked to the Bologna Key Commitments, which aimed to explore if, and to what extent, the tools developed in the European Higher Education Area were applicable to learning provisions that lead to a micro-credential. The particular reference was to the possible implementation of micro-credentials through the lens of the so-called Bologna 3 key commitments, i.e. 3 cycles qualifications framework, recognition of qualifications awarded in line with the principles of the Council of Europe and UNESCO joint convention regulating recognition in the European Region, i.e. the so-called Lisbon Recognition Convention, and quality assurance system in line with the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ENQA et al., 2015). The definition of MICROBOL, contained in the Common Framework for micro-credentials in the EHEA, is aligned with the EU one (MICROBOL, 2022). The MICROBOL definition adds a few elements to the definition and concept of micro-credentials, seen as a way to: increase and diversify lifelong learning provision (in this sense they are not a new concept as such); to quickly respond to learners' and labour market needs; to collaborate between different actors; to reinforce the link between education and research, facilitating knowledge transfer from academia to society. Both in the EU and EHEA context, micro-credentials are seen as complementary and not alternative, to higher education degrees (Council of the European Union, 2022; MICROBOL, 2022).

The definition offered by UNESCO goes in the same direction: "A micro-credential:

- is a record of focused learning achievement verifying what the learner knows, understands or can do.
- includes assessment based on clearly defined standards and is awarded by a trusted provider.
- has standalone value and may also contribute to or complement other micro-credentials or macrocredentials, including through recognition of prior learning.
- meets the standards required by relevant quality assurance" (UNESCO, 2022b).

2.3 How are micro-credentials developed and assessed? Frameworks and standards

The EU Council Recommendation defines the standard elements to describe a micro-credential, that ranges from the identification of the learner to the learning outcomes, and to the form of assessment and of quality assurance (Annex I of the Recommendation). Furthermore, it sets the 'European principles for the design and issuance of micro-credentials', including 10 principles, from quality, information provision, transparency to recognition, authenticity, portability (Annex II).

In the European higher education area, the discussion on the overall framework for development and acceptance of micro-credentials has revolved around the 3 key commitments of the Bologna Process. Research and exchange activities have been carried out also with the support of Erasmus+ projects such as MICROBOL, and more recently with others such as Quatra, Iminqa, and TPGB-LRC Core, that provided an updated common vision of micro-credentials under the 3 perspectives of qualification frameworks, recognition and quality assurance.

A. Qualifications frameworks and ECTS

Policy and practitioner documents developed in the European higher education context converge on the idea that micro-credentials should be included in the national qualification framework

whenever possible, and that such decisions should be taken at national level, as a way to support transparency (Council of the European Union, 2022; MICROBOL, 2022).

With the same objective of supporting transparency and clarity of information, the workload needed to achieve the learning outcomes of a micro-credential should generally be described using the European Credit Transfer and Accumulation System (ECTS). In this direction the Tirana communiqué asks to "review the ECTS Users' Guide 2015 by 2027, to strengthen its key features and adapt it to current developments, including micro-credentials" (EHEA, 2024).

B. Recognition

The key elements to support recognition of micro-credentials are transparency and completeness of information provided. Information should be transparent, reliable, easily accessible to the learner and to the general public, also in a historical perspective (a qualification can be recognised years after it was awarded) (Council of the European Union, 2022; MICROBOL, 2022; TPG-LRC CoRE, 2024). If information is complete following the standard elements defined in the EU council Recommendation on micro-credentials, it is possible to assess micro-credentials in line with the principles of the Lisbon Recognition Convention (LRC), the international Convention regulating recognition of qualifications in the European region (Convention on the Recognition of Qualifications Concerning Higher Education in the European Region, 1997). If these elements are not transparently recorded in the micro-credential, recognition is still possible, by using a Recognition of Prior Learning (RPL) procedure, i.e. the validation of learning outcomes, whether from formal education or non-formal or informal learning, acquired before requesting validation (European Union, 2015). This procedure should be fit-for-purpose from the point of view of HEIs and learners (MICROBOL, 2022; TPG-LRC CoRE, 2024) [Support to understand the level of transparency and of completeness of information comes from the methodology developed in the framework of the Erasmus+ E-valuate project, that supports checking robustness of information across 7 perspectives: 1. Quality of the course; 2. Verification of the certificate; 3. Level of the course; 4. Learning outcomes; 5. Workload; 6. The way study results are tested; 7. Identification of the participant (NUFFIC, 2022). This methodology was incorporated in an online tool called micro-evaluator: https://www.nuffic.nl/en/subjects/recognition-projects/the-micro-evaluator].

C. Quality assurance

The responsibility for quality assurance of micro-credentials lies with Higher Education Institutions through their internal QA processes. External QA should thus focus on reviewing the fitness-for-purpose of the institutional approach to micro-credentials, and quality assurance of micro-credentials can be incorporated in the existing processes (MICROBOL, 2022; TPG-LRC CoRE, 2024). Internal quality assurance processes for higher education provision, including micro-credentials, must adhere to the standards outlined in the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG), which are usually incorporated in the relevant national criteria (TPG-LRC CoRE, 2024).

According to the results of the IMINQA projects, internal quality assurance of micro-credentials stems from the models for offering micro-credentials: micro-credentials that are the result of unbundling existing programmes are covered by the internal QA programme evaluation procedure, and in this sense there is no need for additional quality assurance procedures. For standalone micro-credentials, that are usually offered as part of the HEI's lifelong learning provision, they are covered by the internal quality assurance of lifelong learning (which can be lighter or the same as the internal quality assurance for degree study programmes) (IMINQA, 2023). The key criteria for internal quality assurance for microcredentials are well-defined learning outcomes, transparent assessment methods and information transparency (IMINQA, 2023).

D. Digitalisation

In the framework of lifelong learning, learning pathways and provisions leading to micro-credentials can be offered face-to-face, online, or in a hybrid mode (Lantero et al., 2021). Certificates for microcredentials can be awarded in many formats, but one of the points on which

different documents converge is the idea that a digital format can facilitate portability, transparency, reliability of information and verification of authenticity, and as such support a fast and fair recognition process (Council of the European Union, 2022; MICROBOL, 2022; TPG-LRC CoRE, 2024). Furthermore, digital microcredential certificates should be awarded in line with European and international standard for privacy and data protection, according to interoperability best practices, ensuring that the learners have control over what they wish to share and for how long. At the European level, there are several initiatives aimed at developing interoperable solutions to support agreed criteria for digitalisation of data, secure, transparent and trusted data provision, and platforms of credential sharing. One example with regards to the third point is the Europass platform and the development of the European Learning Model, as a way to establish a unified vocabulary for learning in Europe to enhance recognition and trust in qualifications and digital credentials (TPG-LRC CoRE, 2024). Another example is the European Blockchain Services Infrastructure – EBSI. A third example is the Database of External Quality Assurance Results (DEQAR), created in 2018 to enhance access to quality assurance reports and decisions on higher education institutions/programmes externally reviewed against the ESG, by an EQAR-registered quality assurance agency. DEQAR currently contains around 97,000 reports covering almost 4,000 institutions and programmes. One of the latest developments of the database is the inclusion of information on micro-credentials awarded by both HEIs and alternative providers (TPGLRC CoRE, 2024).

3. Results

Micro-credentials, framed in the context of lifelong learning, are not a new phenomenon: Higher Education Institutions have already been providing for a long time lifelong learning opportunities, through units smaller than full degrees, such as courses, modules, diplomas, parts of degrees, in-service training, etc. (Lantero et al., 2021). But what characterised the discussion at European level was the idea to re-conceptualise this diversity putting the various experiences and concepts together into a coherent and more understandable and verifiable whole (MICROBOL, 2022). The main aim of this effort in harmonisation is to support inclusion, access to education for a wider range of learners, support to upskill and re-skill of professionals, reduction of inequalities in access to education and training for adult learners, and more in general to support skills development, lifelong learning and inclusion in higher education as indicated at the beginning of this paper. The effort in harmonisation and “standardisation” has been maintained as not too restrictive and prescriptive, to allow flexibility and innovation, which are one of the micro-credential characteristics (Lantero et al., 2021; OECD, 2023b).

While the analysis of policy documents shows some recurrent patterns in the conversation around microcredentials, analysis of the literature on micro-credentials by region shows that the emphasis on increased flexibility for learning and the promotion of lifelong learning as well as employability is a specific perspective for Europe, while in other regions the topics associated with micro-credentials are more focused on employability, closing the skills gap, and supporting work-based training and continuous professional development, as in Asia-Pacific for instance (Van der Hijden & Martin, 2023). Some authors argue that this geographical difference could be linked to the social-cultural context and the extent to which education is positioned as a private or public good (*ibid.*).

Some research has been done on providing evidence on the impact of micro-credentials, to assess to what extent they can be an effective instrument in the direction designed by policy documents. While the micro-credential landscape is still evolving, there are some elements that seem to emerge. One element, for example, shows that “adults who possess a higher education degree and higher information processing skills, are of prime working age (25-54), are employed in larger firms and have higher incomes are more likely to participate in non-formal education and training than their counterparts with contrasting characteristics. Similar patterns in learner demographics are also evident in other national and international datasets, such as the European Union (EU)’s Adult Education Survey and Labour Force Survey” (OECD, 2023b). By the same token, also the level of the micro-credentials seems to have an impact on potential learners:

“Short learning programmes at the pre-bachelor level have a much higher proportion of socio-economically disadvantaged learners than micro-credential programmes offered by learning platforms such as Coursera or edX, whose learners are typically experienced workers holding academic degrees” (OECD, 2023a). Looking at the impact on the learner, another element is that programmes specifically linked to in-demand or growing industries show better outcomes. Furthermore “targeted and short-term credentials appear to work well when ‘topping-up’ existing higher education but have a mixed impact on those without a bachelor’s degree” in terms of completion and of benefits after the end of the programme (OECD, 2023a).

With regard to information provision, while according to OECD Higher Education Policy Survey 2022 approximately 70% of responding jurisdictions have either an information portal or a guidance centre that allows prospective learners to explore reskilling and upskilling opportunities at the higher education level, these portals do not necessarily also include micro-credentials. From the OECD analysis, 3 elements emerge: public authorities have adopted a variety of methods to develop micro-credential portals; many portals are not comprehensive, rather, they focus online on a limited number of courses and providers; finally, some online portals provide more in-depth information, such as fields of study, delivery modes, length and fees (OECD, 2023b). In this regard, the establishment of common descriptors that can be used by a range of providers is key to enable learners to make structured comparisons among programmes but also facilitates mutual academic recognition between education and training providers. Additionally, such common descriptors significantly enhance interoperability across various online learning platforms.

Regarding the workload of micro-credentials, there is no suggested amount of credits in main policy documents at international level, to allow for diversity and flexibility at national level. However, while shorter programmes can be helpful in the quick correction of minor skill mismatches, longer programmes appear to be successful at helping adults with career changes (OECD, 2023b).

With regard to quality assurance mechanisms, evidence shows that the system highlighted for the European region is in line with trends at global level, that tends to allow institutions to take responsibility for micro-credential programmes, rather than undertaking programme-level review. In this direction the trend seems to be that quality assurance bodies review the internal quality assurance mechanisms that institutions put in place for micro-credential learning, and not the single micro-credential. A second emerging practice is reliance upon existing quality assurance schemes (OECD, 2023b).

4. Conclusions

There is the need to collect more data and evidence on the impact of public policies on micro-credentials in higher education, as a way to support data-driven decisions and to support the impact of activities undertaken by actors in higher education systems.

Some research areas are related to the expected impact of micro-credentials in upskilling and reskilling of learners. One perspective is how micro-credentials are positioned in the overall framework of public policies for adult and lifelong learning, and how other policy instruments are linked to them [At European Union level, the Council Recommendation on micro-credentials was published the same day of the Council Recommendation of 16 June 2022 on individual learning accounts, and the two recommendations have cross-references between them. The concept of ‘individual training entitlement’ means the right to access a personal budget at an individual’s disposal to cover the direct costs of labour-market-relevant training, guidance and counselling, skills assessment or validation that are eligible for funding. ILAs are seen as a way to support, enable and increase motivation of all working-age adults in accessing training].

Another perspective is around skills intelligence, and how new digital tools and development can serve to identify relevant learning outcomes and skills to match supply and demand [The Erasmus+ “MARTe – A technological approach to micro-credentials” aims, among other objectives, to apply the text-mining technology to the repositories of micro-credentials,

specifically to their learning outcomes, in order to collect consistent data on the information shared by delivering institutions: https://www.cimea.it/EN/paginamarte].

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Appropriateness of the blended learning intensive programme: analysis of a case for the definition of a model

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Abstract

The contribution is made with the aim of analyzing the validity of the blended learning model proposed to students of the Philosophy degree program at the University of Milan. During the current a.y. 2023-24, the 4 mandatory courses of the first year are delivered both in-presence (A-K; L-Z editions) and blended learning (blended learning edition). The blended learning edition model is based on 3 in-presence lectures (6/8 hours), 20 hours of asynchronous lectures, and the remaining in synchronous videoconferencing. With a view to understanding the levels of adequacy of the model for the categories of students who have chosen to participate in this specific edition and its possibilities for expansion to other teaching or degree courses, a mixed method survey was implemented according to the Explanatory Sequential Mixed Methods Design QUANT->Qual model. The research methodology involved the administration of a questionnaire to all students who have taken at least one blended learning course with a participation rate of more than 50%, and 6 interviews with students representative of clusters. To select clusters of students, course participation data, exam results (learning analytics), and questionnaires responses will be analyzed. The results highlighted the benefits of a blended learning model to include students who are not attending either because of jobs or because of frailty or personal conditions. Analysis of the responses enabled the identification and delineation of how to articulate the in-person and distance hours in order to achieve a sustainable BIP Blended Learning Program model.

Keywords: Blended Learning, Higher Education, Mixed Methods, Blended Learning Model, Didactic Innovation.

1. Introduction

The blended learning model is emerging in the context of higher education as an interesting solution to contemporary educational challenges (Garavaglia & Petti, 2022; Rasheed et al., 2020; Castro, 2019), both in an international and Italian context (Ranieri et al., 2023 Bonaiuti & Dipace, 2021; Spinu et al., 2022; Limone, 2021); Combining elements of traditional face-to-face teaching and online learning modes (Rivoltella, 2021; Garavaglia & Triacca, 2021), blended learning offers flexibility to adapt to the diverse needs of students (Boelens et al., 2018), even before the pandemic of Covid 19 (Ma'arop & Embi, 2016; Garavaglia, 2019; Garavaglia & Petti, 2011). Since that event, however, the study and application of blended learning solutions has become increasingly widespread and systematic (Thahir et al., 2023; O'Dea & Stern, 2022). The blended learning approach is particularly beneficial for working students, allowing them to balance work and academic responsibilities while ensuring equitable and inclusive access to educational resources (Allan, 2007). In addition, blended learning is critical for engaging students who are caregivers or have specific difficulties attending face-to-face classes (Garavaglia & Terrenghi, 2022). The ability to attend and complete coursework both asynchronously and synchronously creates a dynamic and interactive learning environment that fosters greater participation and engagement for all students (Fisher et al., 2021; Sahni, 2019; Tay, 2016).

During the academic year 2023-24, the compulsory courses of the Bachelor of Philosophy (University of Milan) included an edition delivered in blended learning. These courses were based

on 3 face-to-face lectures (6/8 hours), 20 hours of asynchronous lectures and the rest in synchronous videoconferencing and had a total of about 100 students participating.

The project, which envisions greater digitization of teaching delivery, stems from the covid-19 emergent teaching period during which at least half of the students found no problem in following at a distance as opposed to being present, and at least 30 percent of the students stating that they hoped for a continuation of online teaching delivery in order to continue accessing faculty teaching (Garavaglia & Terrenghi, 2022). In order to consolidate methodological and teaching skills, the faculty members involved were invited to participate in workshops offered as part of the university's Faculty Development in collaboration with the university's e-learning center CTU.

The proposed delivery model was designed with the need to maintain consistency with courses delivered in-person during the same period. Therefore, a total of 6 hours per week is maintained, but these are distributed according to two proposals.

A model:

4 hours of synchronous teaching via videoconference

2 equivalent hours of video lectures

- occasionally (3 times) 2 hours of videoconferencing are substituted for 2 hours in-presence

B model:

2 hours of synchronous teaching in videoconference

4 equivalent hours of videolessons

- occasionally (3 times) replace 2 hours of videoconferencing with 2 hours in-presence

The in-person and videoconference hours are always recorded, allowing anyone to catch up with the course at any time of the year.

2. Materials and Methods

To explore the adequacy of this proposal and the perceptions of the participants, a mixed methods survey was conducted according to the Explanatory Sequential Mixed Methods Design QUANT->Qual model (Creswell & Plano Clark, 2007).

The data collection phase alternated between two integrated steps:

1. the first consisted of the online administration of ad hoc questionnaire to all students enrolled in at least one course delivered in blended learning mode. The survey was delivered via Microsoft Forms and alternates between different types of questions, both multiple choice and open-ended qualitative: the first five questions are about the profile (Q 1-5), others about the BL courses attended, with particular attention to some typical elements of the model - e.g. evaluation of the adaptability of face-to-face, video and synchronous online lessons to specific needs (Q 6-19) and finally some questions about the student's projection of the future replicability of the model (Q 2023). The questionnaire then concluded with a request for availability for a subsequent interview phase (Q 24-28). Students were given the choice of accepting or declining the offer, and were made aware that their choice would not affect their career in any way;
2. The second phase of data collection was organised through semi-structured interviews, which lasted on average 30 minutes and were conducted online to facilitate subject participation. The interview outline was constructed from some data worthy of further investigation, such as students' perceptions of an intensive blended programme solution.

The course was open to anyone who decided to opt for this educational solution, so it was necessary to analyze access and utilization data to determine the actual sample of students who had taken at least 70 percent of one of the 4 courses provided. This list of 125 students allows us

to define the actual universe of students who joined the project. Considering that the number of freshmen was 670, it is interesting to note that about 19% of the students at a traditional “in-presence” university position themselves as “distance learners”.

The sample of 49 students who responded to the questionnaire maintains good representativeness of the universe of students with respect to the variables sex and age (chi-square test verification). 18 of these made themselves available for interviews, 6 of whom were randomly selected for the small sample of respondents.

While the data from the questionnaires were analysed using descriptive analysis, the interviews were first transcribed and then three different researchers read through the entirety of the interviews and carried out thematic analysis.

The main purpose of this paper is to present a reasoned integration of the quantitative and qualitative data in order to highlight the students' experiences in this first year. It is also very important to analyse and discuss the students' perceptions regarding a future extension of the blended learning proposal. This element of reflection is particularly important with a view to a well-founded design of the training proposal, so that it can be adapted as far as possible to the learning needs of the students.

3. Results

The survey was administered from April 27, 2024, to October 19, 2024. The respondents are mostly female students (F=53%, M=44%) and most of them (about 80%) indicated that they are over 30 years old, while 87% indicated that they are employed, some full time (61%), some part time (14%) and others still working occasionally (12%).

Furthermore, the results indicate the presence of a small percentage of students who self-identify as caregivers or as having a specific difficulty that may significantly impair their participation in teaching and training activities. Indeed, 24% of the students surveyed indicated that they fell into one of these categories. It is of paramount importance to highlight that the respondents were almost equally distributed between those who pursued the course of study in a conventional manner (47%) and those who claimed to be enrolled part-time (53%): this latter option allows students to extend their education for up to twice the normal length of their course at no extra cost and supports the inclusion of those students who, for various reasons, are prevented from standard attendance.

Focusing specifically on the questions related to the students' evaluation of the proposed blended learning facility for the courses, there was a very positive response. In general, students were positive about the communication that professors published on the channels of each blended learning course: they found the information easy to find (about 69 % of the students rated this item very positively), as well as complete (71%), and clear (73%).

The survey also revealed that students believe blended learning courses are more adaptable to their schedules and personal needs than face-to-face courses. Approximately 98% of respondents indicated that the courses were completely or almost completely tailored to their needs, especially with regard to live streaming (Figure 1): almost all students (more than 91%) rated the synchronised teaching time very positively.

This is also supported both by the students' statements in the qualitative questions and interviews. For example, one respondent stated that "the organisation of the Blended Learning facility is great for working students, because it allows them to access the lectures and materials provided by professors and to have direct contact with them. I believe that this mode allows those who cannot attend in person to reach a higher level of preparation than those who do not attend, precisely because of the possibility of receiving training from the teachers” (F, >30, W); someone else insists not only on the courses’ adaptability but also on its effectiveness with respect to learning outcomes: “blended courses offer the possibility to better organize the study of one's teaching and repeat lessons where concepts are unclear better consolidating concepts over time” (M, >30, W) [W = Student Worker].

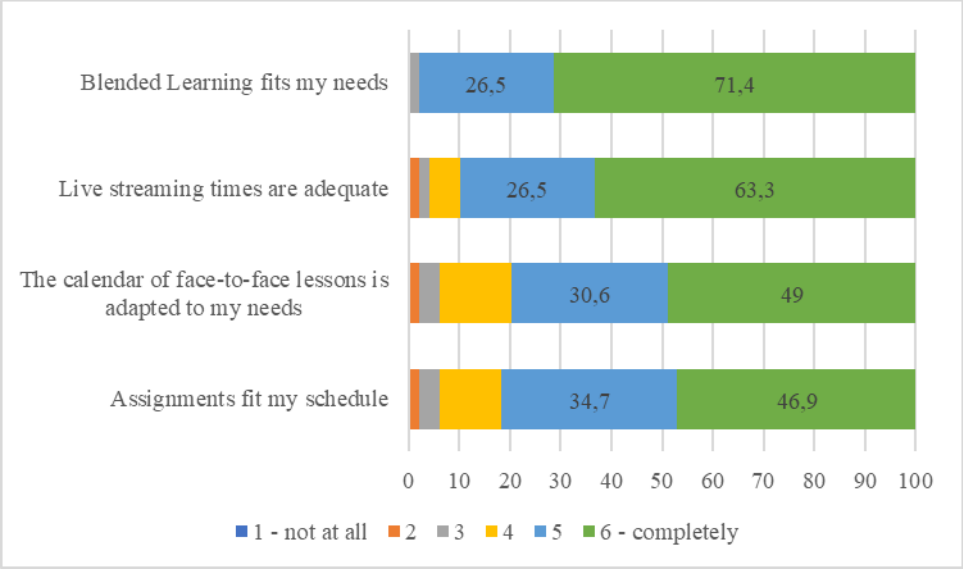


Figure 1 - Evaluation of the main elements of the blended model (percentage)

Many students also stated in interviews that the blended model was very "*convenient*" because "*it is more flexible and fits in better with our working hours*" (M, >30, W) and that the courses have been very supportive of participation (F, >30, W).

This specific issue of learning benefits was explored through an ad hoc question in the questionnaire that asked respondents to select from several items what they believed to be the most important benefits from a learning perspective resulting from taking blended courses. As shown in Figure 2, students rated the ability to review lectures as particularly beneficial (about 98%), the ability to deepen knowledge (about 82%), and the ability to follow and learn at their own pace (about 71%). The activities integrated in the course (exercises and tests) also had a positive impact according to the students, especially in terms of their usefulness in general preparation (about 65 %) and in terms of exam preparation (about 57 %).

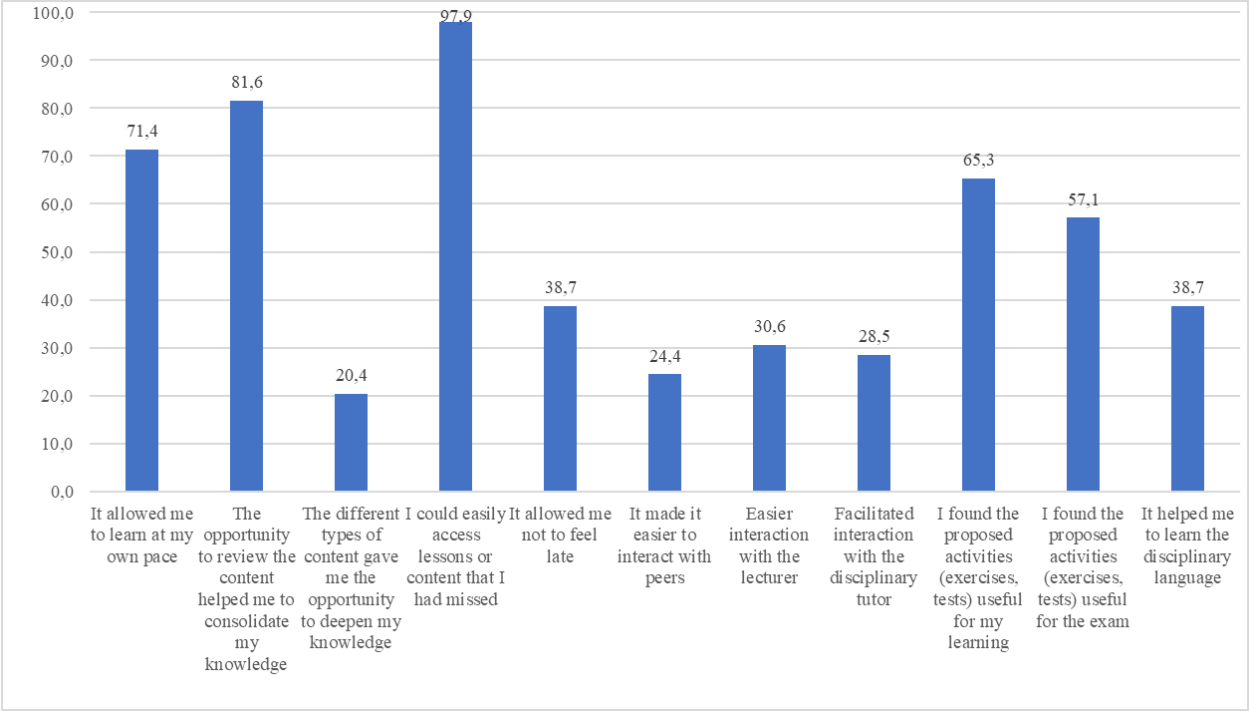


Figure 2 - Student choice as a percentage of perceived learning benefits.

By taking into account each of the didactic elements that make up the blended learning offer (i.e. synchronous face-to-face lectures, synchronous online lectures and video lectures with asynchronous delivery), students generally valued the possibility of reviewing or retrieving recordings, which was always guaranteed. In the case of synchronous face-to-face lectures, the ability to review the recording was rated as completely adequate (highest score on a Likert scale) by 77% of students, as was the recording of synchronous online lectures (around 88%). Video lectures, on the other hand, were highly appreciated because they allowed free use of the content (about 90%), even several times (about 90%).

The last part of the questionnaire aimed to investigate the replicability desired by students regarding the blended edition. Again, the responses collected show a trend of willingness to replicate the experience, even increased (Figure 3). Most respondents (61%) indicated that they would like to see at least some teaching delivered in blended mode in each year of the course, not just the first year; another segment of respondents (34%) felt that a whole course delivered in this mode alongside a traditional course would be useful.

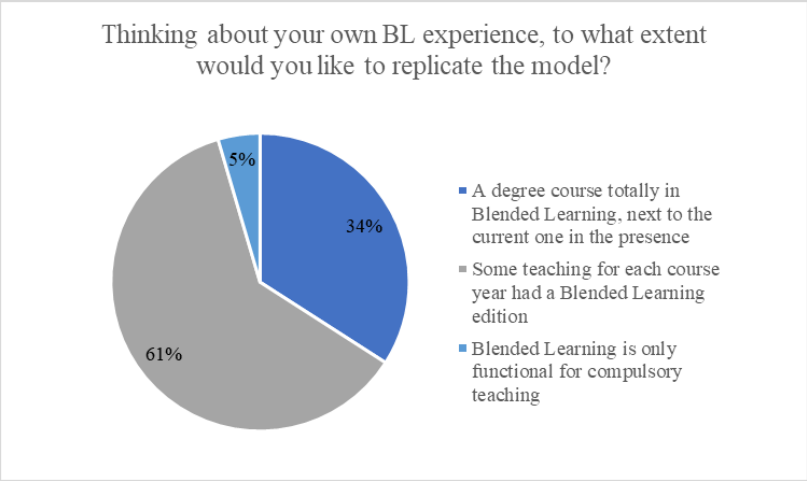


Figure 3 - The percentage distribution in relation to the replicability of the blended model.

A very significant part of the questionnaire asked the students to evaluate the distribution of the model's hours by thinking about which tripartition would be best for them in terms of the adaptability and sustainability of the training provision. The first interesting fact concerns half of the respondents (just over 50%) who expressed their appreciation of the current distribution of hours: many even stated that they would leave the organisation of presence and online hours, both synchronous and asynchronous, unchanged (Figure 4).

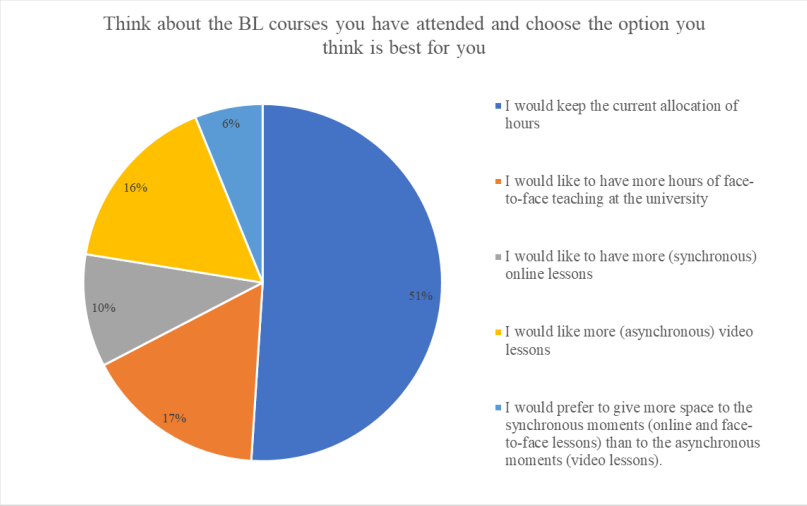


Figure 4 - Percentage of responses concerning future redistribution of hours.

The data from this question then shows two fairly evenly distributed groups of students with two very different ideas: 17% of respondents say they would prefer to see an increase in the number of attendance hours delivered in person at university, while another 16% say they would prefer to see an increase in asynchronous video lessons. The first group states that the decision to increase the number of face-to-face lectures would be functional mainly to develop a collective sense of belonging to the academic world and to improve interactions, both with peers and lecturers. In the interview, a student supports this idea by stating "*you interact, you get to know each other, you compare, you create a group*" (F, >30, W), while a second student appreciates the interaction provided by synchronicity to share with teachers doubts or considerations: "*a synchronous lecture is always the best because it gives you the opportunity to ask questions and better understand the concepts the lecturer is explaining. Video lectures do not allow this*" (F, >30, W).

The analysis of the qualitative responses in the questionnaire also reveals a few voices suggesting an intensive solution, with the proposal of an in-person day involving more hours and more meaningful activities from the point of view of interaction and reworking of disciplinary content: "I *find that coming to the university on Saturdays for only two hours -which then becomes an hour and a half of lecture time- is not very useful for a worker who is busy all week. I would opt for more hours, a kind of intensive Saturday. Coming to the university is a cost and is also a not inconsiderable effort after a work week. I would like the time in attendance to be more meaningful*" (M, >30, W).

However, this is not supported by the analysis of the interviews. Students, when encouraged to reflect more deeply than in an intensive blended programme, indicated that they preferred a day of attendance with a few hours of lectures. In most cases, the interviewees set the number of lecture hours effectively at 3. "*I think that several hours in a day are not useful. Three hours is already too much for me: learning has to be metabolised, spread over time, because a concentrated number of hours makes it difficult to pay attention, for example. So, it is better to spread out the hours than to concentrate them in one day"* (M, >30, L). This tendency to work in presence for a not excessive number of hours seems to be based on the idea that the teaching of philosophy is always and only transmissive and frontal, so much so that there were many students who used expressions such as "listen", "store": "*I would not do a full day of mixed work, say 5 hours, because no one would be able to really absorb it"* (M, >30, NW) [NW = Student Non-Worker].

4. Discussion

From the results it seems to us that we can outline these models of BIP Blended Intensive Program:

A) Single-day intensive BIP

- 40 hours asynchronous lectures
- 12 hours synchronous lectures by videoconference
- 8 hours single-day in-presence (active learning)

B) BIP in several half days

- 40 hours asynchronous lectures
- 8 hours synchronous lessons in videoconference
- 12 hours in 3 half-day meetings (active learning)

The 40 hours of asynchronous lectures can in turn be recombined into synchronous lectures in videoconferencing, but we think it is important not to overdo the synchronous appointments. This attention is related to statistics that showed that a significant proportion of students failed to

attend all the live lectures and often made use of video-conference recording, studying at their own pace.

The two proposed models are presented with the specification of adopting active teaching during in-person meetings. If there are not the appropriate teaching conditions to propose activities during in-presence classes, it is better to opt for model B, which allows more traditional transmissive teaching to be adopted during in-presence meetings. Model B, moreover, suggests a breakdown of meetings into 3 key moments (beginning, middle and end of the course), while Model A entrusts a specific day with activities that allow students to socialize, compare and participate in an active learning community.

5. Conclusion

The research presented here has enabled us to focus on some key points quite clearly:

- the percentage of caregivers/students with frailty is 24%, which means that for a quarter of the students involved, online education translates into an all-around inclusive solution, not only a proposal for the “classic” working student.
- among the main learning benefits of online didactics, the importance of reviewing learning materials emerges, both lessons missed to catch up, lessons already enjoyed to deepen and consolidate, and the possibility of enjoying the course at one's own pace precisely due to the fact that any lesson, even synchronous and in-presence lessons, are recorded.
- in-depth interviews confirm the preference for BIP Blended Intensive Program models with a few hours in-presence in the same day rather than an “intensive” in more day solutions. There is, however, a need to consider that in-presence lectures were mostly conducted according to traditional-transmissive logic, while Blended Intensive Program models generally prove to be more effective if active teaching is mainly proposed in the in-presence meetings. This is the main reason why we proposed BIP models A and B based on judicious structuring of the in-presence hours.

The models will be applied in the upcoming Blended Learning editions of the Philosophy degree program's teachings, with the intention of consolidating the proposal and laying the groundwork for future developments in the inclusion of nonattending students through innovation and digitization of university teaching

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Teaching approaches for blended learning: results of the experimental phase at University of Florence

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Abstract

The B-LeAF project (Blended Learning at University of Florence) aims to evaluate the application of the blended approach and to provide support and training to the teaching staff. The experimentation of blended learning was carried out in 2022/2023, involving 45 courses across 18 degrees. To support teachers, the Guidelines for the application of blended learning have been developed and 3 possible teaching solutions were proposed. The data collected during the experimentation show good agreement between teachers and students regarding the effectiveness of the blended mode, both for the impact on learning and for the greater level of flexibility. The comparison between teaching approaches to blended learning revealed positive feedback, with some differences between teachers and students.

Keywords: Blended Learning, Innovative Teaching, Flipped Approach, Active Learning, Group Work.

1. Introduction

The B-LeAF project (Blended Learning at University of Florence) is part of the process of educational and organizational innovation undertaken after the experience of Emergency Remote Education due to the covid-19 emergency, in order to combine the benefits of in-person teaching with those of distance learning. The project aims to foster the application of the blended approach in different disciplines and courses, to evaluate its learning effectiveness and to provide support and training to the teaching staff (Ranieri et al., 2023). After a pilot phase (Spinu et al., 2022a), the educational experimentation was extensively conducted in the academic year 2022/2023: overall, 45 courses were involved, distributed across 15 master's degree and 3 bachelor courses.

In the literature, the concept of 'blended learning' is described as "the combination of instructional formats that date back to two historically separate models of teaching and learning: traditional faceto-face learning systems and distributed learning" (Graham, 2006, p. 5). This hybrid approach aims to capture the best of both in-person and online learning, capitalizing on the immediacy and interpersonal benefits of traditional classroom interactions while leveraging the flexibility and scalability of online resources. Through this integration, blended learning aims to provide a more adaptive educational experience, aligning with diverse learning styles and enhancing accessibility for a broader range of students.

This model also introduces several pedagogical innovations, including the adoption of flipped teaching solutions, where direct instruction occurs outside the classroom (typically online), and inclass time is reserved for collaborative, hands-on activities. Such an approach encourages active learning, giving students more control over their study pace and fostering a deeper understanding of material through applied practice in a social setting (Hughes, 2024).

In the higher education context, the pandemic has contributed to strengthening a process of rethinking teaching that was already underway, with a focus on possible hybrid scenarios of integration between real and virtual (Spinu et al., 2022b). As highlighted by some studies (Gaebel et al., 2021), blended solutions were already quite widespread: 75% of European universities

provided programs in mixed mode. At the Italian level (Ligorio et al., 2022; Panciroli, 2020), blended teaching can represent an innovation strategy for conventional university courses, capable of responding to the needs of a new and broader typology of students.

2. Materials and Methods

Until the pandemic, the University of Florence had always used e-_earning to support face-to-face teaching: the didactic experimentation of the blended modality therefore required a substantial redesign of teaching methods (Spinu et al., 2022a). To support teachers in this task, the Guidelines for the application of blended learning have been developed and 3 possible teaching solutions were proposed (Ranieri et al., 2023; Bruni et al., 2024):

1. flipped approach, in which the delivery part is anticipated remotely and then interactive activities are carried out in the classroom.
2. active individual approach, with asynchronous activities directly involving students, such as production of papers, exercises, case studies, etc.
3. active group approach, with activities to be carried out in groups throughout the duration of the course.

After a pilot phase in the second semester of 2021/2022, the blended teaching experimentation was carried out in the academic year 2022/2023. The experimentation preferentially involved master's degree courses, which could join the initiative through the participation of one or more teachers, who voluntarily gave their availability. Exceptionally, 3 three-year degree courses were also accepted. In total for the 2022/23 academic year, 45 courses participated in the experimentation, distributed across 15 master's degree courses and 3 three-year study courses (Table 1).

Table 1 – Courses per disciplinary area and teaching approaches.

Disciplinary Area	*Type of degree*	*Number of courses*	*Teaching approaches (multiple responses allowed)*
Biomedical Area	6 Master's course 1 three-year course	21 courses	18 flipped 12 active
Technological Area	8 Master's course	17 courses	8 flipped 8 active 10 group
Social sciences Area	1 Master's course 2 three-year course	5 courses	4 flipped 3 active 1 group
Humanities and education area	1 Master's course	2 courses	2 active 1 group

To formalize participation in the experimentation, a formal passage was required in the Council of each Study Course: the Council had the task of defining which courses and how many credits could be awarded in blended mode, thus guaranteeing that the credits for distance learning did not exceed 10% of the total credits of the course. The choice of the teaching solution to adopt was instead at the discretion of the individual teacher.

A monitoring and data collection action was conducted along the whole experimentation in order to evaluate the teaching effectiveness and the organizational impact of blended teaching, both from the point of view of teachers and students. The three teaching approaches were also investigated to understand their effects on the learning process.

The monitoring activities were conducted by the staff of the e-Learning Desk, active in supporting the teachers along the didactic re-design and implementation process through individual meetings, information was collected on the teaching approaches adopted and on the number of CFU used for distance learning activities.

To collect data on the results of the experimentation, two surveys were prepared, specific to the target audience:

- a questionnaire for students, aimed at detecting their point of view on: quality of learning in relation to the blended teaching approach adopted; level of communication of the experiment and organizational implications; perceived impacts on the teaching-learning process and level of participation. The questionnaire was composed of a series of statements, and students could indicate their level of agreement on a scale from 1 to 5, where 1 = not at all and 5 = completely.
- a questionnaire for teachers, aimed at detecting teachers' impressions on: effectiveness of the blended method and specifically of the teaching approaches identified in the guidelines; level of implementation of the designed teaching solutions and difficulties encountered; aspects to be improved. The questionnaire consisted of closed questions; in the sets of questions with statements, teachers could indicate their level of agreement on a scale from 1 to 5, where 1 = not at all and 5 = completely.

The questionnaire was administered to students close to the end of lessons, in order to collect immediate impressions. The questionnaire was directly implemented in Moodle, within each of the courses participating in the experimentation: the teachers were asked to make the tool visible, at the same time sending a communication to the students. Of the 45 courses taking part in the experimentation, 43 provided the final questionnaire, collecting a total of 1584 responses.

The teacher questionnaire was administered online after the first session of exams: in this way, in fact, the feedback collected could also take into account an initial assessment of the level of preparation achieved by students thanks to blended teaching. In total, the responses collected between the first and second semester were 40 out of a total of 47 teachers.

3. Results

As for the effectiveness of the blended modality, responses are positive for both actors involved (Figure 1). In particular, teachers believe that this didactic approach was effective in stimulating student participation, and more generally also in improving the teaching process, giving greater flexibility to the workload. The students' responses show a positive view of blended learning, although slightly lower than the feedback given by the teachers.

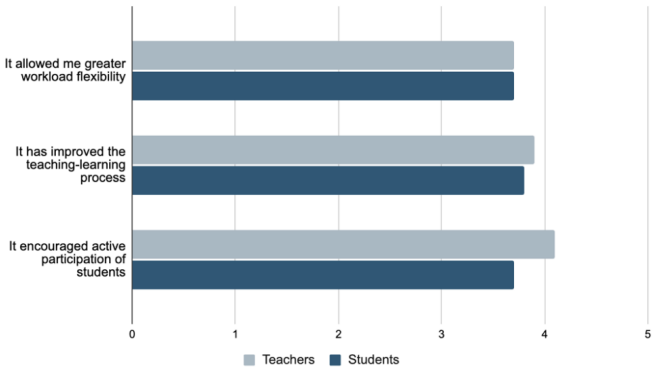


Figure 1 - Teaching effectiveness of the blended modality, mean values (teachers N=40, students N=1584).

Regarding teaching approaches, all received good feedback.

The flipped approach is the one that has been most used: teachers' responses highlight its effectiveness in relation to the possibility of carrying out activities in the classroom that are functional to learning (Figure 2). Furthermore, the responses seem to dispel one of the most widespread fears regarding reversed teaching, namely that students do not use the materials before lessons: the level of agreement with the statement "The students regularly used the study materials provided before the lessons" averages a score of 4.1 out of 5.

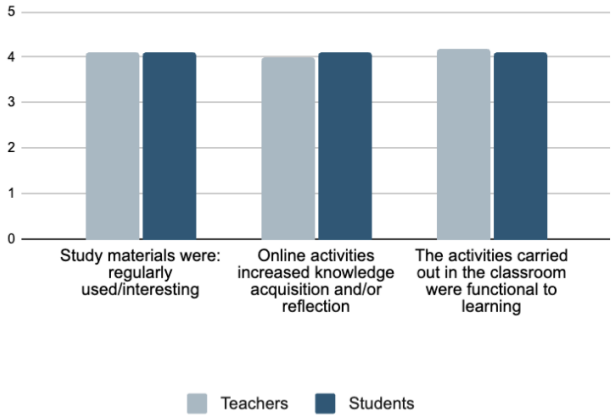


Figure 2 - Opinions on flipped approach, mean values (teachers N=21, students N=1191).

For the individual active approach, both teachers and students recognize the teaching effectiveness of asynchronous activities (Figure 3). Furthermore, the teachers underline that the distance mode has made possible activities that would not otherwise be possible due to organizational problems. Students seem to grasp the organizational benefits to a lesser extent, with an average score that stops at 3.5, almost one point less than the opinion of the teachers (average 4.4).

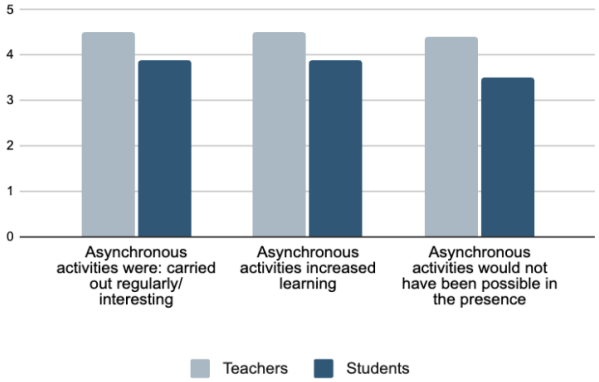


Figure 3 - Opinions on individual active approach, mean values (teachers N=23, students N=797).

For the active group approach (Figure 4), the responses of teachers and students show that the impacts on the organizational factor were captured to a lesser extent compared to the individual approach. However, students' appreciation for group activities is higher than individual ones, as are the effects on learning.

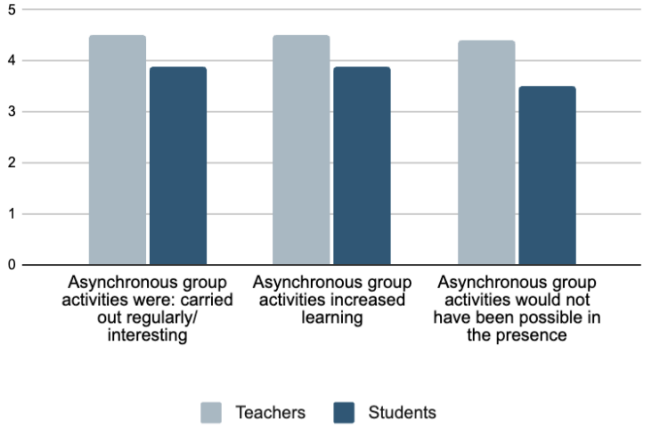


Figure 4 - Opinions on group active approach, mean values (teachers N=14, students N=125).

4. Conclusions

The findings from the B-LeAF project demonstrate the potential of blended learning to enhance the educational experience at the University of Florence. Both teachers and students generally agreed on its positive impacts, particularly in improving engagement, providing greater flexibility, and allowing for a more adaptable workload. These results affirm the blended approach as a viable educational strategy that meets the evolving needs of diverse learners and aligns with postpandemic shifts towards hybrid learning environments in higher education.

Each teaching approach within the blended model – flipped, active individual, and group work – proved valuable, albeit with distinct preferences between teachers and students. Teachers found the active individual approach to be especially effective due to the flexibility it offered for asynchronous learning activities, which might otherwise be constrained by traditional in-person teaching formats. This approach highlights the potential for incorporating technology to overcome logistical and temporal limitations in curriculum design.

Students, however, showed a preference for the flipped and active group approaches. These methods not only facilitated collaborative learning but also allowed students to engage with material in a more dynamic and interactive manner, fostering a sense of community and peer support that is often lacking in solely asynchronous models. This suggests that while technology enables flexibility, students continue to value social interaction and active participation within their learning experiences.

Overall, the experiment underscores the necessity for institutions to tailor blended learning models to accommodate different teaching styles and student needs. The success of the B-LeAF project points towards blended learning as an adaptable framework capable of enhancing traditional education models, provided that sufficient support and resources are available to educators. As blended learning continues to evolve, future studies could investigate long-term impacts on learning outcomes and assess how these hybrid models influence academic performance and student satisfaction across various disciplines.

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The Basic Mathematics Moodle Course: an open and flexible teaching-learning tool for the transition to University

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Abstract

The project aims to support students in mathematics during the delicate transition from high school to university, also considering the post-pandemic situation. To deal with students' cognitive, metacognitive, and socio-cultural difficulties, and considering the institutional needs of our university, we designed the Moodle Basic Mathematics (MBM) course. The MBM course turns out to be a teaching-learning tool shared by different subject areas of our university, allowing customization for the needs of each area. The course aims to strengthen the mathematical knowledge that students should have already acquired at secondary school, presenting it in a form useful for the university setting. The course is organized into thematic sections, providing an organic, longstanding, and self-consistent space containing slides, videos, quizzes, e-books, glossaries, and interactive GeoGebra applets. For engineering students, the MBM course is used in different ways: during the bridging courses, as a support of totally assisted learning; within tutoring activities, as a support of partially assisted learning; by the teachers of the first-year mathematics courses, who indicate the resource to students with difficulties in specific topics, as a support of unassisted learning.

Keywords: University Transition, e-Learning, Blended Learning, Basic Mathematics, Moodle.

1. Introduction

The literature in Mathematics Education highlighted the students' difficulties during the transition between high school and university, i.e. the secondary-tertiary transition (Di Martino et al., 2023; Guedet et al., 2016; Hochmuth et al., 2018). It has been broadly recognized that students experience cognitive and epistemological difficulties, including linguistic troubles, as well as social and affective obstacles. The complexity and depth of mathematical topics to be learned increase, and students need to improve their capability of formalizing and handling multiple representations and languages, developing an advanced view of mathematical concepts and facing proofs (Guedet et al., 2016). They become part of a new community, having specific practices and rules (Biza et al., 2014), where different kinds of relationships should be established, and typically the teacher gives less attention to the individual learning needs rather than in the secondary school context. Moreover, an increase in autonomy, selfassessment, and monitoring is necessary.

Although there is broad interest in the theme of secondary-tertiary transition, few studies have been devoted to the transition for engineering students (Alibraheim, 2021; Vinerean et al., 2023), and the need for research in this respect has emerged (Di Martino et al., 2023). Indeed, this teaching-learning context is typically characterized by a large number of students with heterogeneous backgrounds, exacerbating the critical issues during the transition. As regards affective factors, Alibraheim (2021) deepened the Saudi Arabia engineering students' attitude toward mathematics, finding that it is mainly positive or neutral, and depends on different aspects: a positive (respectively, negative) teacher's approach induces a positive (respectively, neutral or negative) students' attitude. The frustration with grades and assessments concerning mathematics determines a neutral attitude, as well as the difficulty of managing time since facing many courses in a semester is a hard challenge for engineering students. On the other hand, the opportunity to solve many mathematical problems improves their sense of selfefficacy, which is

one of the key factors for the attitude in mathematics. In this respect, also the general idea of success in mathematics should be taken into account: according to the research in Mathematics Education (e.g., Albano & Telloni, 2022; Jaworski et al., 2012), typically engineering students have a mainly operational view of mathematics and perceive the correctness of the procedures as the core of the discipline.

Cognitive, metacognitive, and linguistic difficulties also emerged from the outcomes of the access test to different degree courses at our university. Moreover, the perception of first-year university teachers suggested increasing difficulties in mathematics for freshmen, especially after the pandemic. Students have a distorted perception of their efficacy and skills in mathematics. According to their declarations, the first weeks of lessons at university make them aware of the need to review some content and modify their study method.

To deal with these criticalities, and in tune with some studies concerning the role of digital environments in the secondary-tertiary transition (Di Martino et al., 2011; Silverman & Hoyos, 2018), we propose the design of the Moodle Basic Mathematics (MBM) course. It has been designed considering both the students' difficulties during the transition, and institutional needs, aiming to provide a cohesive, comprehensive, and multimedia-rich learning space where students can access different kinds of resources to strengthen the mathematical knowledge they should have acquired during upper secondary school. A new aspect of our course, compared to other similar experiences known to us (e.g., Di Martino et al., 2011), is that it is designed as a teaching-learning tool common to different subject areas of our university (agriculture, economics, engineering, medicine, and sciences), and allows for customization according to the specific needs of each area. Moreover, focusing specifically on engineering students and considering the characteristics of that particular context, various uses for the MBM have been designed, supporting the traditional teaching-learning process, and, at the same time, partially assisted learning and the students' autonomous learning.

2. Materials and Methods

The study is set at the Polytechnic University of Marche (Ancona, Italy) during the post-pandemic period when the students' difficulties during transition appeared to be increasing. The Polytechnic University of Marche provides an academic offer including five thematic areas (agriculture, economics, engineering, medicine, and science), with 23 degree programs that include mathematics in the curriculum, 12 of which concern engineering. The average number of freshmen enrolled in bachelor's and master's degree programs at our university in the last two years (a.y. 2022-23 and 2023-24) is 4942, 3827 for bachelor's degrees. The average number of freshmen in engineering in the last two years is 1505, 1116 for bachelor's degrees.

All the thematic areas envisaged bridging or remediation courses for reviewing basic mathematics in the weeks before the start of the semester of classes of the first year. For engineering students, a bridging course is envisaged, including 24 hours of mathematics lessons in two weeks. Typically, students' participation in these courses is quite limited, even if strongly recommended, both for logistic reasons (some students are not yet officially enrolled at university, or do not have rented a room) and other motivations, such as the fact that many students are not aware of their learning needs. Moreover, the hours at disposal for the bridging courses are few for the contents to be revised.

The described scenario highlights the need to rethink the organization of activities and resources offered to the students to support their recovery of basic mathematical skills. On the one hand, it would be suitable to exploit the common elements of the courses in the different areas, creating a shared space to collect materials and develop the commonly treated topics; on the other hand, the different teaching-learning needs of each area should be taken into account. So, taking in mind the above-mentioned students' difficulties during the transition and various institutional needs, we aimed to create a digital resource devoted to teachers and students.

In particular, in this study, we address the following research questions:

(RQ1) What principles could guide the design of a digital resource aimed at minimizing the students' difficulties during the transition and suitable for the mentioned institutional needs? (RQ2) What kind of uses could be done for this resource with engineering freshmen?

The reflections developed to answer RQ1 allowed us to identify some principles of design, one by one corresponding to some critical issues characterizing the secondary-tertiary transition in mathematics. These principles and their use in designing the MBM course will be explained in the next section. Moreover, to address RQ2, we considered some different uses of the MBM course, aiming at covering the specific needs of engineering freshmen during the transition process. In particular, we took into account the need to give students time to assimilate the contents covered, also seeing them from multiple points of view and in connection with other mathematical topics. To this end, we choose to use the MBM course to support not only the bridging courses but also each curricular mathematics course, with its specific requirements. Furthermore, based on the MBM course materials, tutoring activities were designed to be conducted in class during the first semester, providing students with opportunities for interaction with peers, tutors, and teachers.

3. Results

3.1 Design principles

The analysis of the existing literature and our experience as teachers of mathematics courses for engineering students in the first university year allowed us to identify some design principles (DP). They correspond to the main students' difficulties in the secondary-tertiary transition at different levels, i.e. cognitive and epistemological difficulties (CE) or metacognitive, socio-cultural, and affective (MSA) difficulties, and also to specific institutional needs (I). We list them in the following Table 1.

As regards the students' difficulties, their lack of mastery of knowledge about topics already treated during secondary school (CE1) and their disorientation in understanding what are the prerequisites for the academic career (MSA1) induced us to envisage a course subdivided into thematic sections covering the topics mentioned in the syllabi of techno-scientific degrees, and agreed among the thematic areas of our university (DP1, DP4). Moreover, the students' lack of mastery of rigorous and specific language (CE2) suggested the presentation of contents in a synthetic but rigorous way, suitable for the academic context (DP2). This would enable students to integrate new aspects of mathematical concepts already met and their reciprocal links, reviewing them from an upper point of view.

The students' difficulty in handling and coordinating multiple representations of mathematical objects and concepts (CE3) pointed out the need for exploiting different semiotic systems and communication channels to make learning as effective and tailored to individual approaches as possible (DP3). As concerns metacognitive and affective difficulties experienced by the freshmen, their disorientation at different levels (understanding what knowledge and competencies are expected by them - MSA1, searching high-quality materials for remediation - MSA2, becoming part of a new community, with specific practices and rules - MSA5) suggested different design principles. First of all, it arose the need to provide an autonomous and self-consistent learning space, where the contents are easily accessible through a system of internal hyperlinks and also external links to high-quality materials for remediation (DP5). Moreover, teacher-driven and student-driven educational paths should be allowed to support individualized learning (DP8), while gradually fostering the development of students' learning autonomy (DP7). The students' lack of awareness of learning needs, self-assessment, and monitoring capabilities (MSA3) pointed out the opportunity for providing formative assessment tools, such as quizzes with response-specific feedback (DP6).

With the students' difficulties during the transition, inducing the design principles D1-D8, some institutional needs arose, which supported the formulation of other design principles for the MBM course. First, the previously described scenario emphasizes the need for a shared learning space where the topics covered in the basic mathematics bridging course are gathered and made accessible to students. This induced us to envisage a unique course, that can be customized to

the teaching-learning needs of each degree course (DP9). Moreover, to fully exploit the educational potential of this resource, we aimed to make it easily accessible and useful for different stakeholders (teachers, students, and degree programs) (DP10).

Table 1 - Students' difficulties, institutional needs, and corresponding design principles of MBM.

STUDENTS' DIFFICULTIES	*DESIGN PRINCIPLES*
CE1. Students' lack of mastery of topics already treated during secondary school.	DP1. Course organized into thematic sections covering the topics which are prerequisites for the academic career.
CE2. Students' lack of mastery of rigorous and specific language.	DP2. The topics should be treated using a synthetic but rigorous language.
CE3. Students' difficulty in handling and coordinating multiple representations of mathematical objects and concepts.	DP3. Exploitation of different semiotic systems and communication channels to treat the mathematical topics.
MSA1. Students' difficulty in understanding what knowledge and competencies are considered prerequisites and what are to be achieved.	DP4. Focus on the topics mentioned in the syllabi of preliminary knowledge required for techno-scientific degrees.
MSA2. Students' disorientation in searching materials for reviewing the contents.	DP5. Providing an autonomous and selfconsistent learning space, with links to high-quality external resources.
MSA3. Students' lack of awareness of learning needs, self-assessment, and monitoring.	DP6. Quizzes at different levels of difficulty, with response-specific feedback.
MSA4. Students' need to develop autonomy in learning.	DP7. Opportunity of teacher-driven and student-driven educational paths.
MSA5. Students' disorientation in the new academic context.	DP8. Individualized teaching-learning paths. Integration of autonomous learning with synchronous, tutoring activities.
INSTITUTIONAL NEEDS	
I1. Need for a common space where the topics treated in the bridging course are shared, considering the different needs of the thematic areas.	DP9. Unique common course with the opportunity of customizing the contents for each thematic area and importing materials into the Moodle course of each interested teacher.
I2. Need for a resource accessible and useful for different stakeholders (teachers, students, degree programs).	DP10. Open and flexible course.

Structure of the MBM course

According to DP1 and DP5, the MBM course is organized into thematic sections to provide an organic and self-consistent space containing different resources and activities, where individualized educational paths are available (DP7). In particular, the introductory page of the MBM course includes a list of all the topics covered in the course sections (DP1), related to the prerequisites for techno-scientific degrees (DP4). Within each course section, there are:

- slides, where the topic is presented in a concise but rigorous way with examples, figures, and diagrams (DP2, DP3); whenever possible, the topic is faced with different perspectives (e.g., from geometrical or algebraic viewpoints);
- quizzes at different difficulty levels; they are characterized by carefully designed questions, some of which are different from those typically faced by the students during secondary school. Many questions aim to accustom students not only to perform computations, but also to develop the ability to interpret the results of those calculations and, if possible, to predict them. This should foster the shift from a mainly operational view of mathematics to a more relational one. Each question envisages formative feedback, taking into account

the most common difficulties concerning the specific topic (DP6). In particular, feedback is automatic, immediate, and facilitative (Shute, 2008). It acts at both the task and the process of the task levels (Hattie & Timperley, 2007) and guides step-by-step students along the solving process;

- videos, showing some exercises' solving processes and explaining little pieces of theoretical notions. We chose to include videos to provide students with as many as possible channels to learn (DP3) and also to offer them selected high-quality materials (DP5);
- GeoGebra applets, providing dynamic examples to be explored, guided exercises, and theoretical insights; each applet has been designed with a specific educational goal, allowing the student to face and explore the contents from different perspectives (DP3);
- e-books containing the same material provided in the slides, but where videos and GeoGebra applets are incorporated, in order to minimize the possible students' disorientation (DP1, DP5).

Moreover, an essential glossary of definitions and properties is available in the course (DP2). It is easily accessible directly or by links from words in the e-book and quizzes (DP5). This has been designed to improve the students' understanding, mastery, and coordination of verbal and mathematical languages (DP3). Finally, two specific sections contain a list of textbooks and MOOC courses on the topics covered, to provide students with a range of high-quality materials for remediation (DP5).

The MBM course has been made available on our university's Moodle platform; all interested teachers and students can freely register (DP8). The course is designed according to a lifelong learning style: students can access the materials at any time during their university career, regardless of the year of enrollment, whenever they need them. Different educational paths are available, both teacher- and student-driven (DP4), to guarantee individualized teaching-learning of mathematics (DP8).

According to DP10, the MBM course is an open and flexible teaching-learning tool at different levels. It can be used by different stakeholders (students, teachers, degree programs), with heterogeneous purposes and within different frames. Indeed, the designers created a generic course that is a common teaching support for all the university's degree programs. Each degree program can duplicate the generic MBM course and modify, integrate, or reduce its contents according to their specific teachers' and students' needs (DP9), so creating a branched structure (Figure 1). Moreover, each teacher can also directly import materials from the common MBM course into her Moodle course.

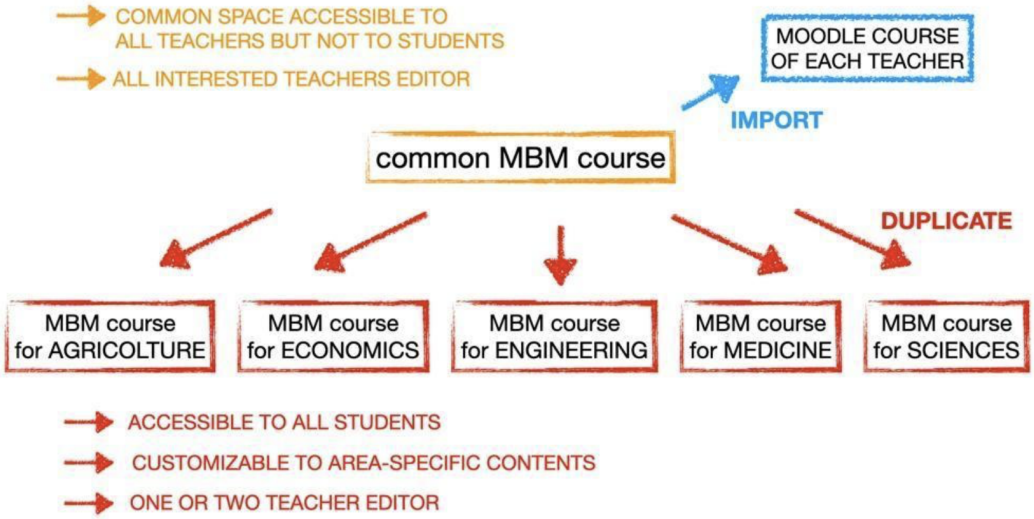


Figure 1 - The implementation of the MBM course.

Uses of the MBM course for Engineering students

To answer RQ2, we took into account the specific learning needs and typical approaches of engineering students. As mentioned in the Introduction, engineering freshmen are often afflicted by exacerbated difficulties within the tertiary transition, including those due to the large number and heterogeneity of the cohorts and their typically procedural view of mathematics. This suggests the specific need for them to have a relationship with academic tutors, countering the possible sense of massification due to the detached relationship with the teachers, and fostering the development of advanced mathematical thinking as well as a relational view of the discipline (Di Martino & Maracci, 2009; Telloni, 2022). As a further element, these students more than others need to develop a good mastery of technology and progressively achieve functional mathematical knowledge mediated by tools (see, for example, van der Wal et al., 2019). This calls for the need for mediation to the use of technological tools, making engineering students self-confident and creating the condition for their future learning as autonomous as possible, also with the aid of technology.

The previous considerations induced us to envisage different possible uses of the MBM course for engineering students. First, it can be used in the traditional teaching-learning process, as a support of totally assisted learning, similar to what the students experienced during secondary school. Moreover, it can be used within a partially assisted teaching-learning, in blended activities. Finally, it can support students in their autonomous learning, without the teacher's presence. The integration of these three uses of the MBM should foster the progressive development of learning autonomy by the students, which is a key competence for the university career, and also their familiarization with the use of technology to learn mathematics, in tune with the idea of techno-mathematical literacy (van der Wal et al., 2019).

In particular, for engineering students, the MBM course is used:

- by the teachers of the bridging courses to share materials and to provide students with tests concerning the faced topics (MBM as a support of totally assisted learning);
- in "blended mode" within tutoring activities, combining it with "synchronous" activities carried out by dedicated teachers with the help of tutors (MBM as a support of partially assisted learning);
- by the teachers of first-year courses to guide students with difficulties or gaps in specific topics (MBM as a support of autonomous learning).

Precisely, for the first use, a specific section is created, with a folder for each bridging course (there are six parallel courses for our engineering freshmen), where teachers could share notes or other material deemed useful and invite students to take specific quizzes concerning the topics treated during the lessons. In this sense, the MBM course is a tool supporting traditional totally assisted learning.

The second use of the MBM course concerns tutoring activities including thematic meetings on specific topics chosen by the students. To encourage students to take responsibility for their learning and become progressively aware of their needs, we ask them, through a Wooclap survey, what topics they would like to review. The topics chosen by the students among a list proposed by the teachers are then deepened during the meetings: first, the fundamental concepts concerning the topic are recalled, then a quiz is proposed, that students face individually or in groups, with the support of dedicated teachers and tutors. These activities are carried out in blended modality, i.e. in person and at distance, so that as many students as possible can participate. The materials used during the meetings are then made available in a specific section of the MBM course, with detailed instructions to complete the activities in asynchronous modality. This use of the MBM is a form of partially assisted learning. It aims to progressively guide the students to achieve autonomy and awareness in learning, also aided by technology, through human mediation.

The MBM course is also used in the first-year courses of mathematics taught to engineering students. In particular, teachers direct their students to the MBM course by providing a link in their Moodle courses and often presenting it directly in the classroom, encouraging them to enroll for review purposes. In this way, students could autonomously access the course to review some

contents, or the teachers could guide students with difficulties to specific sections or materials of the MBM course to fill their gaps. In this sense, the MBM course supports autonomous learning by the students, possibly suggested by the teachers.

4. Discussions and Conclusions

In this paper we focused on the design of an open and flexible teaching-learning tool, the MBM course, aimed at minimizing the students' difficulties in mathematics during the transition to university. These difficulties, as well as some institutional needs of our university, induced us to state some design principles which guided the creation of the course. The MBM course is in tune with other experiences of e-learning (e.g., Di Martino et al., 2011), but, as a new aspect, it is designed as a common tool to different thematic areas of our university (agriculture, economics, engineering, medicine, and science), and the opportunity for customization to the specific educational needs of each area is envisaged. Taking into account the particular characteristics of Engineering university context, such as the large number of students, their heterogeneous backgrounds, and their need to develop techno-mathematical literacy (van der Wal et al., 2019), also through a human mediation toward the use of technology to learn, we elaborate on different uses of the MBM course. For engineering students, the MBM course has been used in three different ways: by the teachers of the bridging courses to share materials, as a support of totally assisted learning, i.e. traditional learning; in combination with synchronous activities carried out by dedicated teachers and tutors (MBM as a support of partially assisted learning, i.e., blended learning); by the teachers of first-year courses who indicate the course to students with difficulties in specific topics (MBM as a support of autonomous learning, i.e., e-learning). In this perspective, according to Alibraheim (2021), the MBM course should also be a trigger to improve the engineering students' attitude in mathematics. Indeed, it provides students with the opportunity for reviewing contents according to the individual learning rhythms; it makes them face activities without summative assessment; and, finally, it offers students many questions and stimuli to test the own level of understanding.

The MBM course designed for engineering students has seen high levels of participation, both in terms of accessing resources and engaging in activities, as well as in attendance at synchronous sessions. The participants have been mostly freshmen: about 800 out of about 1100 freshmen participated, many more than the participants in the bridging courses. Of these, about 300 students enrolled in the course for the first time during the bridging courses; other 400 in the first half of the first semester; around 100 in the second half of the semester (see Table 2).

Table 2 - Data about the first access of engineering freshmen in the MBM course.

	2022-23	2023-24	Average
Engineering freshmen enrolled in bachelor's degree programs	*1081*	*1150*	*1116*
First access during bridging courses (2 weeks)	256	358	307
% over freshmen	24%	31%	27%
% over total access	38%	39%	39%
First access during the first half of the semester (6 weeks)	341	423	382
% over freshmen	32%	37%	34%
% over total access	51%	46%	48%
First access during the second half of the semester (6 weeks)	76	137	107
% over freshmen	7%	12%	9%
% over total access	11%	15%	13%
Total first accesses in the first part of a.y. (14 weeks)	673	918	796
% over freshmen	62%	80%	71%

We hypothesize that the high level of participation in the MBM course for Engineering, especially compared to the involvement in the bridging course organized by our university at the beginning of the first year, could be due to the openness and flexibility of the tool but also to the specific use of MBM made for engineering students. Indeed, it supports students throughout the first semester (and even beyond) and can be used autonomously by the students, as well as with the support of teachers and tutors. However, further future research is needed to investigate about this hypothesis.

In any case, the high participation suggests the effectiveness of the MBM as a tool for increasing the students' awareness of their skills and learning needs in mathematics.

The contribution of this study should be both practical and theoretical: on the one side, we wanted to provide students and teachers of our university with a tool improving the educational process; on the other side, we identified some principles orienting the design of a resource aimed at minimizing the students' mathematical difficulties during the transition, and also the possible uses of this resource. In particular, the flexibility of the MBM course emerges for the different uses that different stakeholders (students, teachers, degree programs) make of it. Moreover, it emerges also in relation to the idea of teaching-learning tailored to the individual learning needs and typical approach. Traditionally, two forms of tailored teaching-learning are distinguished (Baldacci, 2006; Shemshack & Spector, 2020): the *individualization,* i.e. is the differentiation of strategies and learning paths to bring all the students to common formative goals, and the *personalization*, i.e. the differentiation of educational strategies, learning paths and formative goals. The former is mainly devoted to remediation and inclusion, while the latter is mainly devoted to the promotion of excellence. Generally, these two forms are mutually exclusive, and the initial intention of the designers of the MBM course was to promote individualization rather than personalization. This is due to the context and the kind of students the course is addressed to. However, it seems that the MBM course allows to pursue at once both individualization and personalization. Indeed, the opportunity for the students to access the resource autonomously or guided by the teacher, makes the MBM course suitable both for the remediation of contents not adequately acquired (individualization), and for the deepening of some aspects of specific topics, such as different representations or interpretations, and links with other topics (personalization).

These aspects induce us to carried on the research on the design of the MBM course. In the future we plan to systematically monitor the use of the MBM course by the students, in terms of accesses to the single resources and activities. The monitoring should shed light to the preferred students' approaches and the topics they mainly need to review, allowing the improvement of the course, according to the design-based research framework (DBR, 2003). Indeed, the intrinsic characteristic of such a resource is to be in progress, open to the integration of resources and activities to enrich the learning space. Moreover, we want to investigate the perception of students and teachers about the usefulness of the MBM course through surveys and semi-structured interviews. Finally, from the design perspective, we plan to improve the individualization and personalization of teaching-learning within the MBM course, envisaging the possibility of learning paths automatically suggested by the platform on the basis of the difficulties and mistakes emerged by the students' behaviours.

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An investigation into students' perceptions on academic integrity in University Blended Learning Courses

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Abstract

The paper describes the results of a semi-structured questionnaire aimed at students enrolled in blended degree programs to investigate their perceptions and awareness of academic integrity and academic misconduct and evaluate the extent of cheating. The study is part of a broader research that aims to depict the impact of online assessment in the context of university distance courses and carry out an exploratory investigation to map guidelines and best practices developed in the university context to encourage academic integrity. The study employs a mixed methods research design that integrates quantitative tools (semistructured questionnaire) with qualitative ones as focus groups with students and faculty involved in the research. The data collected will also be used to develop guidelines, recommendations, and digital resources on academic integrity to share between instructors and students in blended or online degree programs.

Keywords: Online Assessment, Academic Integrity, Cheating, Plagiarism, Academic Literacy, Blended Learning.

1. Research background

Online assessment has gained increasing popularity, sparking debates and encouraging the adoption of differentiated assessment methods and digital tools in both traditional and distance university courses (Sannicandro, 2023). As a result, the growing prevalence of online assessment experimentation and research in universities has led to the development of a valuable and widely applicable framework for mapping assessment processes (Poth et al., 2014). These processes involve reflexive, technical, and situational approaches (Canadian Evaluation Society, 2015; Patton, 2014). Reflexive approaches focus on theories and evaluation practices, as well as the application of standards and levels. Technical approaches deal with the strategic, methodological, and interpretative decisions required to conduct an assessment. Situational approaches focus on understanding and analyzing the unique circumstances of each assessment.

This fosters greater awareness of assessment processes, which can have a substantial impact when integrated into the organizational culture (House, 1993). Against this complex background, several studies have explored policies and practices surrounding the management of online exams, as well as the viewpoints of instructor and learners. Although many universities have implemented digital proctoring solutions and plagiarism detection software in an effort to mitigate the risks of dishonesty, these tools alone are not sufficient to ensure a safe and transparent assessment environment. Focusing solely on the critical issues of academic misconduct may prove ineffective. Indeed, when assessment needs to respond to different, often opposing interests, it is necessary to use heterogeneous approaches,

methods, and criteria. This requires the involvement of all stakeholders, including instructors, students, and instructional designers, who should share their views on the means and ends of assessment. Academic integrity is based on six core values: honesty, trust, fairness, respect, responsibility, and courage, according to the *International Center for Academic Integrity* (ICAI, 2014). Upholding these values is crucial, even in challenging circumstances. Consequently, academic misconduct may include using resources and other materials not authorized by the lecturer, assisting others to cheat, falsifying one's identity, and plagiarism by using the work of

others, even in part (Hill et al., 2021; Holden et al., 2021). Therefore, we are dealing with complex phenomena that not only involve plagiarism or cheating during assessment tests (Surahman et al., 2022; Tatum et al., 2022), but can also include contract cheating and ghost-writers, not forgetting the use of recent artificial intelligence (AI) tools.

Academic integrity and *academic literacy competencies* have thus taken on a central role in higher education, shaped by various key factors. The development of academic literacy extends beyond a purely cognitive process; it is a socially and culturally situated practice, serving as a crucial tool for students' integration and socialization within the academic community (Li, 2022). The rise in student mobility, the expansion of access to university education, and the growing competition in the labor market (ENQA, 2024) have broadened learning opportunities but have also introduced new challenges. Furthermore, the increasingly diverse student body, with many balancing work and study while engaging in both face-to-face and online learning experiences, has further complicated this landscape.

The study presented here is part of a broader research project that aims to investigate the impact of online assessment in the context of online university courses (Sannicandro, 2023). It begins with an analysis of the main research trajectories developed in recent years (Sannicandro et al., 2024), the elements that characterize online assessment in higher education (Tatum, 2022; Sannicandro, 2023; Verhoef et al., 2021) as, for instance, how online assessments impact student satisfaction, stress levels, and performance, particularly in comparison to face-to-face assessment methods and academic integrity (Akimov, 2020; Marano et al., 2024; Holden et al., 2021; Andreou et al., 2021), each contributing to a deeper understanding of the challenges and opportunity (see Table 1). These aspects highlight the complexity of technological integration and the importance of a strategic approach that considers the diversity in students' digital skills and access conditions. In addition, they underscore the need to rethink learning and assessment processes with the aim of creating a more inclusive, transparent, and equitable educational system for all stakeholders involved.

The objective of the research, involving students and faculty, is to to promote a culture of academic integrity, particularly in the context of distance learning, and conduct an exploratory survey to map the guidelines and good practices developed in the university context to encourage academic integrity (Sannicandro et al., 2023; 2024).

This paper presents the analysis of a semi-structured questionnaire aimed at students enrolled in blended or online learning degree programs to investigate their perceptions and awareness of academic integrity and e-dishonesty and evaluate the extent of cheating.

Section 2 outlines the research methods and provides the stages undertaken during the study. The analysis and summary of the key findings of the part of the research focused on data collected with a survey aimed at students are detailed in the subsequent Section 3. The final section discusses the study's first results and future research actions.

2. Materials and Methods

The study forms part of a larger research project that engaged the process of assessment online learning in distance university courses (Sannicandro, 2023; Sannicandro et al., 2024). A mixed-methods approach was implemented (Creswell, 2014, p. 341; Clark & Creswell, 2008) to analyze diverse viewpoints using quantitative and qualitative research tools such as semi-structured questionnaires and focus groups for students and teachers. We aim to integrate the insights of individuals and institutions, including examining best practices and sharing digital resources concerning academic integrity (Sannicandro et al., 2024).

The mixed-methods sequential explanatory design provides that "the researcher initially collects and analyses the quantitative data. The qualitative data are collected and analysed subsequently, and serve to elucidate or expand upon the findings of the preceding quantitative phase [...]. This approach is justified by the rationale that the quantitative data and subsequent analysis provide a general understanding of the research problem, while the qualitative data and subsequent

analysis refine and explain those statistical results by exploring participants' views in more depth" (Ivankova et al., 2009, p. 5).

Table 1 - Key themes in research on online assessment in university contexts.

Key themes in research on online assessment	*Challenges and Opportunities*
Student Experience and Engagement	How online assessments affect student participation, motivation, and their overall learning experience, including accessibility concerns? Is crucial an investigation of innovative online assessment techniques that extend beyond the conventional format of examinations, including project based evaluations, peer assessments, and formative feedback, with the objective of enhancing student learning and engagement.
Technological Integration	The role of digital tools in facilitating assessments, including the use of artificial intelligence (AI), proctoring systems, and learning management systems, is a topic of great importance in the field of education. Furthermore, it is essential to consider the ethical implications that arise alongside these novel developments.
Academic Integrity	Ensuring the integrity of assessments, particularly in remote and blended learning environments, where opportunities for misconduct might increase due to the lack of direct supervision, represents a significant challenge.
Pedagogical and Methodology Adaptation	A rethink of assessment strategies is required, with a view to aligning them with the learning objectives (also in a digital format). This should ensure that they accurately measure student outcomes. To this end, it would be beneficial to explore innovative online assessment techniques that go beyond traditional exams. These could include project-based assessment, peer assessments and formative feedback. The intention is to enhance student learning and engagement.
Impact on Teaching Practices (and Faculty Development)	The transition to digital assessment has an impact on teaching methodologies, feedback practices and the overall structure of courses. This raises the question of the skills and training required for educators to design and implement online assessments effectively, as well as how institutions can support their staff in adapting to digital assessment platforms.
Fairness and Inclusivity	The objective is to guarantee that online assessments are equitable for all students, taking into account their diverse needs, backgrounds, and potential digital divides. Accessibility and inclusion are key considerations in the development of online assessments. It is imperative to guarantee that online assessments are accessible to all students, including those with disabilities or restricted access to technology.
Data Security and Privacy	Managing the ethical and legal considerations of storing and handling student data in online environments, with attention to privacy protections.

The research is structured into two primary phases. The first phase involved a thorough analysis of existing guidelines, frameworks, and digital resources aimed at promoting academic integrity within the university context. These resources were identified from established organizations, including Teaching and Learning Centers and Centers for Academic Integrity (Sannicandro et al., 2024).

In the second phase, questionnaires and focus groups are administered to students and teachers. In particular, in this paper we focus on some results of a questionnaire administered to students of blended courses, as mentioned above.

The research questions that informed the construction of the questionnaire were as follows: *What constitutes academic integrity or dishonesty in students' experiences [RQ1]? What types of*

behavior do students consider risky or academic misconduct [RQ2]? What resources and activities can be developed in online and blended university courses to promote a culture of academic integrity [RQ3]?

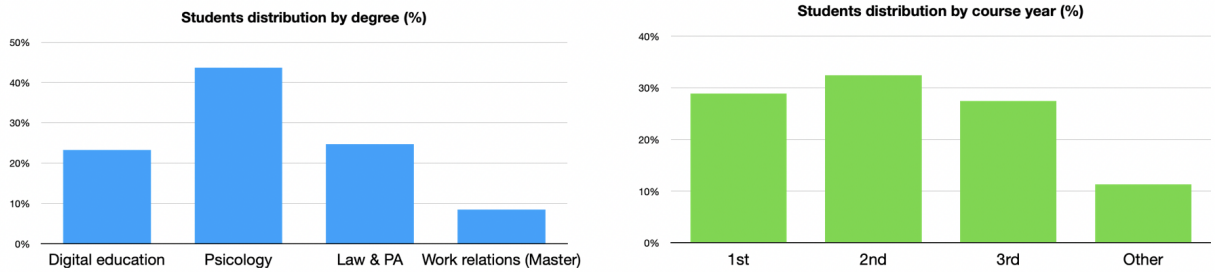
To answer these questions, it has been essential to investigate students' awareness of integrity and misconduct issues and develop skills (academic literacy) to promote a culture of academic integrity (Festas et al., 2022). Students should be viewed as active participants in the learning processes that occur in online environments rather than mere consumers (Lowyck et al., 2004). The aim is to cultivate and strengthen a culture of academic integrity, particularly within the framework of online university courses; the hypothesis suggests that engaging both educators and students in the development of training initiatives and digital resources is crucial for their success (Sannicandro et al., 2024). The questionnaire incorporated closed and open-ended questions, with sections dedicated to personal data, academic integrity and academic misconduct, academic integrity, and assessment practices. For the development of some sections we consulted and integrated questions from validated scales and used in the university context (Bašić et al., 2019; Erguvan, 2022) also with to aim to quantify students' attitudes and experiences related to academic dishonesty, plagiarism, to promote academic integrity. The openended questions (that will be analyzed in the following phases of the research) facilitated a deeper exploration of students' views on what constitutes academic integrity, perceived risks of misconduct, and the types of resources that can foster a culture of integrity in their educational settings.

3. Results

We administered the questionnaire to 2,792 students enrolled in the blended degree courses at the University of Modena and Reggio Emilia (Italy). 210 students (8%) replied to the survey and 146 complete answers (5%) were registered.

77% of students were women, and 67% were workers. The median age is 26, within a range between 19-70. 58% of interviewers declared to be at the first university experience, 17% had a previous degree, and 25% dropped a previous course.

Figures 1 and 2 depict the students' distribution by degree and course year. We can observe a high percentage of students from Psychology degree course (44%) in which there are the most numerous enrollments. A similar percentage of students enrolled in Digital Education and Legal Services in Business and Public Administration (respectively, 23% and 25%) is recorded among respondents, together with a low amount of students from master's degree courses in Work Relations (9%).



Figures 1 and 2 - Students' distribution by degree (*left*) and course year (*right*).

Replying to the first research question (RQ1) on the meaning that students attribute to academic integrity or dishonesty, we can see in Figure 3 that they have chosen *honesty*, *fairness*, and *responsibility* as the main words in the ICAI framework (2021) as the values to speak about academic integrity.



Figure 3 - Students' opinion on values of academic integrity (made using Flourish.studio).

In addition, Figure 4 shows students' agreement level with a list of sentences on their experiences with academic integrity or dishonesty. They mainly agreed with sentences 1, 3-6. These statements deal with:

- the ability of students to identify what constitutes misconduct (1);
- the way in which academic misconduct undermines the value of the work of other members of the community (3) and students' academic reputation (4);
- the feeling of guilt when using sources in assessments without citing them (5);
- the feeling of anger when others use students' own results in their work (6).

Students have a lower level of agreement on statements 2, 8, and 9, respectively, related to the commitment in learning more about behaviors associated with academic misconduct, the role of technologies in preventing academic misconduct phenomena, and the use of a system for checking academic misconduct in assessments.

Students express the most disagreement with sentence 7, which challenges the common assumption that academic misconduct is a significant problem in online courses and less so in face-to-face courses.

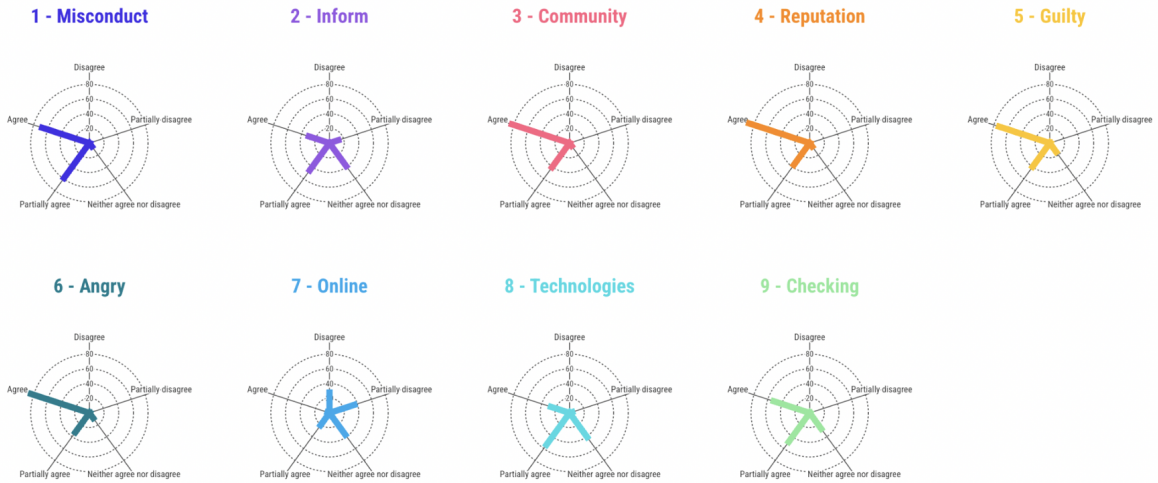


Figure 4 - Academic integrity or dishonesty in students' experiences (made using Flourish.studio).

Moving to RQ2, Table 2 shows the actions students considered more risky during exams. The higher percentage is collected by falsifying research data (64%), plagiarizing examinations (61%), and using unauthorized AI tools (57%). Options related to sharing the exam content (27%), using others' materials (21%), or diffusing their own ones (12%) gather significantly lower percentages. Self-plagiarism (7%) and using others' words when there are few ways to describe a concept (4%) seem to be the misconduct actions that least concern students during exams.

Table 2 - Students' opinions on more severe actions of misconduct during exams (max 3 answers).

More severe actions of misconduct during exams	%
falsify research data	64%
plagiarize examination	61%
use not allowed AI tools	57%
share exam content	27%
use colleagues' materials	21%
share my materials with others	12%
self-plagiarize	7%
use others' words when there are few ways to describe a concept	4%

Finally, for RQ3, Figure 5 presents the resources and strategies to promote a culture of academic integrity in students' opinions. Among the favorite tools by students, we find software they can use to check the integrity of their works (46%), guidelines customized for each course (43%), and training on the ethical use of AI tools (41%). Disciplinary sanctions (19%) or training courses on the topics (16%) are the less chosen option.

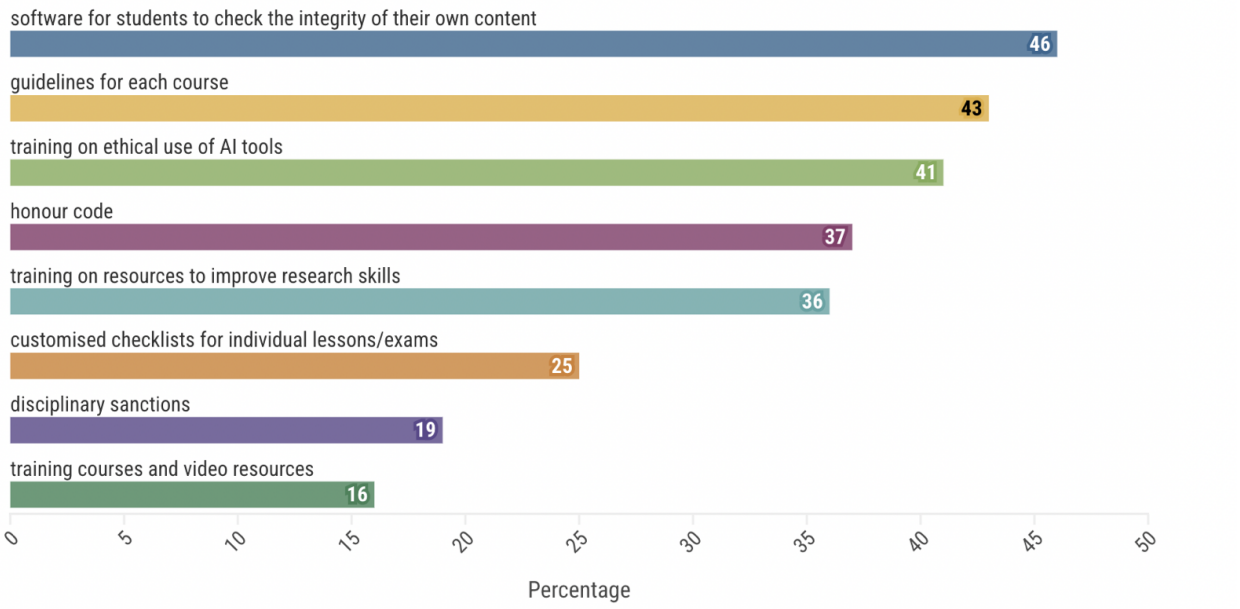


Figure 5 - Resources and activities to promote a culture of academic integrity, max 3 answers (made using Flourish.studio).

In addition, students recognized readiness in the test subjects, the possibility of comparison with instructors and other students, the lack of pressure to obtain good grades and plagiarism by other students as the most relevant actions to promote integrity. Punishment, indicated as relevant by about half of the respondents, is among the last positions in the list (Table 3).

Table 3 - Students' opinion on relevant aspects to promote integrity (the percentage has been obtained by summing the options 4 and 5 in a Likert scale where 5 means "totally relevant").

Elements to promote integrity	%
Knowledge of the test subject	90%
Comparison with teachers and students	80%
No pressure for good grade	76%
No plagiarism by other students	72%
Time not limited	59%
Monitoring tools by teachers	57%
In site assessment	45%
Punishment	44%
Online assessment	35%

4. Discussion and future research

The analysis of the questionnaire administered to students enrolled in blended degree programs revealed several key findings. Students predominantly associate honesty, fairness, and responsibility with academic integrity. Additionally, they link academic integrity to a sense of community, reputation, and emotional responses such as guilt or anger. In many cases, students do not perceive online assessments or digital technologies as primary causes of misconduct. Instead, they mainly consider academic misconduct during exams, including actions like falsifying research data, plagiarizing during assessments, and using AI tools without permission. According to a substantial number of students, knowledge exchange and dialogue with instructors and peers can foster a culture of integrity, while punitive measures are not regarded as the most effective means of reducing misconduct. To enhance academic integrity, students prefer automated tools to independently verify their work, clear coursespecific guidelines, and training on the ethical use of AI technologies.

These findings align with several key themes highlighted in the broader literature, which underscore both the challenges and opportunities of online and hybrid assessment, particularly when considering recent initiatives by international organizations and higher education institutions (e.g., ICAI, ENAI) (Foltýnek & Glendinning, 2024). We understand that one of the most pressing concerns relates to academic integrity, which has become increasingly significant as the prevalence of remote and hybrid assessment practices grows. The integration of digital platforms in blended learning – combining both online and face-to-face components – amplifies the risk of unauthorized access to resources, raising critical issues of academic misconduct, including plagiarism. Addressing these concerns requires the development of innovative monitoring strategies that safeguard the integrity of assessments in both contexts, while simultaneously promoting trust between students and faculty in hybrid learning environments. These solutions must also address the needs and expectations of both students and instructors.

Another critical consideration is the integration of digital technologies in assessment practices. In the context of blended learning, the use of AI and other digital tools has enabled greater automation in the assessment process, yet it also raises ethical concerns regarding fairness and the accuracy of assessment across various formats (Moorhouse et al., 2023; Saúde et al., 2024). It is crucial to critically assess how these technologies are implemented, ensuring that they enhance the assessment process in both online and face-to-face settings without compromising the reliability and validity of outcomes. These evolving educational models also demand that educators reconsider their approaches to feedback and course design, ensuring alignment with the unique demands of blended learning environments. From the students' perspective, there is an expectation for more resources dedicated to educating them on behaviors associated with academic misconduct, as well as the availability of tools to detect potential errors in their work.

Constructively, many students suggest that an approach centered on dialogue and collaboration with instructors and peers may prove more effective in promoting ethical behavior than punitive policies. Furthermore, students express a desire for autonomous tools to check their work, clearer course-specific guidelines, and dedicated training on the ethical use of AI technologies.

The transition towards online assessments in blended learning environments has also had a significant effect on students' learning experiences. It is imperative to guarantee equitable access to learning resources and to achieve a seamless integration of online and offline components in order to address the diverse needs of students in hybrid learning settings. It is also of great importance to consider the ethical and legal implications, particularly in relation to data security and privacy. The growing reliance on digital platforms for both online and face-to-face assessments requires that institutions manage large volumes of sensitive student data, raising concerns about potential misuse and the necessity for robust data protection measures. The ongoing challenge of maintaining academic integrity while ensuring an inclusive and effective learning experience demands continued research, with direct implications on awareness and organizational culture within universities (Bjelobaba et al., 2023).

Using a mixed methods research design, future studies will actively engage lecturers through a questionnaire to explore how their practices and perceptions of academic integrity evolve in blended learning environments. Building on student findings that emphasize the importance of dialogue and collaboration over punitive measures, the research will explore how lecturers use digital tools, such as AI, to promote academic responsibility and ensure transparency in assessments. The study will also focus on the development of guidelines and resources within courses to support both formative and summative online assessment (Figure 6).

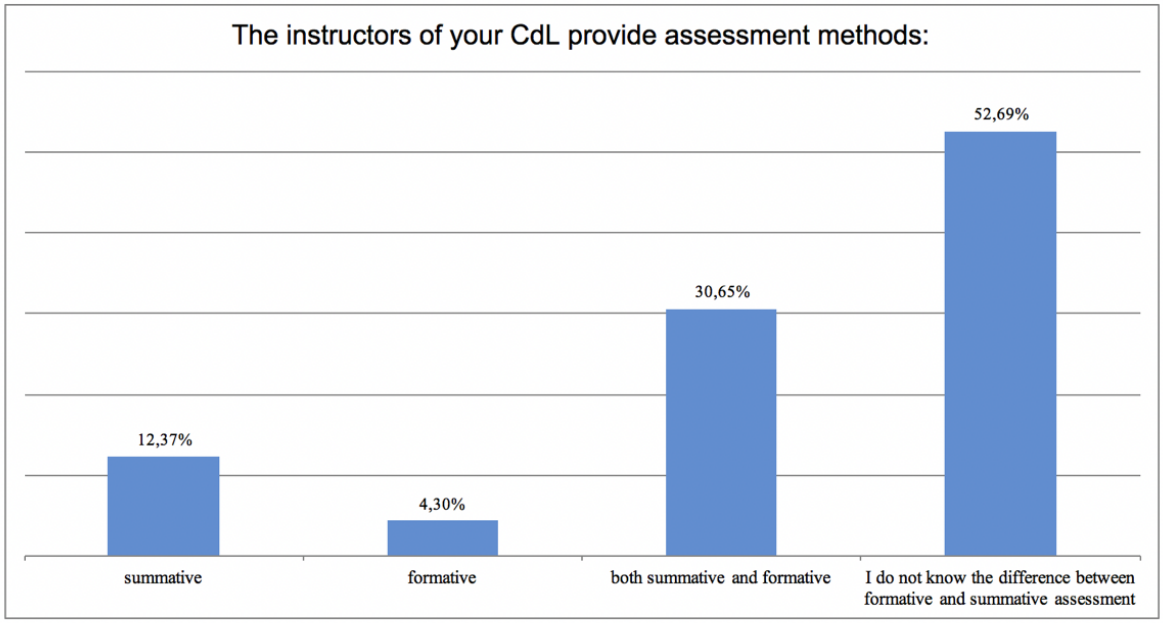


Figure 6 - Assessment methods provided by the instructors according to students.

Research actions will include the analysis of the methods employed by instructors to ensure the fairness of assessments, while maintaining a balance between oversight and mutual trust, and fostering ethical awareness among students. Another aim will be to enhance the efficacy of online assessments, both formative and summative. For example, a qualitative analysis of students' motivations and their assessment preferences could be conducted through content analysis, thereby enabling the identification of recurring themes and opinions that are not captured by closed-ended questions. Responses to open ended questions regarding assessment mode preferences may yield particular student expectations, such as a desire for more interaction with lecturers or the necessity for adaptations due to technological issues.

Authors' contribution

This paper describes the whole research partially introduced in the conference abstract "Academic Integrity and E-Dishonesty in Online Assessment: a student perspective" presented at the Italian SYmposium on Digital Education (ISYDE) 2024.

According to CRedit system *Katia Sannicandro* (corresponding author): Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing-Review & Editing; *Annamaria De Santis*: Formal analysis, Visualization, Data Curation; *Claudia Bellini*: Resources; *Tommaso Minerva*: Supervision.

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Distance learning in time of crisis: the University of Foggia experience and expertise in rethinking distance education in the local and European dimension

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Abstract

In recent years, online training surged due to Covid-19. University of Foggia adapted with synchronous/asynchronous teaching. Amid pandemic, they launched dual teaching mode for 2020/2021, blending in-person and online classes for 400 courses, becoming top in Italy for e-learning usage. Also, thanks to this significant achievement is actively committed in the planning and learning design of distance teaching, both on the general pedagogical reflections as well as on international partnership. Although, the unplanned digital educational response to the Covid-19 pandemic has been called Emergency Remote Teaching (ERT): it ensured educational continuity, according to UNESCO, for 1.5 billion students in 191 countries; today it is used in war-torn countries such as Ukraine, where 5 million students suffer from depression and anxiety (OECD 2023,). Universities have responded with the technological implementation of online platforms such as Zoom and Google Classroom, but the ERT also highlighted disparities in access and concerns over effectiveness.
This contribution will present, as good practices in the field, the results of two Erasmus+ project in which University of Foggia is involved, both as partner as well as leader, which deal with the transition from ERT to digital pedagogy (CLOSER) and with the support for students' digital and psychological resilience in dealing with distance learning and online social activities in time of crisis (DigiPsyRes).

Keywords: Distance Education, Distance Learning, Emergency Remote Teaching, Digital Pedagogy.

1. Introduction

Already in 2017, starting from some reflections on the immense catastrophe of the earthquake that struck Abruzzo, Alessandro Vaccarelli spoke of the pedagogy of emergency, claiming the intellectual's commitment to the wounded community. Then, as now, especially following the COVID-19 pandemic, it is desirable and urgent to consider the development of the pedagogy and didactics of emergency as new disciplines within the landscape of specialized pedagogies. This is an innovative proposal, both from a theoretical and practical point of view, requiring careful reflection and constant research activity. The congenial placement would therefore be at the crossroads of pedagogical thought, scientific inquiry, didactic intervention, and educational action in the field. The lack of professionals specifically trained in pedagogy to address emergency situations is an evident problem. Currently, it is often other actors, not coming from the world of education, who take on the task of providing support to educational systems in crisis. It is therefore necessary to fill this training gap and enhance the role of professional educators in such delicate contexts.

Numerous organizations, both nationally and internationally, are already engaged in supportive actions for communities affected by emergencies, designing educational interventions aimed at addressing the specific needs of children, adolescents, and adults. The pedagogy of emergency could provide these organizations with a theoretical framework and a more solid set of operational tools. Without forgetting that the educational needs of people involved in a crisis are multiple and evolve over time. It is not only a matter of providing immediate support, limited to “the here and now of the catastrophe and its immediate consequences” (ivi, p. 345), but also of accompanying communities on the long journey of reconstruction.

Public opinion tends, in fact, to perceive emergency as a time-bound event, limited to the acute phase of the crisis. However, the consequences of a disaster reverberate on the lives of individuals and communities for a long time, leaving deep wounds at both individual and collective levels and continuing to produce “effects on the material and immaterial dimensions of the affected territories and the involved communities” (ivi, p. 346).

Moreover, one should not forget the risk of developing a habit of pain and a suspension of normality. This latter condition is one of "state of exception" (Agamben, 2003) – which represents a legal void – where norms are paradoxically and legally suspended, finding ample space in today’s political and social reality.

In light of the imminent nature of the emergency and the lack of investment in a culture of risk and prevention, emergency remote teaching, also known as Emergency Remote Teaching (ERT), represents an educational response that was not previously planned for crisis situations that prevent the normal conduct of in-person teaching in universities and schools. This teaching mode has been adopted on a large scale worldwide in response to the COVID-19 pandemic that struck the world in 2020.

During the early months of the pandemic, according to UNESCO data, over 1.5 billion students in 191 countries were affected by school and university closures. This unprecedented scenario pushed educational institutions of all levels, including universities, to quickly seek alternative solutions for emergency remote teaching. This resulted in a significant increase in the use of online platforms, videoconferencing software, and learning management tools, which saw a surge in usage, registering an increase in traffic and the number of users several times compared to periods before the pandemic. For example, Zoom reported an increase from 10 million daily meeting participants in December 2019 to over 300 million in April 2020.

Many students and teachers found themselves navigating a new educational paradigm without adequate training or preparation. Issues related to access to technology, Internet connectivity, and digital competence became evident, highlighting disparities in access to education. Furthermore, according to a survey conducted by Educause in 2020, many students expressed concerns regarding the quality of

teaching, interaction with teachers and peers, and the effectiveness of online learning compared to inperson learning (Brown et al., 2020).

According to data collected by UNESCO, the closure of educational institutions affected over 1.6 billion students in more than 190 countries. It is still being used in war-torn countries like Ukraine, where the education of over 5 million boys and girls has been interrupted, and many suffer from mental health issues such as depression and anxiety following the destruction and damage of more than 3,000 bombed school institutions (OECD, 2023).

Despite these difficulties, emergency remote teaching has also offered opportunities. It has accelerated the integration of technology into higher education, pushing universities to rethink and innovate their teaching methods. It has also allowed students to continue their education in otherwise prohibitive circumstances. Generation Z students, moreover, seem to adapt effortlessly to the new learning environment, organize their learning process, and select their preferred online learning platforms. Students more frequently choose Google Meet and Moodle as distance learning platforms. They also use Zoom, Skype, Viber, and Telegram to stay in touch with teachers and for studying. 19% of the surveyed students consider distance learning to be of high quality, while 75% are currently neutral regarding this mode of learning, and only 6% of respondents deem these necessary innovations ineffective (Dushkevych, Barabashchuk & Hutsuliak, 2020).

Although the challenge has been and continues to be immense, the experience of ERT has provided valuable lessons on how higher education can evolve to address future crises and how it can be rethought to improve accessibility and the quality of learning for all.

Emergency remote teaching in universities has paved the way for a profound reflection on the future of higher education. The transition from an emergency response to more established approaches in digital pedagogy underscores the need for a constant commitment to innovation, student support, and international collaboration to build resilient, inclusive educational systems capable of adapting to any future challenges.

2. The University of Foggia Experience in ERT

In Italy, especially in the first phase of the development of e-learning, there was an initial significant growth of e-learning in the areas that were culturally more advanced and had more substantial financial resources. In fact, the universities that, prior to Covid-19, had already developed a strong e-learning base were the universities of Milan, Rome, Padua and other large universities with large numbers of enrolments and funds (De Martino, 2022, p.111).

In this sense, the catalyst for the widespread development of Distance Learning (FAD) throughout Italy, as mentioned, was the Covid-19 pandemic, which accelerated the adoption and expansion of the FAD modality.

During this period, the region of Apulia experienced significant growth in distance learning and experienced the growth of the University of Foggia (Unifg), which ranks eighth among Italian universities in terms of communication and digital services, with a score of 93 points out of 120 (Figure 1).

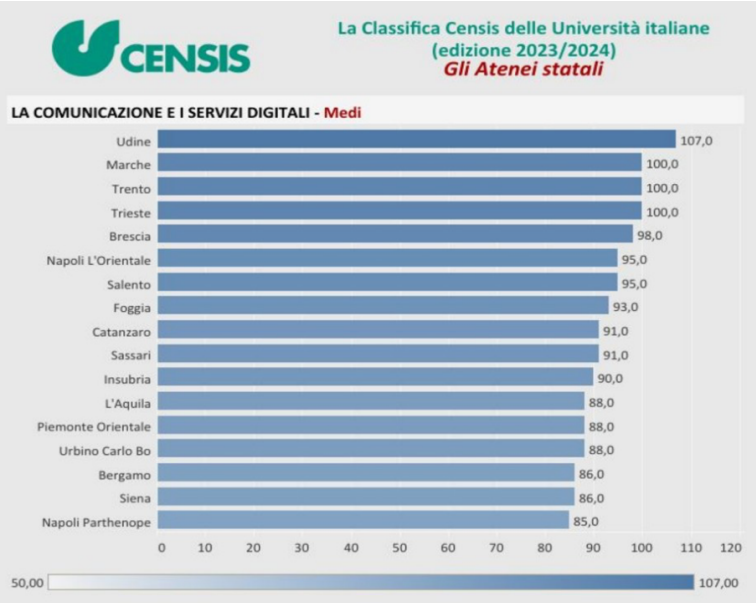


Figure 1 - CENSIS ranking of Italian Universities. CENSIS, 2023.

This outcome is the result of precise strategies of technological and didactic innovation, evolving chronologically from an initial e-learning model to Massive Open Online Courses (MOOCs) (De Martino, 2022, p.121).

The first experiment conducted by the University of Foggia can be found in the Educational Research & Interaction Design (ERID) Laboratory. The ERID lab was established with the aim of developing and promoting new digital methodologies and technologies in teaching. The ERID lab carries out applied research and training activities, offering resources and tools for the adoption of innovative educational practices, often based on scientific evidence. Its activities include the development of online learning platforms, the design of courses, and the implementation of new teaching methods, such as collaborative learning and the use of immersive technologies. The ERID Lab's research programme was developed to respond to societal demands for more inclusive and accessible teaching and training and, above all, more adaptable to the needs of the learner (Limone, 2012).

Furthermore, the ERID lab has the merit of being unique in the Apulian university landscape and has the merit of being the first product of a growth strategy totally focused on the development of its digital services. The legacy of the ERID Lab has been picked up by the University E-learning Centre (CEA) created with the primary purpose of implementing online training of both blanded courses and MOOCs. The growth strategy of the University's e-learning services that the University of Foggia has pursued in recent years has allowed the governance to deal with the

emergency situation effectively. In fact, at the time of the pandemic, the University of Foggia was able to activate in blended mode 1218 courses spread across the various departments of which the university is composed (Table 1, Limone et al., 2020).

Table 1 - Blended courses at University of Foggia at the time of the pandemic (Limone et al., 2020).

Courses	1218
Graduate Schools	6
2nd Level University Master	5
Foreign Language courses	21
PhD schools	6
Training courses	5
Professors involved	521
Active learners on platform	24844
Average daily log in	500

The University of Foggia's strategic trajectory is increasingly shaped by a growing openness towards external collaborations, establishing strong and meaningful partnerships with a wide range of companies, industries, and other training institutions both within and beyond national borders. A particularly significant manifestation of this strategy is University of Foggia's role as one of the founding members of EduOpen, an initiative that has carved out a truly unique position within the landscape of Italian higher education. This distinctive platform, EduOpen, represents a pioneering effort as the very first consortium-based platform in the country that offers high-quality Massive Open Online Courses (MOOCs) entirely free of charge. In doing so, it stands as a powerful embodiment of the core principles and values of distance learning, especially the ideal of universal access to education. EduOpen was officially launched a decade ago, in 2014, and its introduction to the Ministry of Education signalled a significant turning point for the future of digital education in Italy (Bellini, 2017). By implementing forward-thinking solutions such as EduOpen, the University not only enhances and diversifies its own educational offerings, but also fosters international collaboration and strengthens the global academic community. This underscores the University's commitment to making education universally accessible, demonstrating how cutting-edge digital technologies can be harnessed to expand opportunities for students, regardless of their geographical or socio-economic circumstances. The forward-looking approach that the University of Foggia has taken serves as a model for the future of distance education in Italy, providing a clear illustration of how integrating digital innovation with traditional academic structures can unlock entirely new frontiers in higher education.

Furthermore, the global health crisis caused by the COVID-19 pandemic has only accelerated these efforts, prompting the University of Foggia, in collaboration with the Institute of Learning Sciences (LSi), to actively participate in a series of European Commission Erasmus+ initiatives. Through these calls, the University has worked to significantly enhance its online educational offerings, taking full advantage of the capabilities offered by the EduOpen platform and utilising MOOCs as a central tool in delivering flexible, scalable, and high-quality education to a diverse and widespread audience. This strategic participation reflects the University's ongoing commitment to remaining at the forefront of educational innovation and ensuring that it continues to meet the evolving needs of students both locally and internationally.

3. Projects and Results

The University of Foggia vision towards a digital pedagogy also involves increasing openness towards external societies, producing learning material that can be enjoyed by the highest number of learners. In order to achieve this goal, a corner stone for University of Foggia researching staff is the partnerships with other training and research centers.

It is not a case if the University of Foggia is one of the founders of EduOpen, which represents a unique case in the Italian university landscape: it is the first consortium-based platform offering

completely free high-level MOOCs (Massive Open Online Courses), embodying the absolute values of distance learning, which is the universality of education.

The platform is a project funded by the Ministry of Education, University and Research for an extraordinary intervention under Art. 11 of the Ministerial Decree of November 4, n. 815 (allocation of the Ordinary Financing Fund) aimed at the creation of a platform for the delivery of courses defined as MOOCs by a network of Italian universities and a set of selected partners. The established network is open to the membership of other universities and entities/associations/ networks of particular scientific and cultural significance. It was presented 10 years ago in 2014 at the Ministry of Education. Today, EduOpen counts 417 free MOOCs and +150.000 students. The purpose and philosophy of the project is part of the Open and Digital Education movement, a rapidly developing phenomenon that currently has over 60 million users worldwide joining with a monthly increase of over 40,000 new users.

Through the implementation of innovative solutions like EduOpen, the university not only improves its educational offerings, but also collaborates internationally, highlighting the importance of universal and accessible education. The path paved by the University of Foggia serves as a reference model for the future of Distance Learning in Italy, showing how the integration of digital technologies can open new frontiers and opportunities in higher education.

All the MOOCs uploaded on the EduOpen platform are, by the nature itself of the MOOC, Open Educational Resources (OER): there are various definition of OER, but we can summarize saying that an OER is any resource available free of cost, mostly on the Internet (Mishra, 2017). A more complete definition is given by UNESCO, in the OER Paris Declaration (2012, p. 1):

> *"[OER are] teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits nocost access, use, adaptation and redistribution by others with no or limited restrictions. Open licensing is built within the existing framework of intellectual property rights as defined by relevant international conventions and respects the authorship of the work".*

Moreover, after the pandemic, the Learning Science institute (LSi) participated in several European Commission's Erasmus+ call for projects, both as leader institution as well as a partner institution, in order to compare the University of Foggia distance teaching offer with other European universities, and to be active part of the paradig shift in the field of distance learning: from being a solution to help universities and learners in time of crisis, to active part of the universities higher education learning offer.

Two of the Erasmus+ project in which the LSi has been part of and is part of, are particularly important in going beyond the conception of ERT, involving the students' wellbeing and mental health while learning online.

The first one, called "Enhancing digital and psychological resilience through peer networking in the online environment in times of crises" (DigiPsyRes), is a student-centred project, and focuses on understanding and identifying "which personal resources can contribute to minimizing the mental health costs in students incurred due to the restrictions that disrupted safety and predictability in their academic lives" (Litwic-Kaminska et al., 2023). The first goal of the project was to collected data about higher education students' psychological and digital wellbeing and resilience through a questionnaire, in order to understand how to strengthen students' awareness of personal resources and their protective role in maintaining mental health. The questionnaire was submitted to higher education students in the 3 Countries that compose the Consortium of the project: Serbia (project leader), Italy and Poland (project partners). The main goal of the DigiPsyRes project is to build an international online network, in which students can help themselves in a peer-to-peer basis, after an online training in which students work the concept of resilience and mutual support in digital resilience. The results of the survey, presented in Litwic-Kaminska et al. (2023), were used as corner stone to draft and propose activities to the students participating in the online training above mentioned.

The second project, which is already ended, was called “Closing the Gap between Smart Learning and Emergency Remote Teaching” (CLOSER), and it was teacher-centred. Transitioning to online learning, especially when university curricula are planned for face-to-face (F2F) teaching and learning, requires careful planning and design processes: the CLOSER project addressed and provided this support to the transition from ERT to Digital Education through creating evidence-based, open and innovative practices of teaching and learning. For its purposes, the Consortium of the project was composed by 3 universities (University of Foggia from Italy, Universidad Pompeu Fabra from Spain, Bitlis Eren University from Turkey) and 4 institution that are deeply involved in teachers’ training or publishing tools for teachers or directly schools (Rosa Sensat Associacio de Mestres, Spain, Octaedro Ediciones, Spain, Scuola Pascoli-S.Chiara-Altamura, Italy, Wonderful Education, Italy, and Sehit Tahsin BarutCu Anadolu Lisesi, Tuerkey).

Approaches inspired by the neurosciences and cognitive sciences bring a much-needed evidence base to educational practice, but there is growing evidence that educators do not have sufficient knowledge of cognitive processes to apply this knowledge to learning designs: the project achieved these objectives through the research and development of a Framework for teachers’ professional development. The Framework has been implemented through a MOOC about the specific digital and pedagogical competencies that are needed to plan and perform lessons online and specific tools that will be available online for free and in different European languages, under Common Creative license, on a digital hub created by the Consortium and hosted on the Universidad Pompeu Fabra website, which can be found at the link https://ildeplus.upf.edu/CLOSER/.

The digital resources and the MOOC were released during the project final event that took place on July 8th 2024 at Rosa Sensat Associacio de Mestres in Barcelona, at the end of a teachers’ training week, and was attended by more than 300 teachers.

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Blended learning for teacher development: transforming educational practices by harmonising tradition and innovation

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Abstract

This article examines the integration of blended learning models within teacher development programs, with a particular focus on the implementation of Universal Design for Learning (UDL) and the establishment of Communities of Practice (CoPs). Based on the analysis of faculty needs – emerging from the Faculty program, research conducted by TLC research fellows on virtual reality, and the findings from a small Community of Practice established in 2023, which focused for a year on UDL and highlighted the importance of technological innovation without losing the relational aspect – it was decided to design pilot blended faculty courses on UDL and teaching methodologies. These courses were developed with a specific focus on teaching methodologies, as it became evident that a foundational understanding of these is essential for effectively applying UDL principles.

The frameworks and structure of these two pilot blended courses represent the first tangible outcome of previous data collection and literature analysis. These courses, set to begin in 2025, will be evaluated to measure their effectiveness in terms of impact on teaching practices and student learning outcomes. Should the results prove positive, the course catalog will be expanded to include additional topics, with adaptations for dissemination in secondary schools as well.

Keywords: Blended learning, Universal Design for Learning, Communities of Practice, Teacher development, Action research.

1. Introduction

The emergence of universities was propelled by medieval scholars who traversed Europe in pursuit of knowledge, as highlighted by *amor sciendi* (Grundmann, 1957), fostering the establishment of educational communities that reshaped society (Le Goff, 1965). The medieval university model was built on the fundamental relationship between students and professors, fostering the formation of learning communities that were tightly interwoven with societal life. These institutions were spaces for interaction, dialogue, and shared intellectual growth, grounded in face-to-face exchanges. Today, as we navigate a highly digitized, post-COVID world, the need to recapture the essence of these communities is more urgent than ever. Modern society, characterized by fluid relationships and increasing disconnection, faces unique challenges in building meaningful interpersonal connections. In today's globalized landscape, where students and educators are connected via the World Wide Web and engage through digital technologies, academic institutions must remain dynamic. The onset of the pandemic compelled educational institutions to transition lessons to online platforms for nearly two years. In this context, universities must once again become spaces where genuine communities of learning and practice are cultivated, particularly in light of the isolation and fragmentation exacerbated by the pandemic (Perla & Vinci, 2022; Lotti, 2018). However, rather than embracing innovative pedagogical models, there has been a tendency to adhere to the traditional distance learning (FAD) model, grounded in a transmissive approach. Consequently, there has been a predominant utilization of online learning resources in a transmissive manner, neglecting the relational, creative, and connective potential offered by Web 2.0 and crucial to contemporary online learning paradigms. Furthermore, the social, communicative, and cognitive advancement of new generations, spurred by the omnipresence of technology in daily life, necessitates a seamless integration of digital

technologies in educational settings (Calvani, 2001; Bocca, 2003; Rivoltella, 2003; Trentin, 2004; Ferri, 2005; Ranieri, 2005; Bonaiuti, 2006).

One of the critical questions facing contemporary higher education is whether and how educational technologies can be leveraged to support relationality rather than diminish it. There is a concern that the increased use of digital tools could contribute to further dematerializing social interactions, distancing students and teachers both physically and emotionally (Federighi, Ranieri & Bandini, 2019). However, these same technologies offer the potential to personalize learning experiences and strengthen relationships by enabling more tailored, student-centered approaches. The key lies in using these tools to complement, rather than replace, the interpersonal dynamics that are crucial to the educational process.

As illustrated by Iannella and Pagani (2022), the shift to distance and hybrid learning, accelerated by the COVID-19 pandemic, has significantly altered both the relational and content dimensions of educational experiences. The mutual expectations between students and teachers, often referred to as the "didactic contract", have changed, along with the underlying ideological and cultural messages – known as the "hidden curriculum" – that accompany the teaching of academic subjects. These changes have introduced new beliefs and attitudes towards the role of technological innovations in education, fundamentally reshaping how teaching and learning are experienced in digital and hybrid formats.

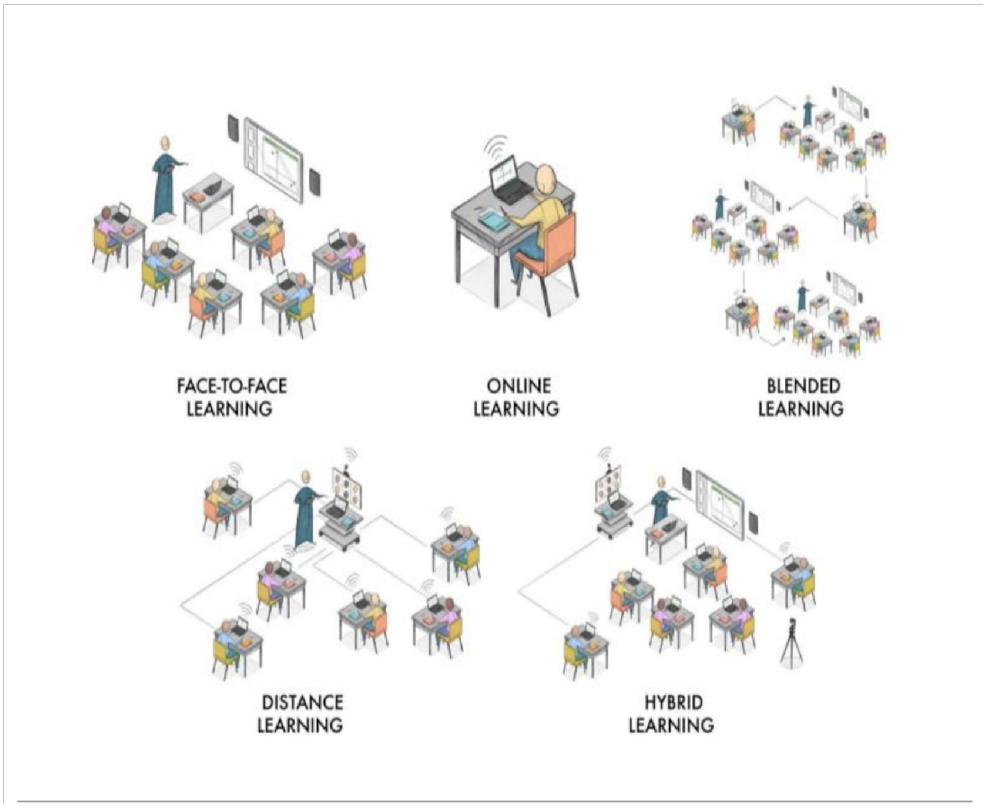


Figura 1 - Le forme dell'evento didattico. (Innella & Pagani, 2022, p. 475).

Blended learning emerges as an effective pedagogical model in this regard. By combining the strengths of traditional in-person teaching with the flexibility and accessibility of digital platforms, blended learning creates opportunities for both relational engagement and personalized instruction. The blended approach facilitates the integration of digital tools in ways that enhance, rather than detract from, the learning experience, supporting student-teacher interactions while accommodating diverse learning styles (Perla & Vinci, 2022; Lotti, 2018; Mangiatordi, 2023). In the light of these considerations, in the context of the Teaching and Learning Centre of the Insubria University, the hypothesis was elaborated to search for an integration between the teaching activity in presence and the potential offered by digital through an idea of blended and hybrid design that would overcome the real-virtual dichotomy and would not limit itself to considering e-learning as a substitute for presence. In recent years, the number of students with SLD enrolled in

universities has been rapidly increasing. In Italy, according to a survey conducted by ANVUR and CNUDD, between 2017 and 2020, the number of students with SLD rose from 6,500 to 16,084 (+147%).

University students with SLDs, particularly dyslexia, face significant challenges in reading, writing, and organizing their studies, which leads to lower academic performance, extended graduation times, and heightened anxiety. These students often report lower academic self-efficacy and life satisfaction, especially in humanities courses that demand intensive reading and memorization. Although some develop resilience, the transition to university remains particularly difficult, necessitating compensatory strategies and personalized support to mitigate these obstacles (Zingoni et al., 2021; Casali et al., 2023).

In Italy, despite Law 170/2010 (New Rules on Specific Learning Disorders in Schools) and the CNUDD (National University Conference of Rectors' Delegates for Disabilities and SLD) Guidelines, which guarantee the right to education and promote academic success through personalized support measures, the implementation of these provisions in universities remains insufficient. This lack of adequate support contributes to an increased risk of academic delays and higher dropout rates among students with Specific Learning Disorders (Benedetti et al., 2022; Zingoni et al., 2021).

In this context, the Universal Design for Learning (UDL) framework appears highly promising as it enables the design of learning experiences that are inclusive of the variability of all students from the outset, regardless of individual conditions, thus reducing the need for post-hoc adjustments. This approach is based on the adoption of "usable, effective, and sustainable" teaching methodologies that respect and enhance diversity (Meyer & Rose, 2014). The UDL model simultaneously addresses the challenges of fostering diversity, promoting inclusive education, and encouraging the critical use of information and communication technologies (ICT), eliminating or significantly reducing the need for personalized adaptations after course design (Savia, 2016; Meyer & Rose, 2014). Furthermore, the UDL framework has proven effective in increasing accessibility and improving academic success for students with SLDs, thereby reducing the risk of dropout or delays in completing their studies (Ferguson et al., 2019; Black et al., 2015).

The use of blended learning, together with the UDL framework, and an in-depth exploration of teaching methodologies, can offer a solution to the current challenges of university education by promoting inclusion, personalization, and relationship-building in both physical and digital spaces. This approach avoids the pitfall of treating technology as a substandard alternative to in-person teaching, instead viewing it as a powerful tool for enhancing educational practices and building vibrant, interconnected academic communities.

2. Materials and Methods

The present study was conducted within the broader framework of the Faculty Development Program at the University of Insubria, with the aim of enhancing teaching practices by integrating innovative pedagogical models. Two key interventions were implemented: a blended learning model focused on Universal Design for Learning (UDL) principles, and a blended learning model focused on teaching methodologies, which will lead to the creation of two Communities of Practice on the same themes among the members of the University who will participate in the training programs. These interventions aim to equip university instructors with the tools needed to meet the diverse needs of students, particularly those with Specific Learning Disorders (SLDs), while also fostering the adoption of innovative teaching methodologies.

Based on the analysis of faculty needs – emerging from the Faculty program and research conducted by TLC fellows on virtual reality, as well as the findings from a small CoP established in 2023 – it was decided to design pilot blended faculty courses on UDL and teaching methodologies. The frameworks and structure of these courses are already the first tangible result of this analysis. These courses were designed with a focus on teaching methodologies, as it was found that having a fundamental understanding of these methodologies is essential for effectively working on UDL.

The frameworks and structure of these two blended pilot courses are already the result of data previously gathered from research and literature. These courses, set to begin in 2025, will be evaluated through an assessment plan designed to measure their effectiveness in terms of impact on teaching practices and student learning outcomes. If the results are positive, the course catalog will be expanded to include additional topics and adapted for dissemination in secondary schools as well.

As emphasized by Bonometti and colleagues (2024), this approach transcends the traditional divide between physical and virtual teaching environments. It refrains from viewing e-learning as a simple substitute for in-person instruction, and instead, it is conceptualized as a complementary tool that enhances teaching through digital platforms (Mangiatordi, 2023).

The instructional design within the blended learning model includes a combination of synchronous and asynchronous methods, such as video lectures, group discussions, and hands-on practical exercises. These strategies are designed to foster interactive and engaging learning experiences, which are essential for promoting active learning (Lotti, 2018; Federighi, Ranieri & Bandini, 2019). The model particularly focuses on addressing the needs of students with SLDs by incorporating the UDL framework to ensure that the learning environment is inclusive and accessible from the outset. This framework facilitates personalized learning paths, allowing for multiple means of engagement, representation, and expression, which is crucial for supporting diverse learning profiles.

Universal Design for Learning (UDL) is a pedagogical framework that advocates for creating flexible learning environments capable of accommodating the diverse needs of all students. Originating from the principles of Universal Design in architecture, UDL extends this concept into the educational domain, promoting inclusivity and personalization (Center for Universal Design, 1997). Within this study, UDL was introduced through comprehensive faculty training sessions aimed at redesigning curricula to be accessible to all learners, regardless of their learning abilities.

Following these sessions, the UDL training was designed based on the work and outcomes of a Community of Practice (CoP) composed of eight faculty members, which ran throughout the previous academic year. In parallel, the training on teaching methodologies emerged from the needs identified during in-person faculty courses promoted by the Teaching and Learning Center (TLC). The collection of data and insights from these experiences led to the development of structured blended learning courses. These courses, as outlined later, have the ultimate goal of converging into Communities of Practice (CoPs), where the shared knowledge and collaborative learning will be further enhanced. The first Community of Practice (CoP) applied UDL principles using Thomas J. Tobin's Plus-One Approach. This approach encourages instructors to identify specific areas where students face challenges and add just "one more way" for students to engage with the material or demonstrate their learning. By gradually implementing small changes, the "Plus-One Approach" makes UDL adoption manageable and sustainable (Tobin & Behling, 2018). The CoP fostered collaboration, reflection on teaching practices, and the development of resources to promote UDL adoption among colleagues (McNiff, 2013; Wenger, 1998).

The effectiveness of UDL was assessed through action research, using a mixed methods approach that combined qualitative and quantitative data to evaluate its impact on teaching practices, student outcomes, and faculty satisfaction (Benedetti et al., 2022; Wenger-Trayner et al., 2015). This approach demonstrated the CoP's effectiveness in facilitating UDL adoption and improving the educational experience for students with SLDs.

To support the ongoing development of UDL and innovative teaching practices, a Community of Practice (CoP) was established for faculty members. The CoP is a collaborative space where educators can meet regularly to discuss challenges, share best practices, and reflect on their experiences implementing UDL and other pedagogical innovations (Wenger, 1998). These meetings, which occurred bi-monthly, created a dynamic environment that encouraged continuous professional development and the refinement of teaching strategies.

The CoP at the University of Insubria also facilitated knowledge sharing around blended learning and UDL methodologies. It fostered an atmosphere of peer learning, where educators could collaboratively problem-solve and innovate new approaches to teaching. Moreover, the CoP

aligns with transformative adult learning principles, as described by Mezirow (2016), which emphasize experiential, participatory, and collaborative learning methods.

To evaluate the effectiveness of the blended learning model and UDL adoption, the program employed an action research methodology. The research framework will follow the methodological approach of action research (Eliot, 1993; Nigris, 1998; Barbier 2007), i.e. the continuous recursiveness between moments of research and moments of action. The research part will make use of qualitative-quantitative data collection, according to the triangulation principles of Mixed Method Research, using MaxQda (Creswell, 2024).

Faculty feedback will be collected through surveys, focus group discussions, and reflective journals. Additionally, student performance data was analyzed to assess the impact of these interventions on academic outcomes, particularly in terms of engagement and success among students with SLDs. The combination of qualitative and quantitative data enabled a holistic evaluation of the program's effectiveness. The action research framework also utilized mixed methods, integrating both qualitative reflections and quantitative performance data. This allowed for triangulation, ensuring the robustness of the findings. Tools such as MaxQda were used for data analysis, providing insights into how the blended learning model and UDL were being implemented across different teaching contexts.

3. Results

The pilot blended learning courses, which incorporate Universal Design for Learning (UDL) principles and interactive teaching methodologies, are set to launch in January 2025. The evaluation of these courses will begin in September 2025 and will focus on two main areas: faculty satisfaction and student outcomes. Notably, since UDL is an inclusive framework designed to benefit all learners, the evaluation will consider the improvements seen in all students, not only those with neurodivergent profiles or Specific Learning Disorders (SLDs).

In preparation for this, feedback was gathered from faculty members who participated in the in-person Community of Practice (CoP) sessions held this year. The following testimonials were particularly illustrative of the impact these sessions had on teaching practices:

- "I had the opportunity to meet colleagues with experience in fields very different from mine and to discuss both common and specific challenges related to teaching."
- "I learned that it is possible to make small changes to one's teaching methodologies to better meet the needs not only of students with SLDs but of all students."
- "In practice, I am trying to apply the new knowledge in my teaching of Bioinformatics: I modified my syllabus according to UDL principles and shared it with my students right away. I'm using diverse and complementary teaching methods (presentations, videos, in-class exercises) to help them learn. I am guiding them toward the final exam by providing examples and intermediate simulations. All this has helped me create a good communication channel with them, which is generating a very positive atmosphere in the classroom."

Additionally, parallel research conducted by TLC research fellows on faculty use of educational technologies revealed that many instructors expressed the need to first train themselves in blended learning methodologies. This interest aligns with the growing desire to integrate educational technologies into their practices more effectively. However, ongoing challenges include ensuring sufficient technological resources and addressing faculty readiness to fully embrace and implement these innovations. The comprehensive evaluation of these courses in 2025 will provide insights into how these technologies and methodologies improve both teaching quality and student success, ensuring a more personalized and inclusive learning experience for all.

Based on the needs analysis, data collected from the initial Community of Practice (CoP), early faculty courses, and interviews with instructors, two pilot blended courses were designed for the Faculty 2025 program. These courses were structured with the aim of integrating relationships

and fostering an educational community through a combination of blended and virtual learning, while also promoting true personalization. Each of these motivations and needs has been carefully considered, and every step in the pilot courses (illustrated in the accompanying images) has a solid foundation rooted in the specific requirements identified. The ultimate goal is to create a learning environment that not only supports relational engagement but also encourages a personalized learning journey, aligning with contemporary educational demands.

The structure of these courses (Figures 2 and 3) represents a solid starting point, informed by data collection and analysis of previous research. As the pilot courses are implemented in 2025, ongoing action research will ensure continuous evaluation, allowing the refinement and potential expansion of the course catalog based on measurable outcomes.

4. Discussion

The design of these blended learning courses reflects the synthesis of previous research and feedback, representing the first implementation phase of data-driven course development. The evaluation of these courses will further refine the structure but is already rooted in solid theoretical frameworks. The integration of blended learning models, particularly those focused on Universal Design for Learning (UDL) principles and innovative teaching methodologies, offers significant potential for enhancing both student and faculty experiences in higher education. The design of these pilot courses responds directly to the growing need for more flexible, inclusive, and engaging teaching strategies. By incorporating digital tools alongside traditional teaching methods, blended learning addresses the diverse learning styles and needs of students, including those with Specific Learning Disorders (SLDs).

The development of these courses was informed by an in-depth needs analysis and feedback from earlier faculty development initiatives, including insights gained from the first Community of Practice (CoP) sessions. These collaborative spaces have proven effective in fostering peer learning and reflection, particularly in the adoption of the UDL framework. The faculty members expressed the value of these CoPs in supporting incremental changes to their teaching practices, particularly through the implementation of the “Plus-One Approach”, which encourages small, sustainable adjustments to enhance inclusivity.

Additionally, the emphasis on relationship-building and community creation within the blended learning model is crucial. As highlighted in faculty testimonials, the ability to connect with colleagues across disciplines and reflect on shared challenges fosters a collaborative culture that enhances both teaching and learning outcomes. This focus on relational engagement is particularly important in a post-COVID context, where isolation and fragmentation in the academic experience have become prevalent issues. By leveraging digital technologies to complement, rather than replace, in-person interactions, these pilot courses aim to rebuild a sense of community within academic institutions.

5. Conclusions

The blended learning courses designed for the Faculty 2025 program, which integrate UDL principles and innovative teaching methodologies, hold significant promise for fostering inclusive, engaging, and personalized learning environments. While the formal evaluation of these courses will begin in September 2025, the foundational work laid by previous faculty development programs and Communities of Practice (CoPs) provides a solid basis for success. By focusing on both student outcomes and faculty satisfaction, these courses aim to meet the evolving demands of higher education, particularly in fostering accessibility for students with diverse learning needs and promoting continuous professional development for educators.

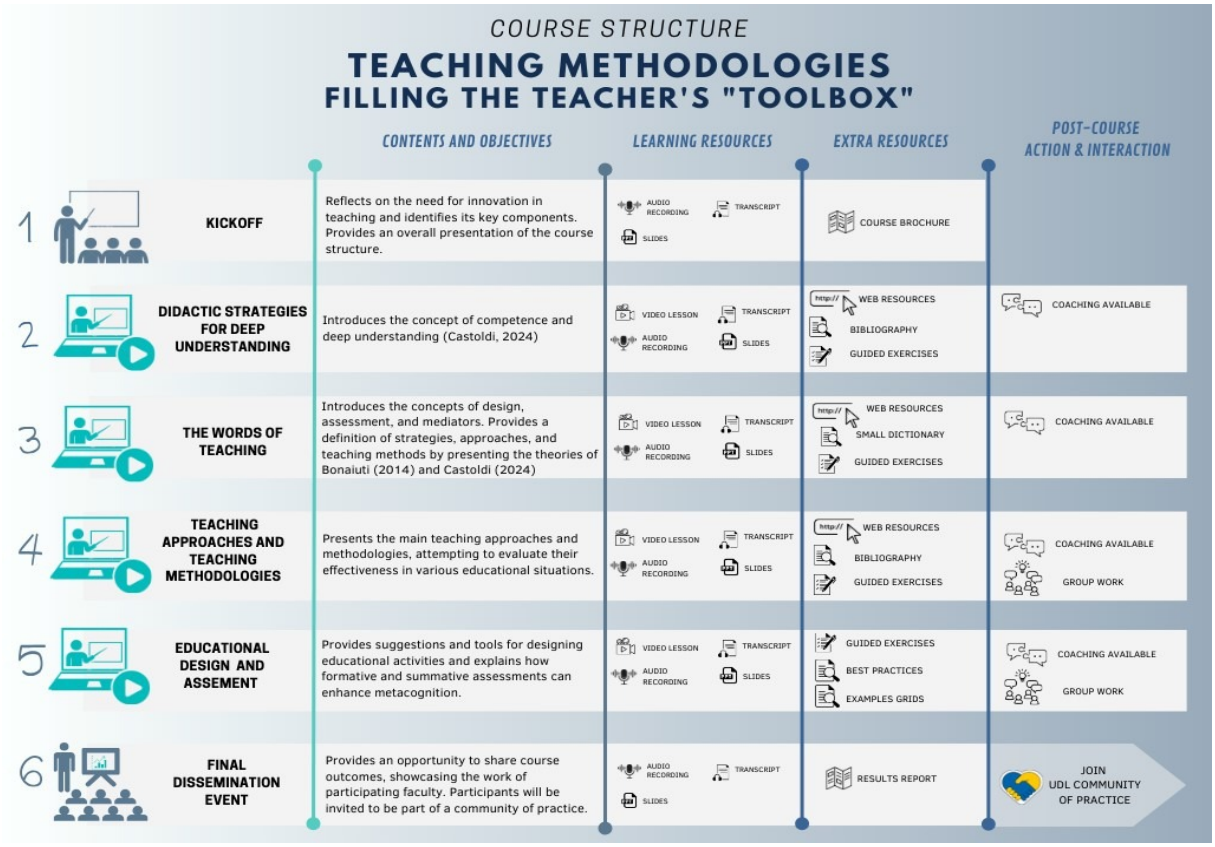


Figure 2 - Blended Course on Teaching Methodologies.

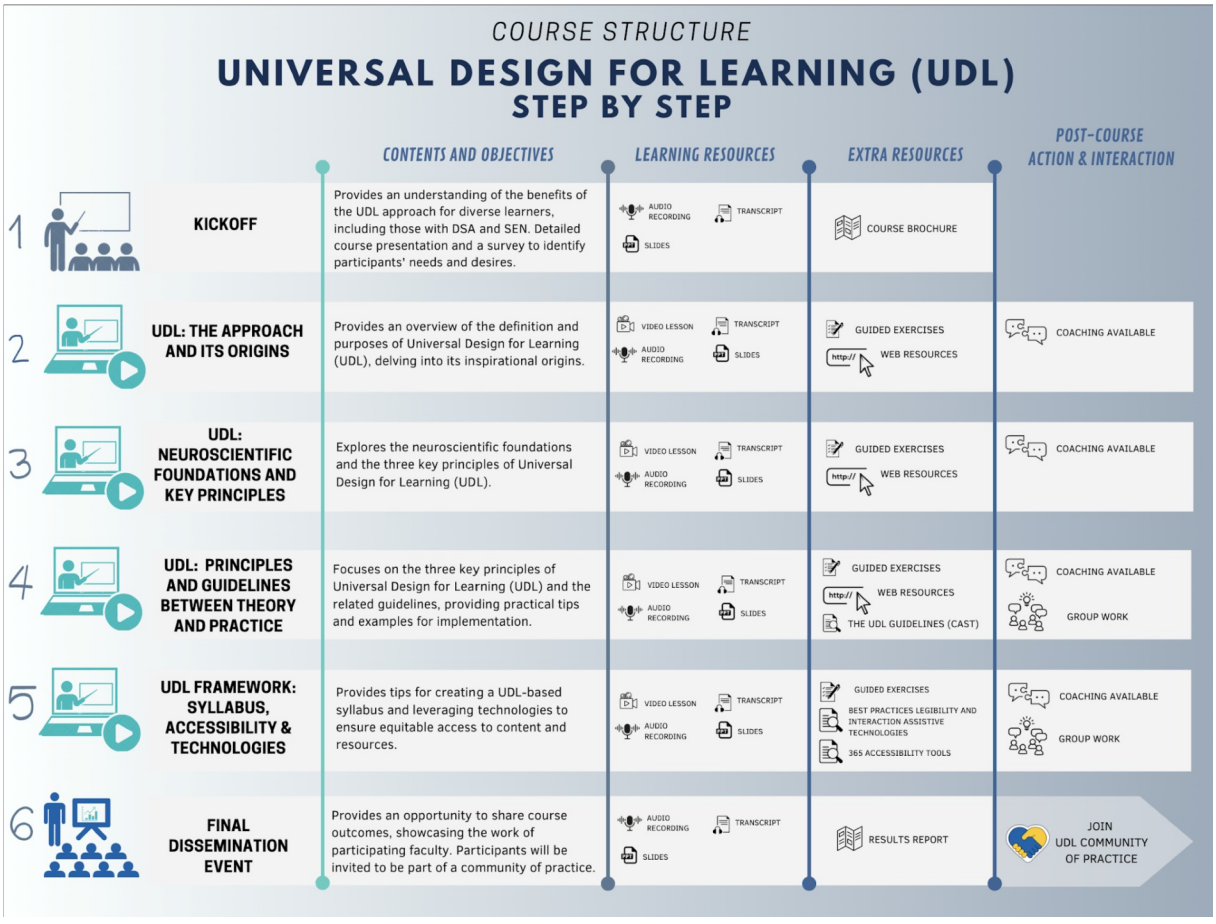


Figure 3 - Blended UDL Course.

As the pilot courses progress, ongoing action research will be essential in gathering both qualitative and quantitative data to assess their impact. The anticipated outcomes include improved teaching practices, enhanced student performance, and greater faculty engagement in adopting inclusive pedagogical models. Ultimately, these initiatives aim to create a dynamic, interconnected academic community that supports both personalized learning and relational engagement, aligning with the broader goals of contemporary higher education. The successful implementation of these models could serve as a blueprint for future faculty development programs, ensuring that universities remain adaptable and responsive to the changing needs of both students and educators.

Authors' contribution

The parts of the different sections pertaining to Universal Design for Learning (UDL) were written by Sara Bocchicchio. The structuring and drafting of the remaining parts were carried out by Letizia Ferri. Stefano Bonometti and Cristiano Termine provided scientific supervision for the work.

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Inclusive museum and digital teaching: enhancing learning in students with special educational needs

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Abstract

This paper aims to explore the crucial role of museum education in the education and training of students with Special Educational Needs. Through a detailed analysis, it will examine how museum experiences can foster meaningful learning and the development of life skills that are essential in today's social and working contexts. A specific focus will be on the integration of digital technologies into museum educational pathways, exploring how they can personalize learning and make content more accessible and inclusive. The importance of encouraging flexibility and critical thinking through museum activities will also be explored. The ability to adapt educational programs to the specific needs of students with Special Educational Needs will be placed at the center of the reflection, demonstrating how a flexible pedagogical approach can encourage engagement and academic success. Through the analysis of case studies, empirical research and practical recommendations, this research will provide a comprehensive overview of the value of museum education for students with Special Educational Needs. The findings of this study may guide museum educators and specialized teachers in the application of effective pedagogical strategies aimed at improving the educational experience of all students.

Keywords: Museum Education, Inclusion, Digital, School, Life Skills.

1. Introduction

School and museum, two realities that are different in nature and function, have gradually come closer together in the educational context. On the one hand, school is the pivotal place of formal, compulsory and structured education, which profoundly influences the growth of each individual. On the other hand, the museum is a space linked to free choice and possibilities offered to the individual, representing an important resource for informal learning. Both places, therefore, contribute to the development of knowledge, each with different modalities and approaches.

Although school remains the main environment for formal learning, it does not exhaust all the educational opportunities an individual may encounter in his or her life context. Education, in fact, extends well beyond the school walls and continues throughout life, through experiences that can be both individual and collective. The need to adapt schools to the complexity of the contemporary world has pushed pedagogues, teachers and educators to open up to new places of learning, among which the museum emerges as a valuable and versatile cultural resource.

In this perspective, museums, cultural heritage, landscapes and other spaces of historical and artistic value offer inexhaustible opportunities for growth, both individually and collectively. The museum, in particular, is an ideal environment to enrich, support and broaden learning processes, providing a complementary and more flexible dimension than school. In addition to deepening already acquired knowledge, the museum opens up new avenues for discovery, promoting education that develops more freely and autonomously.

In the context of formal and informal education, the museum assumes a fundamental role as a cultural mediator. It is not simply a container of objects, but a bridge between the heritage on display and the visiting public. Mediation, in fact, is at the heart of museum action: the objects themselves are bearers of meaning, even without explanatory aids, but their communication is enhanced by the layout, captions, information panels, multimedia technologies and, above all, the

presence of museum educators. The latter play a crucial role in facilitating interaction between the public and the works, not taking a traditional didactic approach, but acting as stimulators of curiosity and reflection. They do not offer prepackaged answers, but invite visitors to explore, interpret and formulate new questions, making the museum experience more active and informed.

However, when the school enters the museum, it brings with it part of its formal structure. Although the museum is an informal place of learning, characterised by the visitor's freedom to choose what to observe and experience, school visits must inevitably adapt to the requirements of formal education. Times are defined, groups are organised by class, and teachers accompany students, ensuring continuity between what is learnt in the museum and what is processed in the classroom. This mixture of approaches, if well balanced, can enrich the educational experience and foster a learning experience attentive to the educational needs of all those involved, but it requires careful management to make the most of the educational potential offered by both contexts, formal and informal (Zuccoli, 2015). Inclusive learning in museums, in fact, represents a resource of great potential for students with Special Educational Needs. Museums, with their offer of visual, tactile, olfactory and auditory stimuli, foster meaningful learning through sensory involvement and direct interaction with objects, allowing a deeper connection between theory and practice. The concrete and immersive experiences offered by museum exhibitions, often interactive and multi-sensory, are particularly effective in promoting understanding and memorisation of information, as learning becomes dynamic and participatory. The museum environment stimulates curiosity, imagination and interest, motivating students to explore independently, find their own pathways and develop self-directed and meaningful learning (Bertolini et al, 2023).

Based on these premises, the role of the museum has been revolutionised in recent decades. The traditional idea of the museum as a place of passive observation, where objects are kept and studied in silence, has gradually been replaced by a more interactive and engaging model. Museum institutions have been transformed into living places of continuous exchange and learning, where knowledge is no longer transmitted only in a top-down way, but built together with visitors through shared experiences.

2. Methodology and research

This study is based on an exploratory scoping review, a literature review methodology particularly suited to examine emerging and ill-defined areas of study, such as museum didactics applied to the education of boys and girls with Special Educational Needs, in order to extensively map existing research and good practice, but also to identify unexplored areas of relevant potential for future theoretical and practical development.

The main objective of this investigation is to explore the contribution of museum experiences in promoting meaningful learning and the development of life skills in young people with Special Educational Needs, as well as their impact on structuring inclusive educational practices. It sought to answer the following key research questions:

1. *Can museum experiences facilitate meaningful learning and promote the development of transversal competences (life skills) in pupils with Special Educational Needs?*

   This question aims to understand whether interaction with museum spaces and educational resources, both physical and digital, can enhance the cognitive, emotional and social development of pupils with Special Educational Needs. In particular, it investigates the effectiveness of museum activities in fostering learning processes that are personalised and adapted to special educational needs.

2. *Can the methodologies and technologies used in museum contexts provide useful indications for the preparation of future educational intervention protocols?*

   This question explores the possibility that experiences gained in museum education can contribute to the creation of operational models or guidelines for future educational interventions, which can also be adapted to other contexts, such as schools or educational support centres.

In order to obtain an adequate overview of the development of teaching practices in museums in relation to Special Educational Needs, a time span of ten years, from 2014 to 2024, was considered in the literature review. The procedure followed can be divided into the following steps:

1. Identification of keywords. Relevant keywords were identified to ensure a broad and targeted exploration of the available literature. These included “Special Educational Need”, “meaningful learning”, “museums”, “life skills”, “soft skills”, “inclusive education” and “digital technologies”. These keywords were used to query major academic databases such as Scopus, Web of Science, ERIC, and Google Scholar.
2. Database search and study selection. The search was conducted using specific filters to obtain peer-reviewed contributions, including scientific articles, book chapters, dissertations, conference proceedings and institutional reports. Only works published in Italian and English, with full-text access, and explicitly addressing issues related to museum education and Special Educational Needs were included.
3. Cataloguing and organisation of data. For each selected contribution, the following data were collected and catalogued: author(s), year of publication, title, journal or publication source (Table 1), and analyzed methodology used and main results. This process made it possible to build a database that enabled a systematic and comparative analysis of the results. In addition, special attention was paid to the description of the teaching and pedagogical methodologies adopted in the selected studies in order to identify trends and replicable models.
4. Critical analysis and synthesis. The analysis phase involved a critical reading of the selected contributions, with the aim of identifying the main theoretical and practical approaches, the most recurring methodologies and the most relevant empirical evidence. Particular emphasis was placed on analysing the educational strategies used in museums to involve children with Special Educational Needs, taking into account the different types of needs (cognitive, sensory, emotional, behavioural). This phase also made it possible to highlight the effectiveness of using digital technologies in museum contexts, both to improve accessibility and to personalise learning paths.

3. Inclusion and accessibility in museums: the digital revolution

Educational inclusion is a crucial aspect of the modern museum mission. The concept of “accessibility” goes far beyond physical barriers to include cognitive and sensory accessibility. For learners with Special Educational Needs, which may include motor, visual, hearing, cognitive or emotional difficulties, it is crucial that the museum offers appropriate tools to facilitate their active participation. This can be done through assistive technologies, tactile panels, subtitled audio and video descriptions, as well as through multi-sensory pathways, which allow for an inclusive and stimulating museum experience.

For example, museums such as the Louvre in Paris, which in addition to being accessible in its spaces also offers specific routes for blind and deaf people, and the State Tactile Museum “Omero” in Ancona, have developed specific programmes to make the museum a cultural space without barriers, pleasant and productive for all and the museum experience more accessible to visually impaired people, using works of art to touch and sensory educational materials and creating a museum where everything could be touched, tired by now of the touch ban widespread in museums all over the world.

The use of edugames and serious games in teaching practices proves particularly effective in promoting an active approach to learning, stimulating curiosity, motivation and problem-solving skills in students. Another major step towards museum inclusion is the use of digital technology. Museums are increasingly integrating online platforms and applications to reach a wider audience, including people who may not be able to physically visit exhibitions. In this context, immersive technologies such as augmented reality (AR), virtual reality (VR) and mixed reality (MR) are changing the way art and culture are enjoyed.

Table 1 - Studies analysed.

Authors	*Title*	*Magazine/ Conference/ Editors*	*Year*	*Volume/ Page*
Bertolini, C., Alessandra, L., Scipione, L., Vezzani, A.	School in the museum: the learning experience from the pupils' point of view	Lifelong, Lifewide Learning (LLL)	2023	14(31), 391-407
Capasso, L., Monza, F., Di Fabrizio, A., Falchetti, E.	Accessibility in Museums. Limits, resources and strategies	Proceedings of the XXIX ANMS Congress, Chieti	2019	23-25
Coppola, S., Zanazzi, S.	The experience of art. The role of immersive technologies in museum education	International Journal of Education and Training Sciences	2020	18(2), 36-49
D'Agnano, F., Balletti, C., Guerra, F., Vernier, P.	A case study of augmented reality for an accessible cultural heritage. Digitalization, 3D printing and sensor for an audio-tactile experience	The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences	2015	XL-5/W4: 207-213
Di Paolo, A., Zollo, I.	Digital Storytelling, museum education and inclusion: simple perspectives	Journal of Inclusive Methodology and Technology in Learning and Teaching	2023	3(1sup)
Eardley, A.F., Mineiro, C.J., Neves, J., Ride, P.	Redefining Access: Embracing multimodality, memorability and shared experience in Museums	Curator: The Museum Journal	2016	59(3), 263-286
Finestone, F., et al.	Museum education and new technologies: beauty within reach of NFC	Pedagogical sciences	2024	315
Luigini, A., Panciroli, C.	Digital environments for art and heritage education	FrancoAngeli	2018	-
Miglietta, A.M.	The accessible museum: barriers, actions and reflections	Scientific Museology, ns	2017	11, 11-30
Perrella, S.	The digital museum. Paths of fruition and web design	Progedit	2023	-
Rossi, M., Berardinetti, V., Peconio, G., Simonetti, C.	Museum Didactics and & Virtual Reality: what educational perspectives?	Pedagogical sciences	2024	380
Todino, M.D., Campitiello, L., Tore, S.	Analysis and creative remodelling of the real world in virtual environments. 3D scanning of archaeological Di finds	Mizar. Constellation of thoughts	2021	15, 212-216

VR allows students with Special Educational Needs to explore museums and historical sites from anywhere and at any time, offering them personalised and immersive experiences. AR, on the other hand, allows digital content to be overlaid on the real world, enriching the visit with additional information and images that enhance the understanding of historical or artistic concepts. These technologies not only enrich learners' experience, but also allow content to be adapted to their specific needs, making learning more effective and accessible (Rossi et al., 2024).

A significant example is the “Google Arts & Culture” project, a platform offering high-resolution digital images of works of art and virtual tours of some of the world's most famous museums. These platforms not only offer free and global access to cultural heritage, but also allow for a

personalised learning experience, allowing students to explore works at their own pace, dwelling on the details that interest them most.
In addition, three-dimensional acquisitions of archaeological artefacts are important for deepening knowledge in archaeological disciplines, from prehistory to studies of ancient civilisations. The use of digital assets in archaeology and education represents a unique opportunity to enhance the cultural heritage, promoting its dissemination and raising a renewed interest in the past. The creation of highfidelity three-dimensional models, obtained through 3D scanning and virtual modelling techniques, makes it possible to accurately replicate the morphological, material and dimensional characteristics of real objects. This digital representation offers countless advantages, including the preservation and dissemination of cultural heritage, avoiding the deterioration of original artefacts and making them accessible to a wider public. The comparative and metric analysis of digital assets also facilitates the indepth study of shapes, decorations and production techniques, contributing to a more accurate understanding of past cultures.
The use of such technologies during a museum visit can be a moment of engagement in the teachinglearning process, facilitated by the use of 3D scanning, as the project “The Ara as it was. A story in augmented and virtual reality” has well shown, a multimedia story, between history and technology in an immersive and multisensory visit of the Ara Pacis, where characters, gestures, divinities and animals come to life in 3D to illustrate, together with color, the origins of Rome and the family of Augustus; or as in the archaeological park corresponding to the ancient Roman fortress of “Carnuntum” in Austria, instead, where an augmented reality application allows visitors to discover how the site originally appeared.
This technology generates digital assets that can be integrated into the Unity3D graphics engine and subsequently incorporated into a web page or application (Todino et al, 2021).

3. The possibilities of digital innovation in museum education

The integration of digital technologies in museum education has greatly expanded educational possibilities, making the learning experience more engaging, personalised and accessible. Tools such as digital audio guides, interactive apps, augmented and virtual reality offer innovative ways to present and explore museum content, allowing the experience to be tailored to the specific needs of each visitor. Digital technologies can be used to facilitate access to information through inclusive tools such as subtitles for the deaf, audio descriptions for the blind, or customised interfaces for people with cognitive impairments. These tools not only make cultural heritage more usable, but also offer new learning possibilities for all, helping to bridge physical and cognitive barriers (Luigini & Panciroli, 2018).

With the advent of virtual reality and the metaverse, which are configured as opportunities for participation despite the distance, difficulties related to the presence, within museums, of architectural barriers, restricted spaces in which to move with familiarity, as well as time issues related to the possibility of accessing the facilities only at certain times of the day, are overcome (Eardley et al., 2016). Several studies have highlighted how the use of technology in museum visits significantly improves the educational experience, particularly for students with Special Educational Needs. Indeed, the introduction of digital tools makes it possible to offer diversified and adaptable ways of learning, fostering inclusion and active participation of a wider audience. Through digital platforms, museums can create customised learning paths that, in addition to meeting individual needs, can be enjoyed both in presence and at a distance. This flexibility opens up new avenues for lifelong learning, allowing users to explore museum content outside the physical context of the museum, thus ensuring a broader and more accessible enjoyment, and offering everyone the opportunity to develop those skills that are today necessary in every life context.

The combination of life skills and digital technologies in museum education offers an integrated and inclusive educational approach, in which the museum becomes a dynamic and accessible place of learning. The potential offered by new technologies allows museums to evolve, responding to the needs of an increasingly diverse and connected society (Perrella, 2023). Hence it is possible to state once again how museums are not only repositories of cultural heritage, but

are increasingly configured as spaces for personal and collective growth, where art and culture become tools for the development of essential life skills. Integrating these practices into museum education not only enriches the visitor experience, but contributes to building a more inclusive and aware society.

4. Museum education for the development of soft skills

Life skills, or skills for life, encompass a set of social, emotional, cognitive and practical skills that are essential for successfully coping with everyday challenges and leading an independent and fulfilling life. These skills range from the ability to communicate effectively and work in a team, to stress management, critical thinking and the ability to make informed decisions. In education, the development of life skills is of crucial importance, as it provides students with tools to enhance their personal, social and emotional growth. Museum education represents a privileged context for promoting these skills, thanks to its ability to combine practical experience, critical reflection and interdisciplinary learning. With their rich collections and interactive approach to learning, museums offer students a stimulating and safe environment in which they can explore, ask questions and interact actively. This context enables the development of skills such as collaboration, problem-solving and creative thinking. Museum learning activities can be designed to encourage teamwork and active participation, which are key elements in promoting personal growth and a sense of social belonging. Through activities that stimulate observation, interpretation and confrontation, visitors, especially younger ones, can sharpen their analytical and communication skills, key competences for dealing with a changing world.

An example of excellence in this area is the “Museum for All” programme, implemented in various Italian museums with the aim of making art and culture accessible to everyone, including those with cognitive and sensory disabilities. The “Museum for All” project, devised in 2015 by the “L'Abilità” association in collaboration with the “Fondazione De Agostini”, was created with the aim of improving the quality of life of people with intellectual disabilities, offering them a space to meet, exchange and integrate into society. This project aligns perfectly with the policy of inclusiveness that the Brera Art Gallery has developed in recent years. Even before the pandemic, and even more so after the health emergency, Brera transformed the principles of “accessibility” and “welcome” into concrete actions aimed at its public. These initiatives have multiplied over time, encouraging the participation of families, children and, in particular, people with special needs, highlighting the value of diversity.

The Pinacoteca's commitment took the form of a targeted programme that saw “Museums for All” grow to include a network of about 30 museums throughout the country. These include the museums of Milan's Castello Sforzesco and a number of FAI - Fondo per l'Ambiente Italiano properties. This network represents the widest cultural offer aimed at the public with intellectual disabilities, ranging from ancient and contemporary art to natural and ethno-anthropological heritage.

The aim of “Museums for All” is to make the experience of visiting places of culture accessible to people with intellectual disabilities, enabling them to appreciate cultural heritage in a deep and meaningful way. The works are not only presented in an understandable way, but also experienced on a cognitive and emotional level, thus offering an opportunity for cultural and social growth. The museum is thus transformed into a place of discovery, confrontation and inclusion, an antidote against isolation. In line with the vision of the museum as a space of access to knowledge for all, thanks to the collaboration between the educational staff of the Pinacoteca di Brera and the team of “L'Abilità” Onlus, the guide “Museo per tutti alla Pinacoteca di Brera” was created. Available both in paper and digital format (PDF), this guide is a tool designed to allow visitors with intellectual disabilities, accompanied by parents, teachers or educators, to independently enjoy an inclusive museum experience. The guide not only facilitates the understanding of the works of art, but also allows visitors to fully immerse themselves in the emotions they arouse. Each work of art is accompanied by symbols that facilitate understanding

and by two in-depth boxes containing key words and curiosities about the artist and the work itself.

In addition to the guide, the Pinacoteca staff has been trained by the "L'Abilità" team to accompany groups of visitors with intellectual disabilities around the museum. The guide is available in two versions: one drawn up according to the rules of easy-to-read, a simplified language regulated by the European Union, ideal for aiding concentration and communication; and a second version that uses the symbols of Alternative Augmentative Communication (AAC), which combines text and images/pictures, facilitating comprehension even for those who have difficulty with verbal language. In this way, "Museum for All" offers an innovative and accessible approach to art, promoting inclusion and enriching cultural enjoyment for people of all ages and conditions.

A programme that not only allows greater accessibility to museum collections, but also actively promotes social inclusion and participation, ensuring that all visitors, regardless of their abilities, can fully enjoy the museum experience. Initiatives of this kind demonstrate how museum education can contribute to creating an inclusive environment, in which every individual, regardless of his or her difficulties, can feel welcome and participate.

5. School-Museum collaboration: an educational partnership

In light of this, the collaboration between schools and museums has intensified in recent years, with numerous projects and activities promoting the museum as a key educational resource. This relationship is based on a vision of the museum as a natural extension of the school, an environment in which students can develop skills beyond the strictly disciplinary ones.

Museum activities can complement and enrich the school curriculum, offering students unique opportunities to develop critical thinking, creativity and cultural awareness. Museum education can be designed to actively involve students, asking questions, encouraging reflection and promoting group work. For learners with Special Educational Needs, these experiences can be particularly useful, as they offer alternative ways of learning that better suit their cognitive styles and special needs.

Museums, therefore, not only transmit knowledge, but also become spaces of social inclusion, where education for diversity and active citizenship is promoted. The integration of museum didactics in the education of students with Special Educational Needs can provide valuable support to overcome traditional educational difficulties, offering them tools that stimulate active participation and personal involvement (Miglietta, 2017).

The evolution of the museum from a static place to a dynamic and interactive space represents a great opportunity to improve the inclusion and learning of students with Special Educational Needs. The synergy between school and museum, enhanced by the use of digital technologies and innovative educational practices, makes the museum an inclusive and stimulating environment, capable of meeting the needs of all visitors. Museum visits not only offer enriching educational experiences, but are also fundamental tools for promoting cultural and social awareness, preparing new generations to become more aware and participating citizens.

Inclusion in museum education, both physical and digital, allows students with Special Educational Needs to explore, learn and grow, offering a unique opportunity to approach the world's cultural heritage in an engaging and personalised way and making the museum and art experience a tool for meaningful learning and psychophysical well-being. Visiting museums, exhibitions, theatres or concerts not only enriches our cultural background, but also activates neural processes that help support and improve brain function while reducing the negative effects of stress. Numerous pathologies typical of modern society are, in fact, closely linked to dysfunctional lifestyles; in this context, artistic experience emerges as a powerful therapeutic tool, capable of positively influencing mental and physical health (Capasso et al., 2019; Coppola & Zanazzi, 2020).

In the face of such evidence, the need for a holistic approach to public health, integrating not only the treatment of physical ailments, but also the consideration of cultural, environmental and

relational factors, is becoming increasingly evident. This paradigm shift requires the collaboration of numerous organisations, going beyond traditional healthcare structures to include sectors such as culture and the arts, which act as true “agents of health”.

A key aspect of this transformation is accessibility. The principles enshrined in the United Nations Convention on the Rights of Persons with Disabilities (Law No. 18 of 3 March 2009), which protect the right of access to culture, have been fully implemented in Italy by the Ministry of Cultural Heritage and Activities and Tourism (MiBACT) through specific regulations and guidelines. These legislative instruments promote a multidimensional vision of accessibility, ensuring that the cultural experience is usable by all, regardless of physical or cognitive barriers.

In recent years, this commitment has translated into a series of innovative and inclusive projects throughout the country. Exemplary is the introduction of routes in Italian Sign Language (LIS) at the Galleria Borghese and the H.C. Andersen Museum in Rome, as well as the adoption of accessible itineraries in the Paestum Archaeological Park, through guided tours in LIS, tactile and olfactory routes, and at the “Omero” State Tactile Museum in Ancona. The latter, in particular, offers tactile tours for visually impaired persons, enabling them to physically explore the exhibited works through a sensorial approach. In fact, the State Tactile Museum “Omero”, as previously mentioned, is an inclusive and accessible space where art can be explored through touch, making it an international benchmark in aesthetic education for blind and visually impaired people. This museum not only responds to a need for social justice, but also opens up new international perspectives on the topic of multisensory enjoyment of art.

The permanent exhibition includes around 200 works, including faithful copies of famous masterpieces of classical art, made of plaster and resin. Works such as the Discobolus, Nike of Samothrace, Poseidon and Venus de Milo dialogue with architectural models such as the scale model of the Parthenon. The collection continues with Roman art, represented by the Capitoline She-wolf and imperial portraits, accompanied by volumetric models and architectural sections of the Pantheon. The tour then moves through the Middle Ages, with examples of Romanesque and Gothic art, to the Renaissance, where the model of St. Peter's Basilica and Michelangelo's famous sculptures, including the Pietà of St. Peter and Rondanini, the Tondo Pitti and Taddei, Moses and David, stand out, as well as original sculptures by contemporary Italian and international artists.

A Museum, therefore, totally accessible, with tactile routes, descriptions in Braille and large characters, and mobile platforms to facilitate exploration by the visually impaired, with areas reserved for educational workshops, accessible to schools of all levels, families, adults and anyone who wants to have a unique educational experience; a permanent laboratory for the appreciation and enjoyment of art that promotes, moreover, tactile exhibitions of national and international importance, as well as thematic reviews.

It is evident that in a constantly evolving technological context, there is a growing demand for devices combining the use of touch and hearing to improve the perception and understanding of cultural heritage by blind people. These tools allow a more complete and autonomous fruition, which is essential when dealing with works of art or large or high-value objects, such as church façades or paintings, which cannot be touched directly (D'Agnano et al., 2015).

Also noteworthy is the project “Il Tulipano Art - Un tuffo nel blu” (“The Tulipano Art - A dive into the blue”) carried out at the National Archaeological Museum of Paestum, an innovative museum inclusion initiative, conceived by the social cooperative “Il Tulipano” with co-financing from the Campania Region, whose main objective is to make museum routes accessible to people with autism spectrum disorders and cognitive disabilities.

As part of the initiative, a dedicated app and digital agenda were developed to support the autonomous use of the museum by these visitors, guaranteeing an engaging and customised experience. A platform for remote visits was also created, enabling the museum to keep its offer active even during the lockdown, facilitating access for schools and families through interactive and stimulating itineraries. The special feature of the project lies in its inclusiveness: the ‘autism friendly’ approach adopted by the museum creates a welcoming environment that values the involvement of everyone, especially people with cognitive difficulties, offering an opportunity for socialisation and learning.

An important aspect of the project is the specific training of museum staff, aimed at creating a scientifically validated reception model to monitor and assess the well-being and degree of participation of persons with autism, guaranteeing an active and inclusive interaction between visitors, their families, schools and qualified staff. A true best practice, therefore, destined to transform museums into places of encounter and dialogue between different communities in the area, promoting accessibility and the right to culture for all

All these experiences and research underline the importance of considering art not only as an educational tool, but also as a means to promote wellbeing and social inclusion, making culture accessible and beneficial to all, regardless of physical or cognitive conditions. The museum is configured as a multidimensional environment, and especially as an educational environment, where the exhibits are only the visible surface of a vast store of meanings, symbols and suggestions. The latter, often concealed or not immediately obvious, contain an intangible heritage of history, culture and identity, waiting to be revealed. The most noble and relevant function of a museum lies precisely in its ability to bring out the deep soul of the works, breaking down the barriers of time and space, and connecting the visitor to the complex web of meanings that each piece carries.

Traditionally, this task of cultural “mediation” has been entrusted to writing - such as captions or catalogues - and guided tours, valuable tools but which, by their very nature, pose limits in terms of accessibility and dissemination of knowledge. The transmission of knowledge remains circumscribed, and sometimes fragmented, preventing a truly global understanding of works and their context. In the face of these limitations, contemporary technologies offer new possibilities. Hypermedia, interactivity and digital connectivity are, in fact, extraordinary tools that greatly expand the potential of museums (Finestrone et al., 2024).

Through the use of these tools, immersive and engaging experiences can be created that not only enhance the quality of access to content, but also amplify its scope and depth. Digital technologies make it possible to enrich the museum experience by integrating images, videos, sounds and interactive texts that allow for a dynamic exploration of the works and their cultural and historical context. Moreover, they foster a collective sharing of knowledge, creating a kind of knowledge network that transcends the physical boundaries of the museum itself. In this way, the museum becomes a place not only of conservation, but of cultural interconnection, where knowledge is continuously enriched and reinterpreted thanks to the active participation of the public.

In short, technological evolution is transforming the museum into a true interactive cultural hub, where the visitor is no longer a mere spectator, but a leading actor in a process of discovery and continuous learning, made possible by an increasingly accessible and sharable network of meanings; a learning process in which knowledge takes on a new guise capable of enabling everyone to develop those skills needed in everyday life.

6. Conclusions

A review of the literature clearly shows how museums can play a significant role in educational inclusion, offering learning experiences that not only stimulate curiosity and critical thinking, but also lend themselves particularly well to the informal education of people with Special Educational Needs. The museum environment, with its visual, tactile and interactive resources, proves particularly suitable for fostering learning through direct and multisensory experiences.

Digital technologies, such as educational apps, interactive guides and augmented reality devices, have been identified as particularly effective tools for improving the accessibility of museum content and adapting it to the specific needs of children with Special Educational Needs. The integration of these technologies in the museum educational pathway represents an important resource to favour the personalisation of the learning experience and the active participation of students.

Museums, therefore, have the potential to become true laboratories of educational inclusion, offering innovative and tailor-made learning experiences for children with special educational

needs. However, existing literature also points to the need to develop more structured and shared protocols that enable museums to work in synergy with schools and educational institutions, promoting greater coherence between formal and informal education.

In the future, it will be crucial to conduct more in-depth empirical studies that can test the effectiveness of different museum teaching practices in concrete contexts and collect longitudinal data on the impact of museum experiences on the development of transversal and cognitive skills in children with Special Educational Needs.

In fact, we have seen how museum education represents a valuable resource for the education and training of all students, with particular attention to children with Special Educational Needs. Museums, with their interactive and multisensory approach, offer a unique learning environment, where knowledge acquisition is intertwined with direct experience and sensory stimulation. This type of learning, based on concrete and engaging experiences, is particularly effective in fostering the development of transversal competences and skills essential for everyday life, such as critical thinking, problem solving and social integration.

In this context, museum education is not limited to the simple transmission of information, but takes the form of a true educational pathway that stimulates personal and collective growth. This is particularly relevant in the formation of political awareness, especially with regard to the understanding of the European Union and its dynamics. As custodians of cultural, artistic and historical heritage, museums have a responsibility to facilitate the understanding of common European roots and current political and social challenges. Through thematic exhibitions and well-structured educational paths, visitors, especially young people, can be accompanied in a learning process that helps them to become more aware, informed and participative citizens. This educational process, integrated into the museum's cultural mission, contributes to strengthening the sense of European belonging and identity, while enhancing cultural diversity.

However, to make museum education truly effective, it is necessary to rethink its role and recognise it as a central element not only in internal museum cultural policies, but also in broader educational and social policies. Museums must be seen as places of lifelong learning, inclusive spaces where every individual, regardless of his or her abilities or difficulties, can access quality education. This implies a redefinition of museum education strategies, making them more flexible and able to meet the needs of an increasingly diverse public.

For inclusive museum education to reach its full potential, it is also essential to promote synergy between heterogeneous professional figures, such as educators, museologists and technologists. Such multidisciplinary collaboration is crucial for the design and implementation of innovative and personalised learning experiences that enhance diversity and promote the inclusion of all visitors. Investing in the continuous training of museum staff is, in this context, a crucial element in ensuring the adequacy of skills required to accommodate and support the diverse needs of users.

Indeed, the integration of digital technologies and training in their use in this context offers new and exciting opportunities to make museum education more accessible and personalised (Di Paolo, 2023). The use of digital tools, such as interactive applications, augmented reality and online educational platforms, allows museum content to be adapted to the learning styles of each individual student, ensuring that everyone, including those with BES, can actively participate in the educational process. These technologies not only overcome physical and cognitive barriers, but also make learning more stimulating and engaging, creating a bridge between the traditional museum experience and the digital world.

Investing in museum didactics and educational technologies is therefore essential to create inclusive, innovative learning environments capable of responding to the needs of an ever-changing society. A commitment in this direction contributes not only to improving the educational offer for students with BES, but also to fostering a culture of inclusion and active participation, indispensable elements for the formation of the citizens of the future. Only through an education that focuses on diversity and accessibility can we hope to build a more equitable and aware society.

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· Section 2 ·
Teaching innovations, Communicating Science and emerging technologies in Education

Exploring retrieval augmented generation to build a secure and effective teaching assistant in learning environments

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Abstract

In the realm of digital learning, the integration of Language Model-based approaches (LLM) and Retrieval Augmented Generation (RAG) presents a promising avenue for developing intelligent teaching assistants. This research endeavors to experimentally explore the construction of a teaching assistant leveraging these technologies. The primary focus lies in identifying the optimal architecture and technologies to create an efficient and secure teaching assistant framework trusted by the teachers and the students. The challenges addressed in this study encompass the conversion from learning material to LLM-understandable information, effective information retrieval and correctness of answers, control over unauthorized information, operational costs, and integrations with Learning Management Systems (LMS). The experiment also addresses the problem of misuse of generative technologies inside learning environments, which often leads to the ban of these technologies, by developing a tool in collaboration with teachers and under their control, which aims to be the bridge between educational institutions and generative AI. Future developments may include special attention towards balancing the assistant's specialization in a particular subject against its broader access to related course materials and employing dialogue analysis techniques to gauge student comprehension levels and dynamically adapt information presentation. This adaptive approach holds promise for personalized learning experiences, enhancing student engagement, and improving overall educational outcomes. Through this research, we aim to contribute to the advancement of intelligent teaching assistants, fostering secure, cost-effective, and engaging educational experiences for learners worldwide.

Keywords: LLM, RAG, Generative AI, Digital Assistant, Conversational Interaction.

1. Introduction

The integration of Large Language Models (LLMs) and Retrieval-Augmented Generation (RAG) technique has recently opened new possibilities in digital learning (Lewis et al., 2020; Fan et al., 2024). Among these is the development of intelligent teaching assistants capable of providing accurate and context-aware responses to student queries (Liu et al., 2024). These tools have the potential to transform learning environments by enhancing student engagement, alleviating the workload on educators, and improving educational outcomes. However, the application of LLMs in educational contexts is fraught with challenges. Issues such as factual inaccuracies, hallucinations, lack of explainability, and uncontrolled responses raise significant concerns about their practical utility, particularly in high-stakes classroom environments (Hu et al., 2024; Li et al., 2023; Dakshit, 2024). This tension between the benefits of generative AI tools and the necessary control and trust required by educators necessitates careful consideration.

This research aims to experimentally explore the development of a teaching assistant that leverages LLM and RAG technologies. Our focus is on designing a system that adheres to pedagogical guidelines, allows teachers control over responses, and delivers accurate, relevant answers derived from course materials. We outline a three-phase plan: the 'Student' phase, focusing on creating a foundational system capable of retrieving and responding to questions based solely on appropriate learning materials; the 'Collaborator' phase, which will enhance teacher input and control; and the 'Assistant' phase, where the system will evolve into a comprehensive learning companion for students. This paper details our approach in the 'Student'

phase, exploring the feasibility of building a RAG-based system to assist students in a university-level machine learning course. Specifically, this paper covers the first complete iteration, including the steps taken to preprocess and structure learning materials, and set up the RAG architecture, concluding with professors testing and feedback, and the population of a question-answer (QA) dataset. The goal of this phase is to establish a robust baseline for future refinements and broader testing with students.

2. Material and Methods

2.1 Participants

In this initial phase of the research, two professors served as the primary evaluators of the intelligent teaching assistant. The first professor, an experienced machine learning instructor and author of the course manual used as the assistant's knowledge base, was actively involved throughout the project. This professor provided ongoing feedback on the assistant's ability to answer both exam-level and more challenging questions from the machine learning course manual. The second professor, an expert in artificial intelligence, contributed by testing the assistant with AI-related questions. Their combined expertise made them ideal for assessing the system's accuracy, pedagogical relevance, and explainability in answering open-ended exam-style questions.

2.2 Research Method

This study employed a *baseline-first*, *iterative exploratory method* aimed at testing the performance of a Retrieval-Augmented Generation (RAG) model, with the goal of setting a performance baseline. This baseline serves as a reference for subsequent iterations focused on parameter tuning, model selection, and architecture design. By establishing a robust initial framework, we can systematically assess the system's effectiveness in retrieving relevant sections of the provided course materials and generating accurate responses based on them. The methodology parallels typical machine learning development processes, where the quality of input data and iterative refinement are key factors in success. For the initial iteration, we concentrated on preprocessing the course materials and designing a simple RAG architecture. The baseline setup enables controlled experimentation, allowing us to identify the impact of individual components (e.g., chunk size, top-K retrieval) on the system's overall performance.

Model Selection

In the model selection process, we prioritized state-of-the-art models, to eliminate any limitations related to model capacity, ensuring that performance could be primarily attributed to architectural and parameter choices. The assistant was designed to support a machine learning course, and leveraging advanced embedding and language models helped ensure that the system could accurately interpret complex queries, retrieve relevant information, and generate precise responses.

By using top-performing models, we aimed to focus the initial iteration on establishing a reliable performance baseline, allowing future iterations to experiment with smaller or more efficient models while maintaining a clear point of comparison.

Architecture Design

For the initial iteration, we employed a straightforward, *naïve Retrieval-Augmented Generation* (RAG) architecture (Figure 1) (Gao et al., 2023). This approach emphasizes simplicity and allows us to evaluate the system's capabilities without the added complexity of advanced retrieval mechanisms. The architecture consists of two key components: a retriever that selects relevant text chunks from the course materials and a generator that formulates responses based on the retrieved content.

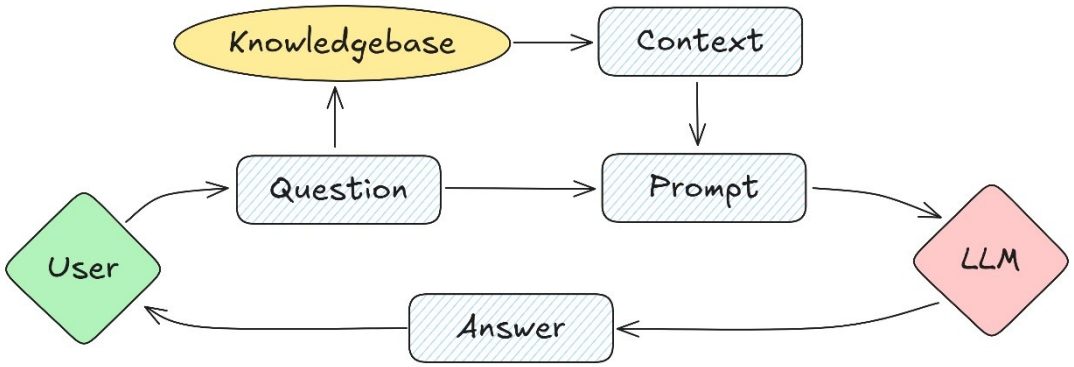


Figure 1 - Naïve RAG architecture overview.

The decision to start with a basic architecture provides a controlled environment to study the performance of core components such as retrieval quality, response coherence, and relevance to the provided materials. More complex architectures, which may introduce trade-offs between computational efficiency and precision, can be explored in later stages once the foundational performance metrics are established. By beginning with a simple architecture, we were able to minimize variables and focus on the primary factors influencing system performance.

Parameter Tuning

Given the naïve architecture, the *chunk size* and *top-K retrieval* were crucial to ensure efficient retrieval and generation. Based on our experience with RAG systems, we selected a maximum chunk size of approximately 2,000 characters, ensuring semantic coherence within the retrieved text. The topK retrieval was set at 8, which provides enough context to answer complex queries while minimizing irrelevant information retrieval.

These values were determined through iterative testing and manual validation to ensure they aligned with the assistant's goal of generating comprehensive, contextually accurate responses without exceeding the model's context window.

Dataset Population and Evaluation

A key aspect of this research was the population of a question-answer (QA) dataset that could serve as the foundation for future automated evaluations (Yu et al., 2024). Two alternative approaches were considered during the design of this evaluation process:

1. *Synthetic Dataset Generation*: in this method, large language models would generate questions and answers automatically, which would then need to be validated by educators. While useful for bootstrapping, synthetic datasets often lack the pedagogical nuance required in real educational settings, particularly when applied to high-stakes environments like exam preparation.
2. *Manual Dataset Construction*: this approach would involve professors manually constructing a full set of QA pairs. While it ensures high quality and pedagogical relevance, it is labor-intensive and may not cover the full diversity of potential student queries.

Ultimately, we adopted a dynamic approach that balances the strengths of both methods. Rather than building a static QA dataset in advance, we allowed professors to interact directly with the system during the testing phase. This interaction not only provided real-world feedback on the system's performance but also generated the QA dataset organically as professors asked typical course-related questions. The responses were stored, along with their correctness labels and any feedback from the professors. This process allowed us to compile a dataset that closely reflects the kinds of questions students are likely to ask, making it more relevant for future evaluations.

2.3 Research Process

Source Material Preparation

The study's primary material was a machine learning course manual, provided by the lead professor in both raw LaTeX and PDF formats. Given that the LLMs process sequences of tokens, implicit visual information in documents, such as headers, formulas, and tables, must be made explicit. To achieve this, the manual was converted to Markdown, which was chosen for its simplicity, support for embedded LaTeX formulas, and compatibility with chatbot interfaces. The conversion process from LaTeX to Markdown involved critical challenges:

1. LaTeX Labels: Many custom LaTeX labels used in the source material were not recognized by Markdown parsers. These caused parsing errors that disrupted the flow of the document.
2. Modular Structure: The manual was divided into multiple chapters as distinct files, with unnumbered formulas and figures. This modular format complicated the referencing system, as the numeric labels in the final PDF were not present in the LaTeX source.

To overcome these issues, we opted to use Mathpix OCR (https://mathpix.com/convert), a tool that accurately converts PDFs into Markdown with embedded LaTeX formulas. This solution eliminated the need for custom regex parsing or manual mapping of LaTeX labels, although some manual refinement was required to correct errors in the OCR output, ensuring that the text was properly formatted for seamless rendering in chat interfaces and suitable for LLM processing.

Data Chunking and Metadata Assignment

The manual, converted into Markdown, was split into text chunks, which is crucial for enabling information retrieval in a RAG-based system. Two key approaches were used for chunking (Figure 2):

1. *Header-Level Chunking*: the document was first split at the header level using a custom version of LangChain's Markdown Header Text Splitter (https://www.langchain.com/langchain). The hierarchy of headers (e.g., chapter, section, subsection) was preserved as metadata for each chunk, enabling the system to understand and provide context about the source of the information.
2. *Recursive Character-Based Chunking*: the resulting chunks were long up to 10000 characters, making them too large for accurate embedding. We implemented a custom dynamic recursive character splitter, built on top of LangChain's RecusiveCharacterTextSplitter that ensured chunks stayed below 2000 characters, preventing the loss of semantic meaning during the embedding process. This dynamic approach adjusted the chunk size depending on the original length of the text, with an overlap of 1/5 to maintain coherence across split chunks.

Embedding and Vector Storage

The chunks were then embedded into vector representations using OpenAI text-embedding-3-large model (https://openai.com/index/new-embedding-models-and-api-updates/). Embeddings act as an index for the chunks, making it possible to retrieve the most relevant information to the user's query during inference (Figure 3).

The embedding vectors, along with the chunks and its metadata, were stored in Chroma (https://www.trychroma.com/), an opensource vector database chosen for its integration with LangChain and in-memory capabilities, which were sufficient given the relatively small size of the knowledge base.

Retrieval-Augmented Generation Pipeline

The core of the system is a naïve RAG pipeline (Figure 4), built using LangChain as the orchestrating framework. The RAG system forms the backbone of the assistant's functionality,

combining information retrieval with natural language generation. This pipeline consists of the following steps:

1. *Retrieval*: the user submits a question, which is embedded into a vector using the same textembedding model that was applied to the document chunks. The vectorized query is matched against the stored chunk embeddings in the vector database. The system retrieves the top-K most relevant chunks using L2 Euclidean distance as the similarity metric.
2. *Augmentation*: the retrieved chunks are combined into a "context" section, limited to 5,000 tokens using the OpenAI tokenizer o200k_base, which is passed into the prompt template for the LLM. The context section and the original user query complete the prompt.
3. *Generation*: the complete prompt is passed to the gpt-4o-2024-05-13 model (https://openai.com/index/hello-gpt-4o/) with a temperature setting of 0 for deterministic responses. The LLM generates a response based on the context and the user input. It concludes by referencing the metadata of the chunks used in its answer, as sources.

Evaluation and Feedback Collection

The teaching assistant was evaluated in a question-answering (QA) setting, with no memory or longterm context retention. The QA pairs generated by the assistant were stored and analyzed using LangSmith (https://www.langchain.com/langsmith), which provides observability and facilitates tracking the accuracy of the assistant's responses.

To test the system, both professors asked a series of questions related to the machine learning theory. The first professor tested the assistant with 20 questions, including both frequently asked exam questions and more challenging ones. The second professor asked four questions, one of which was outside the course scope, testing the assistant's ability to decline answering when relevant material was absent.

The professors were able to label the answers as positive (correct) or negative (incorrect) and provide comments. Examples of the QA pairs can be found in section Appendix.

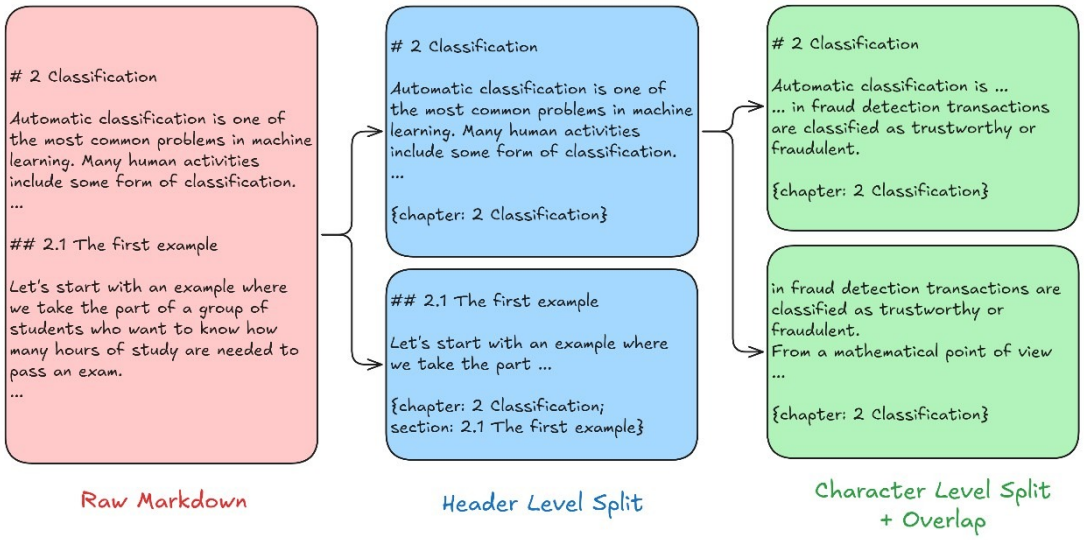


Figure 2 - The two stages of chunking.

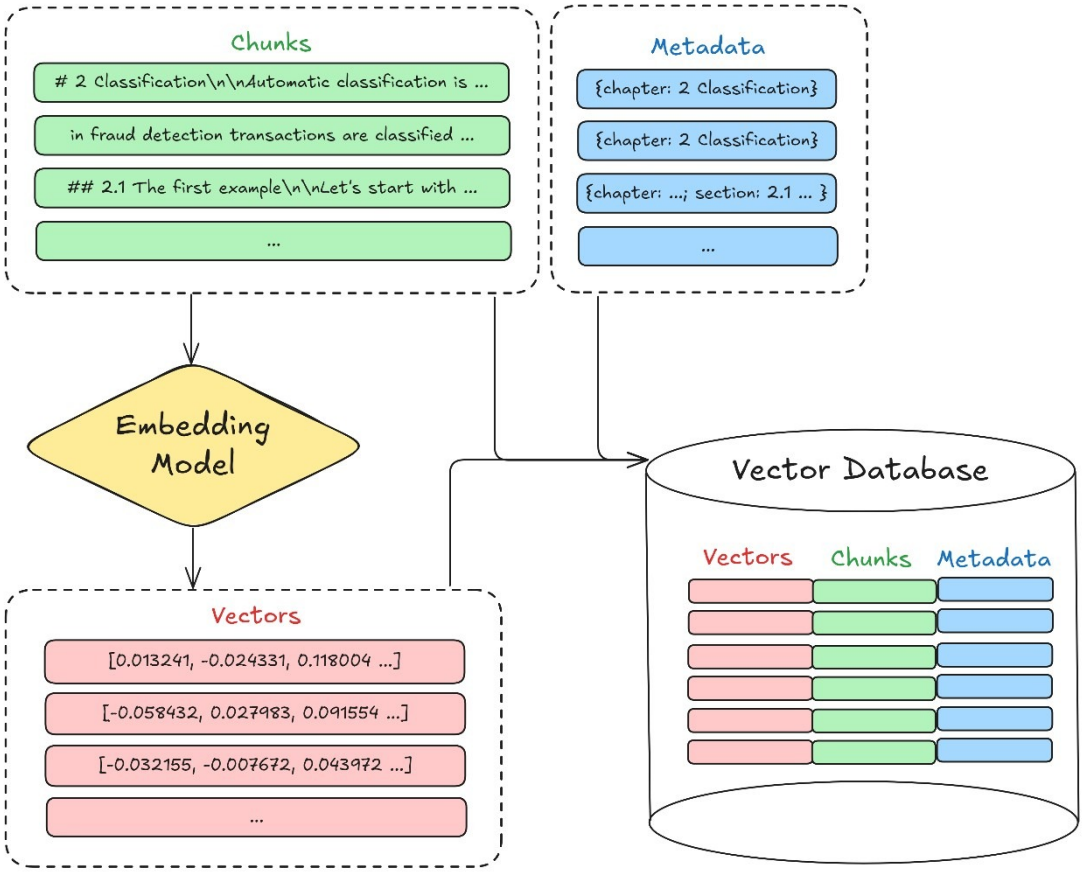


Figure 3 - Embedding and Vector Storage.

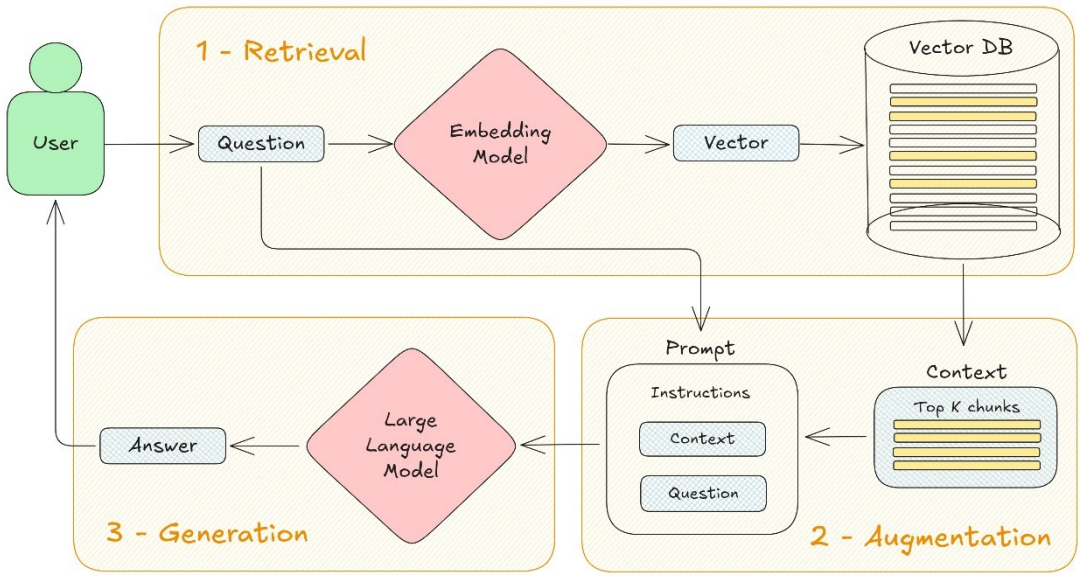


Figure 4 - Retrieval-Augmented Generation Pipeline in Details.

3. Results

3.1 Preprocessing and Data Preparation

The conversion of the course manual from PDF to Markdown was a crucial step, as PDFs are not directly interpretable by language models, which require textual input. Since LLMs process sequences of text rather than visual information, the content of the manual needed to be

transformed into a raw text format that made implicit structural elements – such as headers, formulas, and tables – explicit. This conversion allowed the LLM to accurately interpret these components as distinct entities, ensuring that headers were recognized as hierarchical markers and mathematical formulas were understood as specialized symbols, rather than treating the document as a continuous block of text.

Mathpix OCR was employed to convert the PDF to Markdown, preserving the essential elements of the manual, including its mathematical notations and overall structure. Markdown was chosen for its compatibility with both embedded LaTeX formulas and the RAG pipeline, making it suitable for further tokenization and processing by the LLM.

The manual was then segmented into over 300 distinct chunks, each linked to metadata that captured the hierarchical organization of the source material (e.g., chapter, section, subsection). The recursive chunking method was applied to maintain semantic coherence while keeping the chunks under a 2,000character limit. This method also incorporated a 1/5 overlap between sections to ensure continuity across related content, allowing the system to retrieve contextually relevant information without losing the flow of the material. This approach ensured that the system could provide comprehensive and contextually accurate responses to user queries.

3.2 Performance of the RAG System

The first iteration of the RAG system demonstrated strong performance during testing by the professor (Figure 5). In the initial evaluation, the assistant was tasked with answering 10 frequently asked exam questions from the machine learning course. The assistant provided correct responses to 9 questions, achieving a 90% success rate (see Section 1 in the Appendix, Exam-level questions). The one incorrect response occurred on a complex question typically reserved for honors-level grades. In a second round of more challenging questions, the system answered 8 out of 10 correctly, achieving an 80% accuracy rate (see Section 2 in the Appendix, More challenging questions).

One of the most notable aspects of the assistant's performance was its ability to ground its responses in the course material, consistently using the same mathematical notations and terminologies as presented in the manual. This ensured that students would encounter consistent language and format across their studies. The assistant correctly referenced formulas, figures, and tables by their numeric labels, allowing direct, unambiguous reference to these elements in the manual. Additionally, each retrieved chunk was accompanied by metadata that provided clear contextualization, such as the section or chapter from which the information originated.

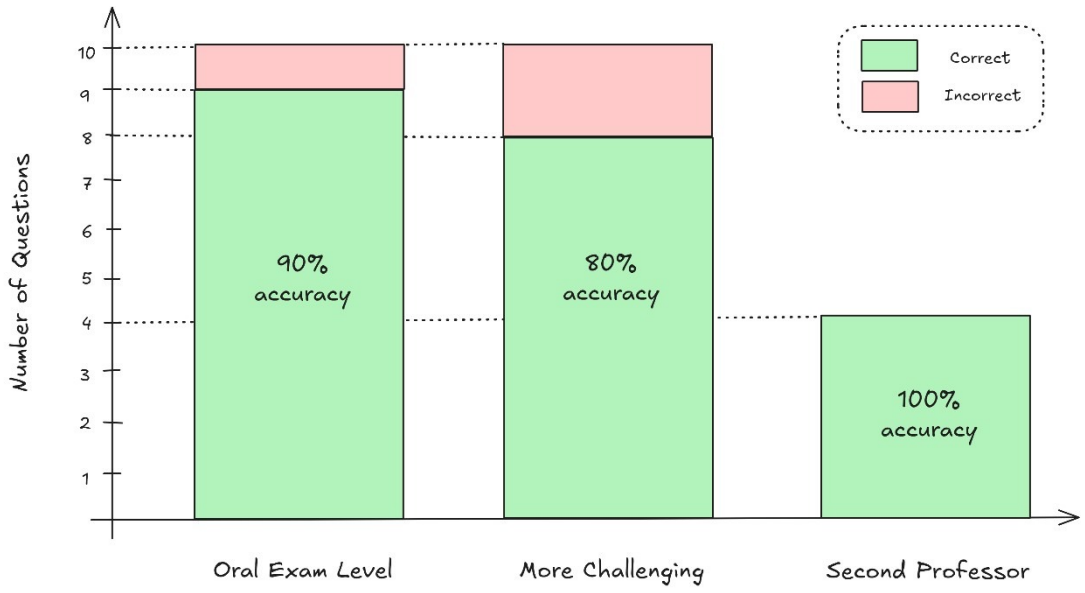


Figure 5 - The three testing rounds.

The second professor tested the system with four machine learning-related questions, including one outside the course material. The assistant correctly answered all in-scope questions and appropriately handled the out-of-scope query by stating that the relevant material was not available in the course content. This accurate recognition of scope boundaries reinforces the system's reliability, as it avoids hallucinating answers when lacking the necessary information (see Section 3 in the Appendix, Second professor's questions).

The professors' feedback was overwhelmingly positive, with the author of the manual endorsing the system for further testing with students. The absence of hallucinations or significant factual inaccuracies during this testing phase, combined with the assistant's accurate handling of references and grounded responses, highlights its readiness for real-world academic use. Future iterations will focus on enhancing usability for students while maintaining the high academic standards established through professor testing.

4. Conclusions

This research highlights the promising potential of integrating large language models (LLMs) and retrieval-augmented generation (RAG) systems into educational environments, specifically in the context of intelligent teaching assistants. Through a carefully designed process involving data preprocessing, chunking, embedding, and retrieval, we developed an assistant capable of answering open-ended questions with high accuracy, grounded in specific course material. The success of this first iteration, named 'Student', establishes a solid foundation for expanding and refining the assistant's capabilities in future phases.

We recognize that professor validation is only one step in the system's lifecycle. While their approval is necessary to ensure academic rigor, the real-world utility of the assistant will ultimately depend on its adoption by students. The way students interact with the system during their academic year will likely differ from how professors tested it. Students are more likely to use the assistant for day-to-day learning and clarification, which will require further tuning to meet their specific needs. This shift from professor validation to student engagement highlights the dynamic nature of the assistant's role in education.

One of the key reflections from the lead professor, who authored the course, was that the assistant's feedback mechanism, when placed in the hands of students, offers an additional layer of value beyond simple question-answering. As students interact with the assistant, they naturally provide feedback on the course material itself. The professor noted that he has already received feedback from students identifying areas in the material that may require clarification or improvement. This implicit function of the assistant – serving as a tool not only for student learning but also for continuous refinement of course materials – could prove highly beneficial. Furthermore, the assistant's ability to collect and analyze student queries could provide valuable insights into both the quality of the material and the overall understanding of the class, highlighting potential areas where students struggle or where the material might need revision.

An intriguing question raised by the professor was whether the assistant's strong performance stemmed solely from the provided course material or if the underlying LLM's pre-existing knowledge of machine learning theory contributed significantly to its accuracy. This inquiry raises broader questions regarding the system's performance in domains less familiar to the LLM. This suggests avenues for future research, where the assistant could be tested on less common or emerging subjects to evaluate its flexibility and reliance on external knowledge sources.

Finally, the rise of AI-driven educational tools, like this teaching assistant, has prompted broader reflections on the future of academia. The professor speculated on how the role of educators and the structure of academic learning might evolve in response to these technologies. As AI systems become more integrated into the educational process, they may shift the focus of teaching from content delivery to mentorship, critical thinking, and guiding students through more personalized learning journeys. This raises important questions about the future direction of educational practices and the ways in which technology can enhance, rather than replace, the human elements of teaching.

The next phases of this research will focus on refining the system's adaptability to individual educator preferences and curricular goals. By allowing teachers to have greater control over the assistant's output and aligning it with specific teaching objectives, the system can evolve into a more interactive and collaborative tool for both students and educators. Additionally, there is potential for incorporating more advanced features, such as dynamic course updates based on real-time student feedback and enhanced analytical tools to monitor classroom understanding.

In conclusion, this first phase of developing an intelligent teaching assistant demonstrates that integrating LLM and RAG technologies into educational environments can support student learning while offering valuable insights for educators. The potential for these systems to evolve, providing deeper collaboration between students, educators, and AI, opens exciting new possibilities for the future of education.

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Lastly, we would like to thank Professor Luca Cavone for providing us with the materials from his course.

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Appendix

This appendix provides a sample of question-answer pairs from the testing round conducted by both professors.

1. Exam-level questions

Q1: How can we justify the use of cross-entropy as a loss function for logistic regression?

A1: The use of cross-entropy as a loss function for logistic regression can be justified through the maximum likelihood estimation (MLE) framework. Here's a step-by-step explanation:

1. Model Definition: Logistic regression is designed for binary classification problems. It combines a linear function with the sigmoid function to produce a probability estimate p" in the range (0,1):

$$z = w\,x + b$$

$$\hat{p} = \sigma(z) = \frac{1}{1+e^{-z}}$$

The logistic regression model assumes that $\hat{p}$ is an estimate of the conditional probability that the correct class is 1:

$$\hat{p} \approx P(y = 1 \vee x)$$

2. Likelihood Function: Given a training set $\{(x_0, y_0) \ldots, (x_{m-1}, y_{m-1})\}$, the likelihood $\mathcal{L}$ represents how likely it is to observe the training set given a particular choice of the parameters:

$$\mathcal{L} = \prod_{i=0}^{m-1} p(x_i\, y_i)$$

Using the definition of conditional probability, this can be expressed as:

$$\mathcal{L} = \prod_{i=0}^{m-1} P(y_i \vee x_i)\, p(x_i)$$

3. Log-Likelihood: In practice, it is more convenient to work with the log-likelihood because it transforms the product into a sum, which is easier to handle mathematically:

$$\log(\mathcal{L}) = \sum_{i=0}^{m-1} \log P(y_i \vee x_1) + \sum_{i=0}^{m-1} \log p(x_i)$$

Since the second term does not depend on the model parameters, it can be ignored for optimization purposes:

$$\log(\mathcal{L}) = \sum_{i=0}^{m-1} \log P(y_i \vee x_1)$$

4. Conditional Probability: For logistic regression, the conditional probabilities can be expressed as:

$$P(y_i \vee x_i) = \begin{matrix} \widehat{p}_1 if\ y_i = 1 \\ 1 - \widehat{p}_1 if\ y_i = 0 \end{matrix}$$

Taking the negative log-likelihood, we get:

$$-\log \mathcal{L} = -\sum_{i=0}^{m-1} \log P(y_i \vee x_i)$$

Substituting the conditional probabilities, we obtain:

$$-\log P(y_i \vee x_i) = -y_i \log \widehat{p}_i - (1 - y_i) \log(1 - \widehat{p}_i)$$

This expression is known as the cross-entropy loss:

$$L_i = -y_i \log \widehat{p}_1 - (1 - y_i) \log(1 - \widehat{p}_1)$$

5. Optimization Problem: The goal is to minimize the average cross-entropy over all training samples:

$$\min_{w,b} \frac{1}{m} \sum_{i=0}^{m-1} L_i = \min_{w,b} \frac{1}{m} \sum_{i=0}^{m-1} \left(-y_i \log \widehat{p}_1 - (1 - y_i) \log(1 - \widehat{p}_1) \right)$$

By minimizing the cross-entropy loss, we are effectively maximizing the likelihood of the observed data under the logistic regression model. This provides a probabilistic justification for using cross-entropy as the loss function in logistic regression.

Sources:

- 'chapter': '2 Classification', 'section': '2.2 Logistic regression'
- 'chapter': '2 Classification', 'section': '2.5 Optimization'
- 'chapter': '2 Classification', 'section': '2.6 Multinomial logistic regression', 'subsection': 'Training procedure'

Evaluation: Correct

Q2: Which is more likely to overfit, the nearest neighbor, or the minimum distance classifier?

A2: The nearest neighbor (NN) classifier is more likely to overfit compared to the minimum distance classifier.

The nearest neighbor classifier has infinite capacity because it memorizes all training pairs and makes no training errors (unless there are identical samples with different class labels). This high capacity allows it to adapt perfectly to the training set, which often leads to overfitting. Overfitting occurs when a model performs exceptionally well on the training data but fails to generalize to new, unseen data. The decision boundary of the nearest neighbor classifier can be very complex and sensitive to the specific training samples, as shown in Figure 3.2.

On the other hand, the minimum distance classifier is much simpler. It assigns a new sample to the class with the closest mean vector, which results in a linear decision boundary. This simplicity generally leads to underfitting rather than overfitting, as it may not capture the complexity of the data well enough. The minimum distance classifier is less flexible and has fewer parameters, making it less prone to overfitting.

In summary, the nearest neighbor classifier is more likely to overfit due to its high capacity and complexity, while the minimum distance classifier is more likely to underfit due to its simplicity.

Sources:

- 'chapter': '3 Generalization and regularization', 'section': '3.2 Empirical risk minimization', 'subsection': 'Nearest neighbor'
- 'chapter': '7 Generative methods', 'section': '7.1 Gaussian discriminant analysis', 'subsection': 'Minimum distance classifier'

Evaluation: Correct

Comment: This was more difficult than most of the others, the answer is 100% correct.

2. More challenging questions

Q1: Compare L1 and L2 regularized logistic regression. How can you improve sparsity in a linear SVM?

A1: Comparison of $L_{\%}$ and $L_{,}$ Regularized Logistic Regression:

L_2 Regularization:

- Definition: L_2 regularization, also known as weight decay, involves adding a penalty equal to the sum of the squared values of the weights to the loss function. The regularization term is given by:

$$R(w)=\sum_{k=0}^{n-1} w_k^2=|w|^2$$

- Effect: This regularization technique tends to distribute the weights more evenly across all features, leading to smaller individual weights. It helps in preventing overfitting by penalizing large weights.

- Implementation: The objective function for $L_{,}$regularized logistic regression is:

$$\min_{w,b} J_\lambda(w,b)=\frac{1}{m}\sum_{i=0}^{m-1}\left(-y_i\log\left(\widehat{p}_1\right)-\left(1-y_i\right)\log\left(1-\widehat{p}_i\right)\right)+\lambda|w|^2$$

- Probabilistic Interpretation: L_2 regularization corresponds to the application of the maximum a posteriori criterion with a Gaussian prior, assuming that "small" parameters are more likely than "large" parameters.

L_1 Regularization:

- Definition: L_1 regularization involves adding a penalty equal to the sum of the absolute values of the weights to the loss function. The regularization term is given by:

$$R(\theta)=\sum_{k=0}^{d-1}|\theta_k|=|\theta|_1$$

- Effect: This regularization technique tends to produce sparse solutions, meaning that many of the weights are driven to zero. This can simplify the model and make it more interpretable.
- Implementation: The gradient of the L_1 regularization term is given by:

$$\frac{\partial}{\partial\theta_i}|\theta|_1=\begin{matrix}+1\,if\,\theta_1>0\\0\,if\,\theta_i=0\\-1\,if\,\theta_i<0\end{matrix}$$

This can be implemented using the `np.sign` function in gradient descent.

Improving Sparsity in a Linear SVM:

To improve sparsity in a linear SVM, you can incorporate L_1 regularization instead of the traditional L_2 regularization. This approach will encourage the model to set many of the weights to zero, leading to a sparse solution. The objective function for an L_1 regularized SVM can be formulated as:

$$\min_{w,b}\frac{1}{2}|w|^2+C\sum_{i=1}^{m}max\left(0.1-y_i\left(w^{Tx_i}+b\right)\right)+\lambda|w|_1$$

Here, C is the regularization parameter for the hinge loss, and λ is the regularization parameter for the L_1 term. The L_1 term will drive many of the weights to zero, thus improving sparsity.

Sources:

- {'chapter': '3 Generalization and regularization', 'section': '3.3 Regularization', 'subsection':
- 'Regularized logistic regression'}
- {'chapter': '3 Generalization and regularization', 'section': '3.6 $L_{\%}$ regularization'}
- {'chapter': '4 Linear classifiers and Support Vector Machines', 'section': '4.3 Support Vector Machines', 'subsection': 'Soft margin'}

Evaluation: Incorrect

Comment: Almost correct the L1 norm has been added correctly, but the L2 norm should have been also removed.

Q2: What is the VC dimension of a multi-layer perceptron?

A2: The VC dimension of a multi-layer perceptron (MLP) is not straightforward to determine as it depends on the architecture of the network, including the number of layers and the number of neurons in each layer. However, it is generally known that the VC dimension of a neural network is related to the number of parameters in the network.

For a feedforward neural network, the VC dimension can be roughly estimated to be proportional to the number of parameters in the network. This means that as the number of layers and the number of neurons in each layer increase, the VC dimension also increases, indicating a higher capacity to shatter more sets of samples.

In summary, while the exact VC dimension of a specific MLP can be complex to calculate, it is generally proportional to the number of parameters in the network.

Sources:

- Chapter 3, Section 3.8, Subsection "The VC dimension (optional)"
- Chapter 9, Section 9.1, Subsection "Multi-layer perceptrons"

Evaluation: Correct

3. Second professor's questions

Q1: Why in the stochastic gradient descent does the loss fuction oscillate?

A1: In Stochastic Gradient Descent (SGD), the loss function oscillates because each optimization step is computed using a single training sample randomly taken from the training set. This means that the gradient of the loss function is estimated based on just one sample, which can lead to updates in the parameters that are sometimes in the wrong direction. However, most of the time, the updates will be approximately in the right direction, and the cumulative effect of these updates will be a progressive improvement of the average loss function.

The randomness in the selection of training samples causes the loss function to oscillate up and down, making it harder to monitor and decide when to stop the algorithm. This behavior is in contrast to batch optimization, where the gradient is computed using the entire training set, leading to more stable and predictable updates.

To mitigate the oscillations, a common improvement is to reduce the learning rate as the algorithm progresses towards the solution. Additionally, using mini-batches instead of single samples can help dampen the oscillations by averaging the gradients over a small subset of the training set.

Sources:

- {'chapter': '10 Training neural networks', 'section': '10.3 Stochastic gradient descent'}

Evaluation: Correct

Q2: How does the random forest method works?

A2: I don't know.

Sources:

- None

Evaluation: Correct

Communicating Science: the impact of the social web on the interaction between science, communicators, and STEM teachers

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Abstract

This contribution examines the influence of social web dynamics on interactions between science communicators and STEM educators. It focuses on the dual role of mediators – viewed both as technological mediation systems and as social actors – in the exchange, creation, and dissemination of scientific knowledge and civic awareness. These mediation processes are framed within "digital plenitude", characterized by the layering of a complex, interconnected "media patchwork".

In the first phase, we present findings from a 2024 survey on science communication in Italy, involving a statistically representative sample of the population. The second phase implies the analysis of online profiles (individual and collective) that teachers follow to access scientific information and educational resources. Profiles were identified through a survey and examined for key attributes, including biography, educational background, conversational strategies, and communication styles.

From the survey, we identified ten notable profiles of science disseminators, on which we conducted a desk analysis to address the second research question: moving from who they are to how they communicate. This analysis employs a semio-pragmatic framework focusing on four dimensions: narrative, textual, communicative, and didactic.

Our findings raise critical questions about the potential for media education to support a pedagogically informed approach to science popularization.

Keywords: Popular Science, Educational Research, Science Dissemination, Social Web, STEM Teaching.

1. Education and science dissemination in the time of 'digital plenitude'

This contribution investigates the relationship between online science communicators and teachers related to STEM subjects, setting itself in two relevant debates and literature.

The first area refers to the social web both as an opportunity for teaching and as a new information ecosystem whose logic impacts teaching methods (Rivoltella, 2021) and, specifically, on dealing with scientific topics (Annacontini, 2023). On the one hand, technologies, and social environments facilitate professional communities of practice (Carenzio & Pasta, 2021) with a fluid membership (Brown & Duguid, 1991) that modifies the number of its members over time, creates fruitful communication with other communities of practice pursuing similar aims, and is continually renewed precisely because it´ generates knowledge. Conversely, the ease of access allowed by the social web guarantees the extension of a right, but at the same time provides for the responsibility required of anyone who takes the floor in the public space, with consequences that are not only individual (Rivoltella, 2020; Pasta, 2018). Today, the public sphere has radically changed: even in the reflection of the communication of science, the idea of the one-dimensional public sphere theorized by Habermas (2024) is no longer applicable, since the 'power' relationship between those who hold scientific knowledge and those who are to benefit from it has undergone a radical change, leading on the one hand to a greater democratization of science, and on the other hand to disorientation of citizens (Huber et al., 2019). The disintermediation and growth of horizontality of the social web (Pasta, 2022), together with the technological convenience of accessing information, have led to layering and a more complex and articulated 'media patchwork' (Raviolo & Pasta, 2023), in what Bolter calls 'digital plenitude'. This term refers to a

scenario in which media culture «encompasses a universe of forms - websites, video games, blogs, books, films, television and radio programs, magazines, and more - and a multitude of practices that include making, remixing, sharing, and critiquing. This multiplicity is so vast that it cannot be comprehended as a whole» (Bolter, 2019). Since the activities of 'prosumers' are characterized by the explosion of cultural products and practices, digital plenitude erases the boundaries between elite and mass culture, high and low culture, competent and non-competent subjects, and in some cases between the true and the verisimilar; any canon is removed and audiences organize themselves into 'cultural niches'. To some extent, this process can deviate and destabilize, even if some authors see in this sort of 'cultural anarchy' (Volterrani, 2021) the opportunity for each individual, alone and with others, to be a protagonist in the construction of the future. In any case, this scenario has profound implications for the transmission and transposition of knowledge: it is the passage that, in the school context, questions didactics and organized mediation systems, such as the school (Pasta, 2021a), and the students' information literacy approach (Ferrari & Pasta, 2023).

The second area of reference in this essay focuses on the relationship between the didactics of scientific disciplines and the popularisation of science, on which the historical perspective notes that «popularised publications are often more innovative than the didactic practices in use throughout time: already in the nineteenth century, the way of presenting science in informative volumes was more attractive, but no less accurate, than the scholastic one» (Grandi, 2022, p. 75). By 'popularisation of science' we intend one of the means that allows knowledge to transcend the limits of the restricted circle of the community of scientists (Govoni, 2018). As for the relationship with science didactics, popularisers' efforts have been directed towards teachers, attempting to sensitize their category towards new ways of communicating science (think of Lucio Lombardo Radice; cf. Grandi, 2023). Traditionally, the element that differentiates popularisation (with an informative and or entertainment and recreational purpose [in the 19th century, popularisation was referred to as 'delightful science']) from science education (with a formative purpose) is the extemporaneousness of the former for the programming of the latter: a popularisation product (a video, a text, a fact sheet) can be enjoyed casually, rhapsodically, intentionally, or in a mixture of these three options, without this representing a problem for the creator, nor for the user. On the contrary, didactic actions involve intentionality and planning for both the maker (the teachers) and the user (the pupils). This extemporaneous character of dissemination represents a point of interesting contact and contamination with the opportunities of the social web. The impact of the digital aspects on communication dynamics in terms of horizontality, sociality, authorship (Rivoltella & Ferrari, 2010), and on information processes in terms of disintermediation (Pasta, 2023) questions the process of science dissemination and requires media-educational skills (Pasta & Ferrari, 2020). Furthermore, it should be remembered that, in the time of the social web, Science Communication (SC) is characterized by strong proximity – at times a fusion – between popularisation and edutainment, for dissemination via social media and cross-platform interactions. This is an opportunity for content dissemination as it promotes communicative reinforcement and personal reflection on users and, through constructing cohesive communities, re-signifies the process within a socially meaningful framework (Silva et al., 2023). The proximity between popularisation and edutainment is often considered in producing educational tools on scientific topics, such as video games (Carenzio, Pasta & Ferrari, 2024).

2. Mediators of scientific information

The two areas of reflection recalled as a premise in §1 – the link between the new information ecosystem and education; the relationship between the teaching of scientific disciplines and popularisation in this scenario – are closely linked to trust in science and how it is acquired and communicated. The Covid-19 pandemic was a significant test case on this issue (The Lancet, 2020). Alongside the official transmission of scientific knowledge, precisely during that health crisis, the communicative dynamics recalled in §1 were partly related to the phenomenon defined by recent literature as 'science-related populism' (Mede & Schäfer, 2020), which emerged in the

forms of contestation of the official science called upon to direct and legitimize government action for managing the pandemic, eventually merging with organized hate groups (Pasta, 2021b).

As part of an ongoing multidisciplinary research project – the Catholic University project 'Communicating Science. Mediation and mediators of scientific knowledge in a complex society' - a survey was conducted concerning science and the dissemination of science on a statistically representative sample of the Italian population in June 2024 [the survey was carried out by the SWG multidisciplinary team with online CAWI (Computer Assisted Web Interviewing) methodology on a quota sampling plan according to official Istat distributions]. We will focus on the data from the questionnaire on other occasions, here we simply note that, among the mediators of science information, science teachers are in an intermediate position: to the question "From whom do you most often learn about scientific topics or scientific research", teachers are indicated in first, second, or third place, by 23.2% of Italians. Amongst the survey options, they are preceded by science popularizers (66.2%), scientists and doctors (46.9%), scientific research institutions (44.6%), science journalists (30.6%), they are followed by public institutions (17.7%), ordinary people (15.4%), influencers (11.9%), other (6.3%), or by those who say they do not learn about these topics and therefore do not learn from anyone (7.6%).

Moreover, as Table 1 shows, "school teachers of scientific subjects" are indicated as more reliable and capable of disseminating knowledge than "influencers", i.e. science popularizers who use the social web as a space for disseminating their products; higher values are reached, on the other hand, by "scientists or doctors", or "science popularizers", who in the survey are understood as popularizers who owe their public notoriety to the traditional media (Alberto and Piero Angelo, Luca Mercalli, Mario Tozzi). Among these mediators, teachers are considered to be the least manipulative.

Table 1 - Possible values from 1 (do not agree at all) to 7 (very much agree); source: “Communicating science. Mediation and mediators of scientific knowledge in a complex society” (Catholic University, 2024).

	School teachers of scientific subjects	Influencers	Scientists, doctors	Scientific Disclosures
Are generally reliable when speaking on scientific topics	4.54	3.39	5.20	4.97
Can make the topic clearly understandable	4.48	3.60	4.83	5.02
Try to impose a particular point of view to regulate choices	3.90	4.06	4.02	3.98
Help reflect on the complexity of the issues related to the topic they are discussing	4.47	3.57	5	4.94
Give tools to explore independently the topic discussed	4.47	3.50	4.53	4.69

3. The mediators of scientific knowledge used by teachers on the social web

Within the same project run by the Catholic University, the Pedagogy Research Unit surveyed 213 teachers of different school orders and grades. The aim was to explore who is considered authoritative (Weinberger, 2002) by the Italian teaching community, asking who and through which modalities become a credible reference in the online discourse.

If the social web (over 70%) outnumbers the static web, three ideal types can be identified that apply to both individual profiles of disseminators and pages:

- science content creators who, after scientific studies, have established themselves through the production of materials on the social web, becoming their main professional activity; they are almost always active on several social networks and sometimes also in the traditional media; they have a pop communicative style and produce materials

designed for the social web and usable by both teachers and students. they are digital content creators who, taking into account the specificity of their audiences, organize their communication to convey content through a clear and comprehensible language, capable of involving more people and thus making scientific knowledge 'viral'; even if communication techniques are central to their public dimension, they are generally also interested in knowledge promotion, the process underlying its elaboration, a widespread scientific mindset to extend the scientific culture of the population.

- professionals (journalists, university professors, scientists) established in their field of research, engaged in science dissemination for different reasons (personal choice, academic appointment, professional commitment); the social channel is rarely the main vehicle of their social affirmation.
- teachers of different school orders who, alongside their teaching activities, share the resources they have experienced in the classroom (worksheets, videos, teaching plans); alongside the social web, the static web constitutes an archive with the important function of repository of teaching material.

As for how teachers share materials, a few issues emerge:

- the sharing of materials between colleagues via WhatsApp or email remains a priority, with a kind of investment limited to one's institution/community;
- participation in conversations in social and subject- and school-specific groups, thus opening up the range of sharing to the outside world;
- attendance at training events involving the circulation of practices and resources, including university workshops.

More than 60% do not contribute to the exchange of resources with colleagues or in social spaces: a trend that limits the opportunities offered by co-authorship on the social web, i.e. the possibility of producing (exchanging) educational content and enjoying it. Also linking to other research (Silva et al., 2023), this data points out that one of the challenges for science disseminators is the ability to promote positive exchanges and interactions between community members, up to the possibility of community members to provide disseminators with useful feedback to orient or reorient their action.

4. The narrative, textual, communicative, and didactic dimensions of the disseminators selected by the lecturers

In a subsequent step of the study, the ten most frequently mentioned mediators by the respondents to the questionnaire were selected - Geopop's Facebook channel, Barbascura X's YouTube channel, the Instagram profile of the project La Fisica Che Ci Piace [few months after the research, La Fisica Che Ci Piace has become a television program (La fisica dell'amore) aired on the national channel Rai2. The first season started in April 2024, with 7,3% share (a great success, in particular considering the topic). See https://www.raiplay.it/programmi/lafisicadellamore], Dario Bressanini's YouTube channel, Luca Perri's (astrowikiperri) Instagram profile, Alessandro Bogliolo's profile, Elia Bombardelli's YouTube channel, Il Piccolo Friedrich's Facebook page, Maestra Mary's Facebook page, Maestra Marta's Facebook page [these are the data updated as of October 25, 2024: Geopop's Facebook channel: 3.4 million followers; Barbascura X's YouTube channel: 972.000; the Instagram profile of the project La Fisica Che Ci Piace#: 2.6 million followers; Dario Bressanini's YouTube channel: 566.000; Luca Perri's (astrowikiperri) Instagram profile: 69.200; Alessandro Bogliolo is analyzed across multiple media channels; Elia Bombardelli's YouTube channel: 559.000; Il Piccolo Friedrich's Facebook page: 42.671; Maestra Mary's Facebook page: 253.799; Maestra Marta's Facebook page:26.800].

These profiles were analyzed employing a semio-pragmatic analysis grid of the enunciative choices and conversational strategies (Rivoltella, 2010; Rivoltella & Ferrari, 2012) derivable from the profiles used, based on four dimensions: narrative, textual, communicative, and didactic.

Referring to another site (Carenzio, Ferrari & Pasta, 2024) for a more detailed analysis, some traits are reported here.

As for the narrative form, understood as the self-narration of the biographical information chosen to make themselves known, a solid scientific background emerged, with recognizable profiles (degrees in chemistry, physics, and geology, for example), whose provenance, year of birth, first names, and surnames are known (except for Barbascura X), as well as their academic track record of excellence, often marked by periods abroad or assignments in scientific bodies. In the case of lecturers, university collaborations are also included.

Another aspect refers to a 'civic scientist' posture (Davies, 2013) and a general commitment to countering the spread of fake news, conspiracies, and conspiracy theories that challenge 'official science' that can be seen in popularisers, resorting to scientific explanations even when the tone is very goliardic, closed to comedy or pop culture. This transforms a potentially purely informative process into an educational action, for instance when some influencers engage in countering the spread of unverified or unreliable news through debunking [while in prebunking, the audience is engaged preemptively to recognize the nature of information by understanding the techniques determining whether it is true or false, debunking involves identifying and refuting false information after it has already spread, following the logic of what is termed "meticulous exposure". Sander van der Linden (2023) suggests prebunking could help achieve a form of herd immunity against misinformation, limiting its impact] and fact-checking actions, proposing scientifically rooted behaviors such as checking sources and critically analyzing information, making the process of constructing rigorous knowledge behind their content more transparent [see the video 'RESPONSE to MAURO BIGLINO and his "ALIEN FRUMENT"' by Dario Bressanini, 5 December 2017, Bressanini's YouTube channel (https://www.youtube.com/watch?v=BXF11C_B-HM)].

An explicit identity strategy can be seen from the textual dimension, as textual brands are used to represent oneself and to reconstruct the profile of enunciation and model reader (Eco, 1979) that the owner intends to construct (Hine, 2000). Two issues can be highlighted.

Concerning the choice of images in the profiles analyzed, all of them use recurring icons (common for all the platforms used): the project logo, their own smiling face in the foreground, a referential poetic image or a black and white type, or images that are contextual to their professional background and their audience (stylized drawings or children's handwriting), especially for teachers.

This confirms the subdivision noted in a previous study by Rivoltella (2010), in which the selection of the image for the social network profile followed a precise semiotic scheme for selfrepresentation: *identity performance*, «which places the author at the center of the page and insists on the contents of the page itself as linked to the author's experience and skills» (2010, p. 8); *identity erasure*, «which instead plays on masking, on the identification of one's face through its replacement or negation» (*Ibidem*).



Figure 1 - Examples of identity performance.



Figure 2 - Examples of identity erasure.

As for the communicative dimension, it is observed:

- the choice of a popular (rather than educational) approach that is accessible and open, capable of bringing the public closer to science, guaranteeing correct, concise answers, and appealing to curiosity; the breadth of the audience may vary, the informal and pop style is prevalent: even with profiles from the academy, there is an effort to make the style less formal; therefore, a horizontal direction prevails in communication.
- part of this open choice is the free access to dissemination materials: for almost all of the profiles, dissemination is also a professional activity, with financial gains and commitments in other more traditional media, publishing, or educational spaces, but the activities on the social web enable open fruition.
- social media use has different purposes: narrative, sharing, and opinion-making, combining horizontal and vertical communication logic.
- the different profiles share the communicative versatility that takes the experiences beyond social, with broad formats, also declined according to cross-media and transmedia logics and using the digital storytelling formula.
- there are four prevailing styles: traditional, pop colloquial, charismatic innovative, academic/didactic.

Finally, the didactic dimension is interpreted from two different perspectives. The 'web teachers' – teachers, lecturers, and university professors – use the web to disseminate their knowledge and their teaching products, such as worksheets and projects; rather than dissemination in a strict sense (and, therefore, rather than the widening of the audience), what prevails is the use of the web's opportunities as a space for sharing, vertically and unidirectionally, by communities, which tend to be professional or, in any case, have elements of affinity. On the other hand, the 'popularisers 2.0', although they come from and are active in scientific research, have in the network the space of notoriety and public outreach, thus interpreting the classical function of popularising science. In some cases their action as creators stops at this level. In other cases, they use forms of 'pop culture' as the keystone for conveying only scientific 'content', and above all the logic behind it, in terms of building trust in science.

5. Between ‘strategies of generosity’ and ‘defense of borders’ for a disclosure with a ‘pedagogical head’

This analysis of the profiles of popularisers followed by teachers leads to questions, as research development, about how the specificities of the social web (Floridi, 2017; 2024) change the relationship between science popularisation and teachers, the challenges it poses to models of science communication (Trench, 2008), to the figure of the science communicator (Bencivelli, de Ceglia, 2013) and the implications for STEM teaching (Carenzio, Ferrari & Pasta, 2024). It is a process that also involves higher education (Said-Hung, Martín-Gutiérrez & Marcano, 2024). In particular, in the reported research, it was seen how science professionals and lecturers adopt certain established self-construction logic from influencers on social media, disseminating and at the same time supporting their professional activity. This leads to the production of even

innovative or experimental mediation formats, linked to specific logics and cultures of each platform. Thus, scientific knowledge has become the nexus to build a relationship of accreditation and trust with one's audience, while social media platforms have become mediation spaces. This practice, which is linked to a tradition that has educational, formative, and instructional value, has been able to renew itself by adapting to the new media and innovating in style, content and format, showing a protean competence in knowing how to use and exploit with increasing effectiveness the potential made available by digital products and social media, increasingly used, especially by the young and very young, to "give (rather than get) an idea" of the world around them (Annacontini, 2023).

In this perspective, science communicator-teacher (but also science communicator-student) communication on the one hand takes the shape of a multi-channel and multi-functional relational asset, since it is based on the activation of multiple *touchpoints* (websites, social media, events, newsletters, interventions in newspapers or radio and TV channels, personal communication, messaging with email and WhatsApp) and multiple communicative promises information, engagement, loyalty, support, sharing materials, service delivery). On the other hand, it nurtures a form of reticular and inclusive *expertise*, balanced between specialist closure and communicative openness, giving rise to a new arrangement in which the discourse of experts leaves specialist boundaries without the world of non-experts taking full possession of it, according to a dynamic that combines 'strategies of generosity' and tactics of 'boundary defense' (Caselli, 2020), experimenting with many forms of hybridization.

Together, these two processes change the relationship between expert and common knowledge and contribute to new ways of forming opinion and trust in scientific disciplines, finding their place of experimentation in school teaching and learning contexts.

In the editorial of the journal *MeTis*, Giuseppe Annacontini (2023) argues that scientific popularisation lacks a pedagogical 'head', if it does not take into account the critical task that nontrivialised knowledge must fulfill, it risks favoring a solid alibi for ignorance and the justification of the worst archaicizing postures, legitimizing social hierarchies that in turn affect the emancipatory potential of individuals. In these cases, popularisation betrays its task and assumes characteristics much more akin to forms of propaganda, which, as is well known (Gili, 2010), is often supported precisely by the media. A long season of studies has noted how the media cannot escape the suspicion of manipulation, historically situated in specific contexts, throughout the century, and it is partly to respond to this suspicion that Media Education emerged in the second half of the 20th century, based on education in critical thinking (Rivoltella, 2017).

At the time of *digital plenitude*, precisely the dialogue between science education (and science communication) and media education can contribute to promoting a science popularisation "with a pedagogical head" (Annacontini, 2023), understood as a useful tool to support the practice of a democratizing sapiential, capable of giving impetus to research, verification, documentation, argumentation, commitment and capable of bringing subjects closer to knowledge and science, overcoming the barriers of specialisms (including linguistic ones) and promoting curiosity, investigation, meaning.

In this way, scientific popularisation can be understood, with a pedagogical outlook, as a bridge between non-knowledge and knowledge, insufficient in itself but a viaticum for acquiring intellectual and experiential tools suitable for taking a responsible position in and for the world.

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“I Saw it on YouTube!”. The role of Science Communication in the post-digital era

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Abstract

In response to global challenges such as climate change and health emergencies, there is a growing need to foster active and responsible citizenship through enhanced Scientific Literacy (SL) (EU, 2015). SL involves making informed decisions through critical and reflective analysis (Akerson, 2018; Reincke et al., 2020), and Science Education (SE) is crucial for its development. However, to improve SE’s effectiveness, innovative teaching and learning strategies are required.

A promising area for innovation is the connection between SE and Science Communication (SC). SC uses entertainment to communicate scientific messages, creating an edutainment process (EC, 2020) that enhances motivation and engagement with SL. Social media plays a significant role in SC by facilitating interactive and shareable content (Sandu & Christensen, 2011; Pinto & Riesch, 2017). SC also promotes Media Literacy (ML), which, alongside SL, is vital for navigating the modern information landscape (Potter, 2013; Livingstone, 2003).

Building on this premise, our study investigates the intersection of SL and ML to create educational models that foster active citizenship. The research unfolds in two phases. In the first phase, two surveys were conducted – one for science communicators and one for their audiences. The data was analyzed using a mixed-method approach (Dahler-Larsen, 2023), with descriptive frequency analysis for quantitative data and phenomenological content analysis for qualitative data (Mortari, 2007). The second phase, reported here, involves semi-structured interviews to explore users' experiences with SC and its impact on their lives, with the aim of strengthening the link between SC and SE to enhance SL development.

Keywords: Science Education, Science Communication, Science Literacy, Semi-Structured Interview.

1. Introduction: what we are looking for and why

The aim of our study is to understand the role that Scientific Communication plays in the post-digital era in the experience of those who are involved in it, both as users and creators, in order to understand: a) if and how it can support the development of a more widespread Scientific Literacy also through its possible connection with formal education; b) if and how academics can support this process.

In the last ten years, it has become increasingly clear how poor scientific literacy can have a negative impact on both the life of the individual and society as a whole, particularly when we are called upon to face the changes occurring in our world which require new skills to deal with daily issues (EU, 2015). The awareness of this need has emerged with ever greater force following the pandemic emergency (Howell & Brossard, 2021; Sherpa, Ferreira & Santos, 2021; Fortus, Newmann & Sadler, 2022) and this has also led supranational organizations to underline the importance of directing a specific commitment towards the development of greater Scientific Literacy (SL), essential to promote a more active and responsible citizenship (EU, 2020).

But what do we mean when we talk about SL? It can be defined as the ability to gain and elaborate scientific notions, using them to make well-informed decisions through a critical and reflective analysis process (Akerson, 2018; Reincke et al., 2020; Akcay, 2018).

Defining SL in this way highlights not only its impact on each person's daily life, but also its flexibility, or rather its permeation of different aspects of human life. Indeed, until a few years ago, it was taken for granted that the main source of development of SL in the life each of us came

from our own school experience, and it was, therefore, mainly the task of Science Education (SE) to "form" the scientific mentality of future citizens, leaving primarily open the question of "how" this should happen and assigning to Scientific Communication a role of consolidation (Holbrook & Rannikmae, 2007), while nowadays we are facing a more complex scenario.

While it is true that the potential of Science Communication (SC) has been known for some time, and in particular, its ability to encourage and support the acquisition of scientific knowledge through edutainment (Duffy, 2008), it is equally true that we have recently understood that it can not only improve the effectiveness of SE by supporting learning and teaching innovation but it can also be a way to transform the ways (and the times) through which people gain a SL. In recent years, a new way to use communication tools in order to “spread” scientific content, particularly through social media (such as YouTube or Instagram), has caught the attention of scholars who deal with SL, both with its opportunities and its threats (Rosenthal, 2020).

In Italy, this phenomenon is taking on particular nuances both for its size, which has led to a massive diffusion of SC products, and for the type of professionals involved in this type of activity, which increasingly testify to a strong hybridization between the world of scientific research and that of communication, and for the ways in which this is happening, placing SC in close relation with edutainment, through significant interactions with comedy or pop culture, making them keystones for conveying not only scientific "contents" but above all the logics that underlie them (Cinelli et al. 2022, Silva et al. 2023). This evolution has made it necessary not only to review the connection between SC and SE, in light of the specificities that edutainment and, in a more transversal sense, Media Education (ME) can bring in a perspective of greater diffusion of SL in formal education contexts, but also to question how this phenomenon can be "systematized" to consolidate the diffusion of a scientific thought, made of notions and intellectual curiosities and also of a way of approaching reality rooted in data and capable of supporting a continuous learning process.

2. Materials and Methods

The research involves two subsequent steps. In the first phase, which took place between May and September 2023, the creators of scientific dissemination products (podcasts, videos, posts, etc.) and their users were involved through two separate surveys. The surveys prepared through the LimeSurvey platform were checked by the Ethics Committee of the Department of Human Sciences of the University of Verona and were subsequently disseminated. The two surveys were intended, one for the creators of SC content and one for the users. As for the creators, in order to identify the inclusion criteria in order to define the sample, select, starting from aggregator profiles (such as @divulgatori_italiani), the disseminators active on the main social media (in particular YouTube and Instagram) active on the topics of scientific dissemination with particular reference to the hard sciences, continuously and with a large community (over 10,000 followers). The creators thus identified were invited to participate in the survey and, at the same time, asked if they were available to publish an invitation to participate in the research on their platforms aimed at users. As regards the survey aimed at users, in fact, we opted for a snowball sampling, both through contacts received via informal networks and through posts published by the disseminators themselves. Both surveys initially contained profiling questions (age, gender, background, type of platforms used, themes, etc.) followed by open-ended questions that investigate in more depth, for the creators, the motivations and specificities of their professional actions, while for the users their relationship with scientific dissemination (characteristics considered important for the choice of products, assessment of reliability, impact on daily behavior, etc.). The analysis of the data collected through these surveys required a double look, capable of integrating a quantitative analysis, in particular for the profiling questions, and a qualitative analysis, for the open-ended questions, in order to allow access to the data and their flexible interpretation (Zhang, Creswell, 2013; Trinchero and Robasto, 2019; Dahler-Larsen, 2023). The richness of these approaches lies, in fact, in the ability to overcome the dichotomy that traditionally opposes these perspectives to embrace instead a complex view. This position is well suited to the objectives of this research (Koopmans, 2017). The quantitative analysis focused

mainly on a descriptive analysis to outline the trend lines that characterize the profile of the respondents and define the main contours of their actions within the SC. As regards the analysis of qualitative data (open-ended questions), an analysis method was used to insert a qualitative and inductive content analysis into a phenomenological framework. The phenomenological dimension, thanks to its ability to maintain a constant rooting in the phenomenon as it is perceived by the subjects directly involved, appears consistent with the desire, already stated, to enter into the folds of the object of investigation already outlined above (Mortari, 2007, 2022; Giorgi, 2009). The choice to use a content analysis for the analysis of open-ended questions lies in the flexibility that characterizes this tool, as well as its ability to guide the process of understanding the data towards a progressive definition and systematization of its salient elements, allowing the fundamental elements to be synthesized without losing their nuances (Elo & Kyngäs, 2008). Furthermore, choosing to use this tool from a qualitative and inductive perspective, in addition to responding to the specific characteristics of the data, promotes a bottom-up vision that is consistent with the exploratory dimension that characterizes this research (Hsieh & Shannon, 2005; White & Mash, 2006; Elo & Kyngäs, 2008). This analysis method, acting on the basis of the principles of identification and clustering of significant elements, allows the creation of a coding system that can have different levels of abstraction (Smith, 2000; Elo & Kyngäs, 2008). The results of the first phase data analysis allow us to identify the aspects to focus on in the second phase of the research, which involves semi-structured interviews. In this paper, we will report the results from the second step, which investigates users' lived experiences to understand better the role that SC has in their lives and the aspects that characterize their experience.

The interviews developed starting from this analysis are semi-structured because of the capability of this specific type of interview to facilitate the opportunity to engage in dialogue with respondents, enabling a more comprehensive exploration of topics initially addressed (Kallio et al., 2016). Indeed, semi-structured interviews are used in qualitative research since they allow for gathering in-depth information about the interviewees' points of view, being flexible and adaptable. Precisely, they are based on a template with some fixed questions and selected topics, which are expanded based on the respondents' feedback (Ruslin et al., 2022). Hence, we choose semi-structured interviews in order to go deeper into the experiences of both content creators and users (Ruslin et al., 2022) and understand their beliefs and feelings. As regards the sampling process, interviewees are recruited from two primary sources. Firstly, individuals who expressed interest in participating in subsequent steps during the initial phase of the study are contacted. Secondly, the dissemination actions that helped us to spread the results that emerged from the first phase (also through informal networks and social media such as Facebook, Instagram, and LinkedIn) helped us connect with creators and users interested in participating in the project. We collected a total of thirty-four interviews, twenty-two users of SC, and twelve content creators; four of them are to be considered emerging science communicators since they do not reach the threshold of 10.000 followers that we defined as an inclusion criterion at the outset of the study. As previously underlined, the key questions of the semistructured interviews are developed starting from the analysis of the survey data in order to explore the fundamental themes that emerged. The questions were customized to suit the specific characteristics and utilization of SC for each group, interrogating them about their personal engagement with SC and its main characteristics, such as communicative style and the presence of a community. Furthermore, users are asked to describe the assessing of the credibility of information sources and the impact of SC on daily routines, while content creators narrated their utilization of the medium and the potential for fostering dialogue between academia and science communicators. As regards the analysis of the interviews, in this case too, content analysis was used as an analysis tool, inserted within a phenomenological framework.

3. Findings

In this paper, we will focus on the perspectives of users, specifically examining the similarities and differences that emerged between their interview responses and the survey responses from the first phase of the study.

Following the methodological framework outlined above, we developed a coding system, visually represented in the Figure 1, to clearly show the key findings. The first column presents the labels that emerged from the analysis of the survey responses (later mentioned as "U.*n*°", viz "User *n*°"). The second column categorizes these labels, while the third column displays the macro-categories, which encompass the topics addressed by the categories in both survey and interviews. In the fourth and fifth columns, there are respectively the categories and labels resulting from the analysis of the interview responses (later mentioned as "I.*n*°", viz. "Interviewee *n*°"). This graphical representation shows the similarities (in bold) and differences (in bold italics) between the topics identified in the two phases of the research, which will be discussed in detail later in this paper. Due to space limitations, not all labels will be discussed; instead, we will focus on those most relevant to the research question.

Survey responses analysis		Both	Interview responses analysis	
Labels	**Categories**	**Macro-categories**	**Categories**	**Labels**
First contacts through "old media" (books, magazines, television)	The how/where of the first contacts with the SC	Relationship with SC	First contacts with SC	**First contacts through "old media" (books, magazines, television)**
First contacts through "new media" (Social media, podcasts, etc.)				**First contacts through "new media" (Social media, podcasts, etc.)**
First contacts during childhood or adolescence	The when of the first contacts with the SC			First contacts during childhood or adolescence
First contacts during adulthood				First contacts during adulthood
				First contacts with different mediums
First contacts for fun	The why of the first contacts with the SC		First contacts with SC	**First contacts for fun**
First contacts for learning (both academic and professional)				**First contacts for learning (both academic and professional)**
First experiences for information on issues considered relevant (e.g. during the pandemic)				Contacts for personal interest
				Contacts for a professional relationship
			Threats of SC	***Passive use of content***
				Risk of commercialization
				Risks related to the characteristics of Social Media
				Poor control of sources
Ability to adapt complex content even to a non-specialist audience	Good communication skills of the communicator	Characteristics of a good SC	Good communication skills of the communicator	**Ability to adapt complex content even to a non-specialist audience**
Ability to highlight the various aspects of an issue (objectivity)				Ability to highlight the various aspects of an issue (objectivity)
Ability to effectively manage the community				***Ability to communicate transparently***
Presentation skills				Ability to create short and immediate content
				Engaging presentation skills
Ability to identify current and relevant topics	Good "specialist" skills of the communicator		Good "specialist" skills of the communicator	**Ability to identify current and relevant topics**
In-depth knowledge of the topic covered				In-depth knowledge of the topic covered
Use of clear and authoritative sources				**Use of clear and authoritative sources**
Presence of positive exchanges and interactions between community members	Presence of a welcoming community			Ability to effectively manage the community
Absence of scientific exchanges and interactions between community members				Creating collaborations between experts
Presence of already known users in the community				***Promoting a relationship between SC and academia***
			Presence of a community	**Presence of positive exchanges and interactions between community members**
				Absence of scientific exchanges and interactions between community members
				Poor community adherence
				Risk of mental closure
Provision of useful information (both from a personal and professional point of view)	Increase in the number of knowledge	Effects of SC on the users' lives	Increase in the number of knowledge and skills	**Provision of useful information (both from a personal and professional point of view)**
Encounter with previously unknown themes and problems				Encounter with previously unknown topics and issues
Growth of a critical-reflective posture	Development of transversal skills			**Growth of a critical-reflective posture**
Growth in the ability to engage with others				Profitable use of free time
Profitable use of free time	Increased well-being from a personal point of view		Increased well-being from a personal point of view	Opportunities to meet others
Opportunities to meet others				Opportunities of in-person events
In-person events				Educational opportunities
			Increased ability to assess content reliability	***Search for external sources***
				Reliance on one's own knowledge
				Analysis of the profession of the popularizer
				Analysis of the popularizer's following

Figure 1 - The imagine presents the comparison of two coding system.
On the left the category and labels emerged from the analysis of the first phase data.
On the right the category and labels emerged from the second phase, while the central column refers to the macro-category for both the phases. Similar concepts are in bold, different ones are in bold italics.

3.1 Characteristics of a good SC

Regarding to the first macro category, the similarities identified in the analysis of users' responses from both the first and second phases of the research, are about the good skills of science communicators, both communicative and specialistic ones.

According to the respondents, both in the first phase of the research (Silva et al., 2023) and in the second one, one of the more important skills is the “ability to adapt complex content even to a non-specialist audience”. This is necessary to “maintain access to information” (I.10), making “something simple that is not simple for people who are not familiar with it” (I.17). Indeed, this is viewed as the objective of SC, that “is not just knowing things, but knowing how to transmit them, knowing how to do, briefly, making them understandable by everyone” (I.2). The collected data indicate that the ability to clearly explain a scientific concept is the most meaningful aspect of SC for the audience, who require communicators able of adapting information to different levels of preexisting knowledge. In this way scientific information is understood by individuals with diverse backgrounds, promoting wider accessibility and engagement with scientific contents.

To be able to do it, science communicators should use a specific type of communication, with a “very unformal language, accessible to the target” (I.10). They should simplify the concept even if “it is a very difficult point as they are not explaining superficial contents” (I.13). In addition to a simple language, the content should be “accompanied by images or sounds, because above all, those who are perhaps not in the profession, in addition to having to understand the technical terms, perhaps also struggle to imagine what they are talking about” (I.19). In this way, the idea of science as unachievable can cease: “talking about it in this way with easy words that reach everyone, gives the idea that finally it is not so difficult to understand what science communicators want to say” (I.22). The use of ordinary language, characterized by visual and acoustic elements that facilitate the understanding of scientific concepts, is one of the characteristics that makes SC so effective for encouraging broader participation and engagement with scientific knowledge. Moreover, this point is particularly relevant for fostering the deconstruction of the notion that science is an exclusive discipline reserved for the few, a perception that appears frequently in our culture.

Additionally, respondents declared to appreciate a language when it is clear but specific, since it makes them understand that science communicators “are experts in a certain sector, but they are still understandable” (I.8). Indeed, even if they use informal language to attract more people, they show to the public “that they are serious and they know what they say” (I.14). By employing this strategy, they are recognized both as experts in their field and users-friendly, engaging their audience and fostering trust and confidence. The relationship of trust is important in SC since allows the communicators to make their own community that supports them, through ideas sharing and exchanging and even economically.

Another relevant element which appears in both phases of the research is the “engaging presentation skills” of science communicators, especially because they apply a “mixture of formality and informality” (I.14) “involving, even with anecdotes, those who listen/read” (F.30). Science communicators create contents that engage and are “visually appealing” (I.11), which are characterized by “images, descriptions, funny stories, aphorisms” (I.14) or “meme” (I.9). All these elements engage a certain target since they exploit the benefits of “comedy” (I.9), and personal communicators characteristics such as “charisma” (I.18), “enthusiasm” (I.13), and “passion” (I.6), which help them to convey to the public in their contents, especially since “if you are passionate you automatically attract the people you talk with” (I.6). The personality of science communicators plays a crucial role in their success on social media. Respondents identified various personal traits that attract them, including charisma, enthusiasm, and passion. These features enhance the communicators' ability to engage their audience, and further solidify the already mentioned relationship of trust, fostering deeper audience involvement.

In addition to the presenting methods used by science communicators, the users highlighted also the importance of the topics they chose, valorised the “ability to identify current and relevant issues” for the audience and the historical and cultural context. First of all, most respondents declared that SC provides them with practical tools for everyday life: “practical example of the practical impact on the public it is certainly better than abstract ones” (I.3) since it helps to “know how a product used by everyone daily works” (F.72). This characteristic is a value for the audience, who appreciate knowing and learning about topics related to their personal and daily life. Indeed, responds recognized that science communicators “aim both to talk about topics that interest people and that arouse interest, because it is about everyday things” and “the contents

proposed are something that must reach the majority of people, connected to items that people wonder a lot about, such as body care or skin care" (I.15). More than one interviewee agrees with this declaration, especially they believe a content "is easier to follow if it is connected to people's real lives, or maybe to current events or even politics (I.21). Analysing deeply their words, it appears that people are interested to know about topics connected to their real lives, both in a personal way, such as for personal care, "cleaning or cooking" (I.8), and in a social way, as politics, current events, "geopolitics" (I.6) or "ecology" (I.21). This aspect is interested since it shows the desire of citizens to know about the world and society, and the necessity to count on experts to learn about issues that, even if present in everyone's daily life, are complex and require scientific knowledge to be understood. Hence, SC is viewed as something that connects social events with citizens, since it makes them informed and aware about their lives. This process illustrates once more the deconstruction of the notion of science as a remote subject. Actually, an interviewee outlined that "using social media, even the youngest, are able to get closer and understand that science is not something very far from us, but it is in every day" (I.22).

Speaking about the differences between the two research phases, interviews allowed to investigate deeply some aspects mentioned in the first one, such as the "promotion of a relationship between SC and academia" and the "ability to communicate transparently".

Regarding the first topic, although it is mentioned mainly by science communicators, users also alluded to the importance of building a relationship between SC and the academy, as it improves the sharing of scientific knowledge and enhances the work carried out by the universities.

Interviewees think that academia and SC, even if with different languages, aimed at disseminating scientific knowledge (I.1). For this reason, they should foster a closer relationship between each other, even with "the right incentives and the right help from the university" (I.20). This relation would bring a series of benefits for both citizens and academia. Specifically, the first could have the opportunity to engage with scientific knowledge, and the second one could improve citizens' perceptions of its effectiveness (I.20). As a result, the academia could increase its prestige and the incentives necessary to sustain its teaching and research activities (I.20). Moreover, the relationship between SC and the academic community is largely associated to science communicators, as this issue has been one of their primary concerns, however, the presence of this topic among users highlights its significance and urgency.

Concerning the second point, interviewees reported that science communicators help them to understand the scientific process beyond the scientific studies, helping "not to take things for granted" (I.19). In particular, they believe that SC promote the comprehension of scientific updating and science's limits because it explains "how the scientific process works" and how they "acquired the information" (I.2). The communicative transparency of science communicators promotes users' acquisition of the scientific method, which is essential for critical thinking and consequently for informed decision-making. This aspect is especially important in the development of SL among citizens. By understanding the scientific process, individuals engage with scientific content through critical and reflective thinking, fostering an in-depth understanding of these topics, which enables them to participate in society in an active and responsible manner.

Moreover, the promotion of a trust relationship between them encourages the construction of a community of knowledge, that is mentioned in both the research phases as a space characterized by the "presence of positive exchanges and interactions between members" (Silva et al., 2023). However, besides these positive considerations, the depth of the interviews showed also the risks of it, such as the "risk of mental closure". In particular, they portrayed the community as "a double-edged sword" (I.1) since it can have positive exchanges and interactions between community members, but it can also promote a closed mentality without opening dialogue. Indeed, "sometimes perhaps it could become a little closed, that it could favour the formation of a certain bubble" (I.18), where people feel "a sense of security, protection, serenity, tranquillity" (I.2), but where they can also "become fans, like in football, that whatever one says is right, there is no contradiction" (I.20). The "formation of these bubbles is a bit particular, a bit slippery, as a situation" (I.18) and scares people, as "it scares me a little, because then I am afraid it might end up a bit like a cult" (I.5). This phenomenon, that confine people in filter bubbles marked by selective filters and confirmation bias (Höttecke & Allchin, 2020), is considered by interviewees

dishonest as it makes people feel safe about the information they gain in a community, even if they do not have the opportunity to gain different thoughts, forcing them to create a partial and incomplete ideas of scientific contents.

3.2 Effects of SC on the users' lives

Speaking about the effect of SC on the users' lives, there are many similarities in the data of the two research phases, the most relevant are "providing of useful information (both from a personal and professional point of view)" and "blooming of a critical-reflective attitude".

For instance, participants revealed that SC provides them with information about personal interests, such as "science in everyday life", granting them "to receive information and knowledge for free" (I.8). In this way, SC "helps people to make themselves feel, let's say more reassured, and it responds a little to human nature, which is intrinsically curious" (I.10). This answer showed the idea of participants about the use of information, that can be constructive for everyone who wants to learn about specific contents. Indeed, this element is closely related to the concept of Lifelong Learning, as highlights how SC fosters a permanent learning in its audience, providing them with the stimuli and tools necessary to acquire new information on a wide range of scientific topics.

In addition to scientific knowledge related to personal interests, SC also offers professional information, providing insights that can support individuals in their professional job, such as providing information on skincare products for who work in the personal care industry (I.2). It is evident that SC intersects with various aspects of citizens' lives, both personal and professional. Therefore, it has the benefits to encompass a wide range of topics, that allow it to address diverse needs and interests.

Moreover, this characteristic fosters a critical-reflective attitude about science because users learn how to think critically about scientific contents, becoming more awareness and informed. For example, participants said: "enjoying scientific content allows me to understand a little better and to validate my thesis that behind everything there is a world" (I.19), or the "explanations make me understand better what surrounds me, they also make me more responsible" (I.12). The opportunity to gain a deeper understanding of various aspects of life enables people to reflect on them and make informed decisions about how to act responsibly: SC shows to citizens "what substances do they breathe, what substances do they touch, what substances do they swallow and then... Nothing, be more careful" (I.21). In conclusion, it leads people "to ask many more questions about everyday life" (I.22), increasing their critical thinking and ability to cope with daily challenges.

The dissimilarity in this macro category concerns the introduction of a new topic, the "increasing of the ability to evaluate the reliability of contents". During the interviews, users explained some actions they implement in order to evaluate the reliability of contents found online. First of all, a lot of them search for different sources outside the community, such as on "European guidelines, different channels" (I.2), "Google" (I.7), national and international press (I.12), "research papers" (I.22) or to specialists (I.15). Anyway, they recognized the difficulties of verifying the sources, admitting, as mentioned above, that sometimes there is a lack of adequate control over them.

In addition, someone reported evaluating the reliability through the curriculum vitae of science communicators. For instance, if someone "has been working on that topic for thirty years, so it's obvious that I believe it" (I.3). The respondents reported they look at the professional career of the communicators since "it is a reliability that is based on the profession they do, on what other information they produce" (I.16), in detail they check "what collaborations have they done, where do they work, who do they collaborate with and who are they" (I.12). On of them said "I am going to see what work they do, whether they do real or parallel work with dissemination on social media, whether they publish in magazines or whether they teach at university" (I.8). It is evident that, even in this case, the interviewees do not immediately trust individuals encountered on social media. Instead, they seek additional information from sources beyond the internet, on scientific events, conferences, and academic institutions, such as looking "where they published" their works (I.21). Besides, some of them check this information on the social media, such as

looking the followers they have: “they are followed by many people and is highly appreciated by many people, in the group there is someone who has studied in depth, especially if the numbers are large” (I.10). The fact that many other people follow a communicator creates a sort of “more confidence” in the contents (I.11), as there is the perception that it is impossible to delude all those people. The responds implement evasive actions to analyze sources, which can result in their susceptibility to disinformation and fake news. This demonstrates the need to educate in a critical use of the contents enjoyed on social media, equipping individuals with the skills to employ appropriate strategies for understanding context and distinguishing between accurate and false information.

3.3 Potential threats of SC

In the macro-category concerning the relationship of users with SC, the main labels are about the exposure methods to SC—such as engagement through both "old" and "new" media—and the initial motivations to take contacts with it, whether "for fun" or "for learning," which were evident in both survey and interview responses. Beyond it, the interviews revealed a new concept of the “threats of SC”. The respondents declared their worries about the passive use of the content, considered “the scourge of online entertainment” (I.11), as it encourages acquiescent consumption of online content, leading to the assimilation of information without adopting a critical scientific stance. Furthermore, they highlighted the risks associated with certain characteristics of social media, which hinder the consolidation of scientific concepts. For instance, they pointed out “the risk of being so quick to give, of giving more value to speed rather than content”, a specific characteristic “of the media” (I.3). While the rapid dissemination of content is seen as beneficial for engagement and motivation, some expressed concern about the difficulty in deeply understanding the concepts conveyed through this medium, identifying it as a drawback of SC.

The participants also considered the risks linked to the marketing aspects that may affect the presentation and rigor of science communicators, particularly when they are paid by specific brands to promote content and utilize SC “only and exclusively from an economic point of view” (I.7). This topic is especially found in relation to the need for communicators to create advertising content on their channels, in order to be compensated for the work done, an aspect that is still controversial in the Italian panorama.

Finally, some respondents reflected on their own potentially harmful behaviours, such as “Inadequate verification of sources”, admitting that sometimes they “never go to check” (I.9). In particular, they emphasized the importance of reliable sources for validating both the information and the credibility of the science communicators themselves. However, they also acknowledged that they do not always verify the sources, often trusting the communicators either because they are familiar with them or because the presence of cited sources is already perceived as a sign of trustworthiness.

It is noteworthy that the interviews revealed more veiled aspects of the users' relationship with SC. In the survey, participants merely described how, when, and why they engaged with SC, whereas during the interviews they provided more in-depth insights into their current relationship with it, elaborating on both its positive and negative sides.

4. Learning and media-educational implications

The analysis of the interview responses highlights several elements typical of learning and media education approaches. This is particularly interesting, considering that the aim of the research is to draw from the experiences of those directly involved in the contemporary landscape of science communication (both producers and consumers) in order to understand how to create educational-didactic pathways that bridge Science Education and Media Education, fostering a productive dialogue between academia and science dissemination (Silva et al, 2023).

Although Science Communication on social media often appears as a form of entertainment, the interviewees identified key elements traditionally associated with teaching within its approach.

First of all, it is possible to recognize didactic transposition (Chevallard, 1991), the restructuring process through which expert knowledge (*savoir savant*) is transformed into knowledge that is taught (*savoir enseigné*) and eventually becomes learned knowledge (*savoir appris*). As seen in the preview paragraph, one interviewee noted the importance of adapting complex content for non-specialist audiences, describing it as "making something simple that is not simple for people who are not familiar with it" (I.17). Another added that it's "not just about knowing things but knowing how to transmit them" in a way that everyone can understand (I.2). Science communicators, much like teachers, must strike a balance between maintaining scientific accuracy and making the content accessible to non-specialists. This often requires simplexity (Berthoz, 2011): using precise but simplified language, ensuring that the core message remains intact while being clear to a general audience, providing this way tools capable of making accessible a complexity that cannot be eliminated (Rivoltella & Rossi, 2017). Respondents particularly appreciated language that was both clear and specific, as it demonstrated the expertise of the communicator while still being understandable (I.8). Another respondent emphasized the importance of clarity, stating that science communicators "show to the public that they are serious and they know what they say" (I.14).

Equally important is the use of didactic mediators (Damiano, 2004), tools needed "to construct a bridge between learning and teaching" (Rossi, 2017), which enhance understanding by making abstract or complex ideas more concrete. One interviewee mentioned that the use of images, videos or sounds is crucial to helping non-specialists imagine what is being discussed, especially when technical terms are involved (I.19). These tools are not merely supplementary but integral to the process of engaging diverse audiences, particularly in digital spaces where attention spans are short. In informal environments such as social networks, science communicators have a unique opportunity to leverage informal language tools like memes (Davison, 2012), aphorisms, and digital storytelling. Memes, for instance, distill complex concepts into culturally relevant, bite-sized pieces of information. As one respondent stated, science communicators often rely on images, descriptions, funny stories, and memes to make their content visually appealing and engaging (I.11). Another emphasized the role of storytelling, noting how communicators mix formality and informality (I.14), using anecdotes to engage their audience (F.30). This informal approach can be particularly effective in engaging younger audiences or those less familiar with traditional academic formats.

Another key principle in effective Science Communication, as said during the interviews, is situating the content within the life experiences of the audience. This concept is very well known in the educational community, where the contextualisation of learning has been explored in different fields, from school (Rivoltella, 2013) to videogames (Gee, 2007). One respondent noted that practical examples of everyday objects and how they work make scientific content more relatable and easier to follow (I.3). By relating scientific concepts to familiar, everyday situations, communicators can enhance both the relevance and appeal of their content. This not only increases engagement but also demonstrates that science is woven into the fabric of daily life, making it feel less abstract and more applicable and close. When individuals recognize how science influences their everyday experiences, they are more likely to see the academic world and knowledge as something directly impactful and necessary. This shift can lead to greater public support for scientific endeavors, as people begin to understand the broader societal implications of scientific research and innovation.

Talking about the media-educational aspect, another pivotal finding from the interviews is the role of Science Communication in fostering critical and reflective thinking. By exposing audiences to the methods of scientific inquiry, science communicators provide a framework for understanding how science works. This process encourages individuals to apply similar critical thinking skills in their own decision-making, leading to more informed, conscious choices in their everyday lives. Although the primary goal of Science Communication is to convey scientific knowledge, this development of critical thinking skills is a further objective whose importance is not at all negligible. It also contributes to broader media literacy, as audiences learn how to assess the credibility of information found online and critically evaluate both content and its source. This emphasis on media literacy has significant implications for the development of digital citizenship

competencies. In today's digital age, where vast amounts of information circulate rapidly online, the ability to critically evaluate sources is more important than ever. Science communicators, whether intentionally or not, play a crucial role in teaching audiences how to navigate this information-rich environment responsibly. By equipping individuals with the skills to analyze the content they encounter, Science Communication helps foster a more informed public capable of making decisions based on evidence rather than misinformation.

The significance of community in Science Communication also emerged from the analysis, as interviewees emphasized the importance of a trust-based relationship between them and the science communicators.

This relationship helps create a space defined by "positive exchanges and interactions among members".

When science communicators collaborate and share their knowledge, they contribute to what Gee (2013) refers to as a "big Mind", a collective intelligence (Levy, 1994) you get «when you plug minds and tools together in the right way» (Gee, 2013, p. 165). This exchange of ideas not only strengthens the knowledge base, as the result is greater than the sum of the efforts of those who took part in it (Rivoltella, 2015) but also creates a space where diverse perspectives can be explored. However, this communal aspect carries a risk, as interviewees pointed out. As audiences become more engaged with specific science communicators or communities, they may form "a certain bubble" (I.18)", better known as echo chambers (Jamieson & Cappella, 2008), where people become too attached to one viewpoint, reinforcing their existing beliefs. These ideological bubbles, while seemingly informed and well-rounded, can lead to polarization and, in extreme cases, fanatical adherence to certain ideas (I.20). This polarization runs counter to the goal of science communication, which is to promote critical, reflective thinking and open-mindedness. Instead of encouraging debate and exploration of alternative perspectives, these bubbles can limit intellectual growth and hinder the very critical thinking skills that Science Communication aims to develop.

5. Conclusions

The recognition of the risks associated with low levels of SL, particularly in the current context of global changes that require new scientific skills (EU, 2015), increased the emphasis on the need to enhance SL to foster active and responsible citizenship (EU, 2020). To reach this goal, this study is aimed at exploring the role of SC in the post-digital era, understanding whether, and how, it can contribute to the development of SL in citizens, including its potential integration with formal education, and the role of academics in supporting this process. The integration of SC, which supports the acquisition of scientific knowledge through edutainment (Duffy, 2008), can transform how and when individuals acquire SL, enhancing the effectiveness of SE and promoting learning and teaching innovation. In particular, the rise of social media platforms such as YouTube and Instagram has drawn scholarly attention to both the opportunities and challenges associated with using these tools to disseminate scientific content (Rosenthal, 2020).

Building on these premises, the research aims to analyze the experiences of both users and creators in order to understand their relationships with SC, its impact on their daily lives, and the factors they perceive as effective in engaging them with SC content. Initially, these elements were explored through two surveys – one targeting creators and the other users of SC. Based on the results of the first data analysis, specific aspects were identified for further investigation in the second phase, which involved semi-structured interviews. These interviews revealed both similarities and differences, offering deeper insights from the participants and introducing new perspectives on the topic, which may inspire future research directions. For instance, the interviews revealed the characteristics of effective SC, as the elements that, according to users, make it attractive and impactful. In particular, respondents highlighted the ability of science communicators to convey complex content in a simplified but accurate way, using different communication styles, including visual language and references to pop culture. Additionally, they noted the presence of interesting and useful topics, both on a personal and professional level,

also related to social or political issues. Understanding these elements, that make SC engaging and effective, is essential for its integration into educational settings, allowing to exploit its educational potential critically. Furthermore, respondents reported the impact that SC has on their daily lives, emphasizing how it enhances their critical thinking abilities by fostering a deeper understanding of the scientific method underlying aspects of their everyday experiences. Moreover, they also noted improvements in their ability to evaluate the credibility of scientific content, an aspect that is crucial for developing the capacity to identify reliable information. Nevertheless, interviewees expressed concern about the passive consumption of SC and the lack of source verification that sometimes characterizes the use of scientific content on social media. These two perspectives underscore the importance of source analysis and the ability to assess the reliability of information, as well as the need for more specific training that provides people with the tools necessary to navigate new media landscapes, which are rich in both information and misinformation, that must be strategically avoided. Academia should assume a role in this process by building a stronger connection with SC, improving its credibility and enhancing public knowledge, especially considering its role in spreading knowledge. Lastly, another aspect that should be explored further in future studies is the role of community in SC, especially in relation to the concept of the filter bubble, which poses relational and knowledge co- construction benefits but also significant risks.

The findings and unresolved concerns clearly demonstrate the vital role of media education in scientific dissemination, both formally and informally. While the interviews highlighted several effective strategies for knowledge sharing, such as didactic transposition, the use of didactic mediators, contextualization and situated learning, and fostering critical thinking, they also revealed potential pitfalls. The risk of creating echo chambers and the need for more diverse perspectives within science communication communities are particularly concerning. By equipping people with the skills to critically evaluate information and engage with diverse viewpoints, media education can help ensure that science communication remains a valuable tool for promoting informed decision-making and an engaged citizenry.

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Peer Feedback as an innovative strategy to overcome the frontal lesson

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Abstract

In recent years, research in the pedagogical-didactic field has focused its attention on the opportunities deriving from the active participation of students in the teaching-learning process. Placing students at the centre of the learning process responds, in fact, to the dual purpose of making them develop a greater degree of awareness concerning the learning objects and, at the same time, guiding them in the development of metacognitive skills. In this same scenario, research has highlighted the significant role of feedback in learning processes and has aimed to underline the benefits derived from the implementation of peer evaluation, as an effective tool to integrate the traditional model of frontal lessons. Despite clear evidence, active teaching practices in the Italian context are still rather limited and the use of feedback remains mostly a teacher's prerogative. Considering these premises, this work delves into the practice of peer feedback in the context of primary school to propose it as a useful strategy for overcoming the limits attributable to the traditional model of frontal lessons.

Keywords: Active Learning, Formative Assessment, Peer Feedback, Frontal Lesson.

1. Introduction

In recent years, research in the pedagogical-didactic field has seen a growing interest in teaching methods that promote active and participatory learning, aimed at encouraging the overcoming of the traditional model of frontal lessons, of which some negative aspects are highlighted (Brown, 2014; Coggi & Pizzorno, 2017; Grion, Serbati, Tino & Nicol, 2018). Commonly, the term “frontal lesson” refers to a widespread teaching model, which is divided into two main moments: the one in which the teacher presents content and the one in which he carries out individual questions. In this model, the teacher tends to speak extensively, showing a predominant concern for the quantity of information to be transmitted and almost completely neglecting the interaction with and among students. However, the frontality of the teacher-student relationship should not be identified exclusively with the negative traits typical of this model. The frontal lesson has not always had the same form and even today it does not manifest itself in a single modality. Other forms of frontal lessons are accompanied by evidence of effectiveness, such as those characterized by moments of discussion or continuous dialogue between teacher and class (Calvani & Trinchero, 2019).

The theoretical framework to which the work presented here is ascribed is the socio-constructivist one which promotes active teaching strategies and the assessment as a regulatory process that precedes, accompanies, and follows each teaching itinerary, considered as a training practice, an integral part and an irreplaceable tool for improving the entire teaching-learning process.

Starting from these premises, the results emerging from the National Surveys on Learning (INVALSI, 2020), with reference to the data relating to the questionnaires administered to the teachers and students of the sample classes, offer interesting ideas regarding teaching styles and methodologies currently used in Italian classrooms. A specific section of these tools aims to reveal how teaching actions develop along a continuum at the extremes of which there are vertical teaching and horizontal teaching: the first is achieved through a class structure where the teacher speaks and the students listen, often passively (Margiotta, 2013), the second, however, which refers to active and participatory practices that place the construction of knowledge as a shared and negotiated process at the centre.

In general, from reading the data, there is a gap between the poor diffusion of active practices and the literature, which highlights the link between this type of activity and the strengthening of students' skills. For example, the component weights relating to the first dimension of the *Vertical teaching - horizontal teaching component* investigated through the 2018-19 Teachers' Questionnaire, administered to Italian teachers in primary schools, allow us to observe higher values in correspondence with the items aimed at detecting the frequency of the teaching methodologies typical of vertical teaching. The lowest value is recorded, however, for item D5 a) *frequency of teaching methodologies: activities between peers*, which investigates the development of horizontal teaching. This last data provides a clear example of the existing gap and recalls, as supported by the EBE approach, the need to provide educational decisionmakers with a picture of the available scientific evidence, with reliable information on what currently "works" in the classroom, which, when integrated with professional judgment skills, can allow educational decisions to be made (Whitehurst, 2002) in a conscious and informed way.

Also interesting are the data relating to the verification methods, which reconstruct a picture in which the evaluation still seems to be largely relegated to its summative rather than formative function, recording a lower frequency in correspondence with the items aimed at investigating the use of type *metacognitive evaluation*, *systematic observation practices with an evaluation rubric*, and activities that involve *discussion* and *conversation* (INVALSI, 2020). This condition is also confirmed by Grion (2023) who highlights how voting still seems to be the most used form of feedback in both Italian schools and universities. On the contrary, national and international literature has long highlighted that evaluation represents an intrinsically formative moment and has focused its attention on the opportunities deriving from student participation in evaluation processes. Placing students at the centre of the evaluation moment responds, in fact, to the dual purpose of making them develop a greater degree of awareness concerning the learning objects and, at the same time, guiding them in the development of a personal evaluation literacy (Ducan & Buskirk-Cohen, 2011). In this same scenario, research has highlighted the main role of different types of feedback, in addition to voting, in learning processes (Grion, 2023) and has aimed to underline the benefits deriving from implementation in educational planning, of peer evaluation (Marzano, 2023). Peer feedback (PF) is an innovative teaching strategy, capable of transforming the dynamics of the classroom and involving students in a collaborative learning process.

The perspective that we intend to outline here promotes the use of this strategy while not denigrating the use of frontal teaching; rather, it aims to integrate the traditional model with strategies that ensure that the fundamental principles that should regulate effective teaching are taken into consideration, including, for example, the crucial importance of feedback, the involvement of the student's prior knowledge student, the activation of metacognitive strategies and the active participation of the students. If, as argued by David Ausubel (1968), learning is more effective when it builds on pre-existing concepts and connects significantly to what the student already knows, the frontal lesson can be effective, if it is accompanied by techniques that facilitate these connections and stimulate critical thinking. This essay explores how the peer feedback strategy can contribute to overcoming the limits of frontal teaching, analysing its use from a socio-constructivist perspective.

2. Theoretical framework

The socio-constructivist approach represents one of the most influential perspectives in contemporary education, assigning the subject a central role in the learning process. Rooted in the Piagetian theory that describes cognitive development as a process of active construction the socio-constructivist framework looks at learning as an active process in which students build their knowledge through experience and interaction with the surrounding environment (Piaget, 1964). It is Lev Vygotsky (1978) who, broadening this perspective, emphasizes the social nature of learning, highlighting the need to deal not only with cognitive processes as a product of development but also with how these processes are generated and consolidate in the interaction of the subject with the social context in which he is inserted. Starting from these premises, Bruner (1976) develops his theory of learning, understood as a cognitive activity that is not reduced to

the simple reception and memorization of stimuli, but which takes the form of a gradual process that takes place mainly together with others, through collaboration, discussions and comparison that characterize the subject's relationships with the community to which he belongs (Marzano, 2013). A new concept of evaluation, the new assessment, thus evolves in the wake of the reflections of these authors, giving ever greater attention to the entire learning process and student participation. From an evaluation exclusively oriented towards expressing judgments on individual performances and exclusively ascertaining cognitive processes, there is a transition to a multidimensional evaluation which has competence as its object and aims to describe the entirety of the process activated by the student. The process implemented by the subjects who participate in the teaching action in a specific context is linked to the learning products. Alongside traditional or heteroassessment, self-assessment is accompanied by self-assessment, a form of subjective assessment that calls into question awareness, the activation of metacognitive strategies, and regulation processes that allow the subject to control what happens in the process of learning (Vegliante, 2016).

The evolution of the socio-constructivist approach, redefining the role of the subject as an active builder of his knowledge, has represented the driving force behind the birth of teaching practices that respond to the needs of an increasingly participatory education aimed at developing the skills of students. students. Among these, peer feedback stands out for its ability to promote collaborative and reflective learning. In fact, through peer-feedback practices, students not only receive evaluations from their peers but are also involved in a critical review process that encourages the development of personal evaluative literacy. Following what Vygotsky (1934) claimed, comparison with peers and work in the zone of proximal development (ZPD), which constitute the essential aspects of these practices, become crucial for the cognitive progress of learning subjects. On the other hand, what was supported by Bruner (1966) and Ausubel (1968) also finds a direct implication in peer feedback practices, where it is believed that learning is more effective when students are engaged in the process of discovery and construction. active and shared knowledge. The involvement of students in mutual evaluation processes, in fact, not only provides them with the opportunity to receive constructive criticism from peers but encourages them to reflect critically on both their work and that of their classmates. This process of mutual and continuous review and feedback fosters the development of meaningful learning, encourages students to analyse, evaluate, and propose improvements, and supports them in developing skills essential for both personal and academic growth.

As highlighted by Stecca et al. (2022), peer feedback helps develop students' greater awareness of their learning processes, stimulating critical self-evaluation, in full agreement with Dewey's thinking (Stecca et al., 2022). Even the latter, in fact, by emphasizing the role of community and practical experience in learning, and maintaining that students learn better when they are involved in collaborative activities that reflect real-life situations, represents a fundamental prerequisite for teaching practices of peer feedback. Dewey (1938) argues that school is a miniature democratic community, where collaborative experiences foster deeper and more authentic learning. In particular, the author believes that education must be oriented toward reflective experience, towards learning understood as a dynamic and interactive process that involves the individual in a continuous cycle of action and reflection. This gaze represents the solid foundation on which peer feedback practices are developed, in which students become active participants rather than passive recipients of information. They are not only involved in peer evaluation and self-evaluation activities, but are also called upon, before starting these activities, to collaborate in arriving at the definition of the evaluation criteria and, subsequently, to discuss and reflect on their answers to reach a shared result. The active participation of students and the sharing of responsibility in the evaluation and learning processes determine the added value of peer feedback which, if implemented regularly and systematically, not only favours an improvement in learning outcomes but also the development of metacognitive regulation, motivation, the ability to develop evaluative judgments (Serbati, Grion & Fanti, 2019), to learn from one's own mistakes and comparison with the work of others (Marzano, 2023).

3. Going beyond the frontal lesson: the peer feedback

Many studies push towards overcoming the preponderance of frontal lessons (Andrich, Miato & Polito, 2001; Cohen & Lotan, 2014; Fedeli, 2019), which is still very strong and prominent in many schools and in many teaching activities. As supported by Marzano (2023), frontal teaching can be improved if supported by tools that stimulate active participation. It is therefore appropriate to limit the frontal lesson and reverse the time dedicated by the teacher compared to that used by the students (Hattie & Zierer, 2017). This does not mean, however, rejecting the frontality and importance of the teacher function, but reconsidering the role of the latter in terms of fundamental guidance in a learning process in which it is the student who plays the role of protagonist (Calvani & Trinchero, 2019). From a simple transmitter of knowledge, the teacher becomes a facilitator of learning, guiding students on their journey of discovery and understanding. This requires greater flexibility and ability to adapt, as well as continuous reflection on one's teaching practices.

In this regard, Schön (1983) argues that the role of the teacher in school contexts must evolve from a simple transmitter of knowledge to a reflective professional who does not limit himself to following a predefined teaching model but constantly reflects on his practice during and after the action. The teacher as a reflective professional can integrate theory and practice flexibly and adaptively, improving not only the effectiveness of teaching but also continuous professional growth. Furthermore, he must promote a collaborative learning environment, where students are encouraged to actively participate and develop critical and analytical skills. This change is necessary to address the complexities and uncertainties of the contemporary educational world. Peer feedback represents an innovative and effective resource in this challenge, allowing us to overcome the traditional frontal model to promote participatory teaching in which students, taking an active role in evaluating peers, develop critical and reflective skills (Stecca et al., 2022). Despite the most recent research in the educational field highlighting its effectiveness, in Italy, peer evaluation practices in school contexts still reach rather low percentages (Restiglian & Grion, 2019), while frontal lessons continue to be appreciated for their efficiency. in transmitting structured knowledge in a short time. As Trinchero (2012) states, one of the major benefits of the lecture model is its ability to convey complex contents quickly and systematically, offering students an overall vision of a specific topic. In situations where there is a need to cover large portions of the material or where a high level of precision and rigor is required, the lecture remains an effective method. On the other hand, lectures have been widely criticized for their one-way nature, which limits students' active participation and discourages the development of critical and reflective skills, reducing opportunities to strengthen skills essential to each student's life, such as those of problem-solving, cooperation, and critical thinking. As noted by Hake (1998), lectures offer few opportunities to explore ideas in depth or to apply knowledge in new contexts. To address these critical issues, Calvani (2014) discusses the importance of designing the frontal lesson so that it is effective from an educational point of view, emphasizing the need to balance the clarity of presentation and the active involvement of students. The frontal lesson, according to Calvani, can be made more effective if the teacher adopts multimedia tools and techniques that stimulate interaction, preventing students from adopting a passive attitude. In this context, the use of formative feedback and moments of discussion are of considerable importance and can contribute to ensure that students are not limited to passively receiving information but they are encouraged to reflect on the proposed content. This approach aims to transform the traditional lesson into an active learning experience, which stimulates students to reflect, ask questions, and discuss with their classmates. Cooperation between students not only stimulates critical thinking but helps create a learning community, where ideas are shared and analysed in a more dynamic way than in the traditional face-to-face context. This approach recognizes the formative value of evaluation and the centrality of a particular aspect of it, feedback (Sadler, 1989; Kluger & DeNisi, 1996; Hattie & Timperley, 2007; Shute, 2008), i.e. the information that can be given and/or acquired by the student to improve their performance. Pellerey (2004), in focusing on the role of formative evaluation within the frontal lesson, underlines on the one hand that the latter can be effective in the transmission of contents but, on the other hand, highlights the need to introduce elements of reflection and self-evaluation that allow students to monitor their learning. According

to the author, lectures, if not integrated with moments of feedback, can reduce students' active participation and compromise their emotional and motivational involvement.

Peer feedback activities seem to respond effectively to these critical issues and, fitting perfectly into the reference framework of formative evaluation (Scriven, 1967), aim to promote student learning through a continuous process of reflection and improvement. A key aspect of formative assessment is its ability to make ongoing adjustments, that is, changes during the educational process aimed at improving the effectiveness of teaching and learning. Ongoing evaluation has an eminently formative nature as it enables the various actors involved to introduce corrections and adjustments (Galliani, 2014). Furthermore, the teacher's ability to provide immediate feedback during the lesson can help maintain student interest, facilitating deeper and more lasting learning. The objective of the ongoing evaluation is, therefore, to identify possible gaps in the knowledge achieved so that on the one hand, the student can become aware of his shortcomings and on the other, the teacher can propose recovery and/or consolidation activities (Marzano, 2021).

The peer feedback strategy, which actively involves students in mutual evaluation, can be a key element to integrate into this process. Through peer feedback, students learn to give and receive constructive criticism, developing critical thinking and self-evaluation skills. This not only promotes a collaborative learning environment but also encourages students to reflect on their work and that of their peers, improving their understanding of the content and skills required. Additionally, peer feedback helps create a learning community where students feel supported and valued. If implemented regularly it can reduce the anxiety linked to evaluation, ensuring that students develop the ability to interpret feedback as an opportunity for growth and improvement rather than as a final judgment. In this way, formative assessment and peer feedback work together to create a continuous and dynamic learning cycle, where students are actively involved in their educational journey and motivated to constantly improve.

Another fundamental construct to consider to trace the limits of the traditional frontal lesson and guarantee its integration and improvement is the theory of cognitive load, developed by Sweller (1988), which is reflected in the context of Evidence-Based Education, a perspective aimed at making evidence available that allows teachers to be shown the methods and operational strategies that have the greatest probability of improving learning (Calvani & Trinchero, 2019). Sweller (1988) points out that students' cognitive capacity is limited, and that the amount of information that can be processed simultaneously in working memory is small. Therefore, the lecture, if too rich in content or presented in an unstructured way, can overload students' working memory, leading to a decrease in understanding and memory. Integrating cognitive load theory into lecture design means that teachers avoid introducing too many concepts at once and use techniques such as splitting content and reducing extraneous information. For example, providing frequent pauses for reflection or including interactive activities helps reduce cognitive load and allows students to better process and internalize information.

According to a framework that brings together field research and the theoretical constructs examined so far, it is possible to define a training model that tends towards the effectiveness of the teaching-learning action (Piacenza & Trinchero, 2022): an expert teacher begins the lesson with a brief review of previous learning and with a quick presentation of the learning objectives that students will have to achieve (Calvani & Trinchero, 2019). This means formulating the learning objectives in terms of cognitive processes that the student must activate and the contents on which to activate them, to work synergistically on both aspects. It then means communicating in advance the performance expectations expected from students through the definition of evaluation rubrics, learning guides, and evaluation grids (Piacenza & Trinchero, 2022). Furthermore, the teacher directs the student's attention by presenting the new contents in small steps so as not to overload the working memory; provides continuous training feedback, before, during, and after the teaching moment (Hattie & Timperley, 2007); deconstructs and restructures the learning task by adapting it to the students' abilities and urges the latter to use high cognitive processes (Calvani & Trinchero, 2019). To this end, it is essential to adequately plan the lessons and teaching sequences, use materials appropriate to the learning objectives and the current level of the students the teacher is dealing with, and use a variety of teaching strategies with proven effectiveness (Piacenza & Trinchero, 2022). The use of different teaching strategies is essential to

overcome the limits of the traditional frontal lesson and promote a more effective and engaging teachinglearning action. For example, concerning students' ability to understand and analyse complex texts, numerous studies (Slavin, Madden & Leavey, 1984), including that conducted by Duke and Pearson (2002), highlight that the combination of different teaching techniques can significantly prove useful in enhancing not only the ability to understand but also the ability to reflect critically and apply one's knowledge in varied contexts (Duke and Pearson, 2002).

Based on this evidence, in the already started experimentation process undertaken by the S.Ap.I.E Scientific Association, the "Peer Feedback - Reading Comprehension - Reciprocal Teaching" (PF-RCRT) research program was developed and implemented in third classes of primary school in Campania during the 2023/2024 school year. The RC-RT program, associated with the PF (Peer-Feedback) methodology, intended to encourage, as well as an improvement in learning outcomes, the construction of a classroom environment aimed at developing the students' evaluative literacy, thus contributing to providing a structured framework for the critical analysis of texts by encouraging the crucial role of formative feedback, promoting significant improvements in text understanding and peer collaboration (Calvani & Chiappetta Cajola, 2019).

4. Limits and potential of peer feedback

Despite its growing use in educational contexts, peer feedback has both potential and limitations that must be considered to ensure its effective implementation. One of the main advantages of peer feedback undoubtedly lies in its ability to promote metacognitive and self-evaluation skills. Students, through the critical analysis of the work of others, acquire awareness of their strengths and weaknesses. Furthermore, peer feedback helps to internalize evaluation criteria, improving the ability to reflect on personal and collective performances. Such activities encourage the development of social skills, such as the ability to communicate clearly and constructively, and to manage conflicts. Students learn to provide feedback respectfully and helpfully and to cooperate within the class group (Grion & Restiglian, 2019). During peer feedback activities, students not only evaluate peers' work but also develop the critical thinking necessary to identify errors and make constructive suggestions. Serbati and Grion (2019) highlight that the IMPROVe model, developed to facilitate peer assessment, helps students engage in high-level cognitive processes, such as analysis and comparison, promoting critical reflection. According to Marzano (2023), students' active participation in the evaluation process stimulates greater motivation and deeper involvement in their learning path. Peer feedback is particularly effective in transforming classroom dynamics, allowing students to move from a passive to an active role, in line with the principles of active learning. As mentioned, however, this teaching strategy has some limitations: one of these concerns the quality of the judgments expressed by the students. Nicol (2014) warns that without adequate training, students can provide superficial or imprecise feedback, which does not lead to real improvement in work. Lack of evaluation experience can lead to insufficiently structured or uncritical feedback. Peer feedback, therefore, can also generate emotional distress, especially among students less accustomed to receiving criticism from peers. Stecca et al. (2022) note that some students may feel uncomfortable receiving feedback, especially when they perceive it as overly critical. Furthermore, class dynamics and peer relationships can have a negative impact, with the risk of feedback being distorted by prejudice or friendships. Effective implementation of peer feedback requires time both for training students and carrying out the activity. Grion and Restiglian (2019) highlight that preparing students to provide constructive and useful feedback requires specific training and that this process can require considerable effort, especially in large classes. In contexts where instructional time is limited, peer feedback may not be easily implemented. Peer feedback may not be equally effective for all students, especially in classes with widely varying proficiency levels. Less prepared students may not be able to provide adequate feedback, and more advanced students may not fully benefit from lower-quality feedback. Hattie and Gan (2011) therefore suggest that for peer feedback to be truly effective, it is necessary to ensure that students have a sufficient understanding of the assessment criteria and learning expectations. To respond to these critical issues, peer-feedback activities should be

structured at specific moments, on the model already tested and proven effective with university students (Marzano, 2023):

1. Definition of shared criteria;
2. Presentation of the topic and definition of the task to be carried out individually;
3. Discussion of the topics relating to the task;
4. Peer evaluation activity in which students anonymously receive the assignment of another student present in the classroom to evaluate it according to previously established criteria. Once the operation is completed, the feedback is sent again to the student to whom that task is assigned who can proceed to read the feedback;
5. Classroom discussion aimed at encouraging students to present their answers and reach a shared result.

5. Conclusions

Peer feedback proves to be an effective pedagogical strategy to overcome the limitations of frontal lessons and promotes active and collaborative learning. Through comparison with peers, students develop metacognitive, self-evaluation, and collaboration skills, in line with constructivist and socioconstructivist principles. Although the implementation of peer feedback requires attention to emotional training and the quality of the feedback, the results demonstrate that this approach can positively transform classroom dynamics by promoting more inclusive and participatory teaching.

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Between metaverse and gamification, new learning perspectives in university teaching

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Abstract

In recent times, the attention of scholars, researchers and experts has focused on the metaverse, Augmented Reality and Virtual Reality, technologies that seem to offer new learning possibilities through the creation of highly immersive learning environments. The recent field of exploration known as "eduverse", which sees the use of the metaverse in education, paves the way for significant and participatory teaching experiences characterized by considerable pedagogical potential. Multitasking, networking, distributed knowledge, collective intelligence, simulation, gaming are the characterizing dimensions of the new forms of communicative appropriation and of the informal culture of students, dimensions that require educational systems to change and adapt curricula, practices daily routines and teaching styles. At the same time, the use of playful approaches has increased in order to make learning an engaging and motivating experience. This contribution describes a gamification experience in the metaverse in a university context in order to reflect on the educational potential it offers teachers to set up innovative environments in which physical and digital integrate mutually to encourage experiential and collaborative learning.

Keywords: Metaverse, Gamification, Education, Virtual Reality.

1. Introduction

The increasingly imperceptible boundary between the analogue dimension of real life and the virtual dimension mediated by technologies (Floridi, 2017) together with the allencompassing presence of digital applications and the increase in hybrid teaching as a consequence of the Covid-19 pandemic have contributed to tracing a route, now irreversible, which leads in the direction of educational innovation. It sees continuous technological innovation as the main driver for thinking and developing alternative teaching/learning strategies to traditional practices, in order to allow personalized, engaging teaching experiences capable of meeting the different needs of students. In the unprecedented reality we live in, already predominantly dominated by artificial intelligence, new and vital challenges arise which concern the physical, mental, relational health and every area of development of individuals. Education systems, which have the task of training prepared and competent citizens, capable of moving autonomously and critically in a context characterized by high complexity and variability, find themselves facing digital plenitude (Bolter, 2019) and are called upon to adapt quickly to the characteristics of the media ecosystem. The necessity is to introduce virtuous and appropriate teaching practices into the school and university context, suitable for the current world, that of the post-human (Parisi, 2019), namely an unpredictable and fast-paced world where knowledge of the past is quite useless for regulating one's behavior in the present and future. In recent years, the developments that have affected ICT (Information and Communication Technology), and in particular the Web, have introduced elements that completely redesign both the training models of communication and provision of knowledge and the strategies and methodologies of acquisition and construction of knowledge and skills (Piu, 2007). Much more recently, the education technology sector is affected by significant changes due to the appearance of some technological trends that seem destined to have a very strong impact on teaching as well. This is a new generation of technologies represented by: Metaverse, Virtual Reality (VR), Augmented (AR) and Mixed (MR), Blockchain, Non-Fungible Token (NFT), Internet of Things (IoT), crypto currencies and Artificial Intelligence (AI). All these have made possible the growth and development of immersive virtual environments in

which knowledge becomes immersion in things, unlike in the past, when knowing was conceived as distancing from them (Colazzo, 2022). Teaching has the possibility of experimenting with new learning methods, which pass through the simulation of reality and the valorisation of bodily and motor experience in cognitive processes: the action is embodied (Baloian & Zurita, 2012) as the user embodies in a virtual body, or avatar, which together with the sense of presence makes the experiences and

interactions within the simulated world realistic, as if it were a character in a video game (VanFossen & Gibson-Hylands, 2023). The virtual body will allow us to live new experiences and dimensions of reality that are currently inaccessible to the physical body, manipulating the rules of time, the body and physics within immersive paths with a high educational density that imply the performance of interactive activities, authentic and dynamic tasks. The extension of the senses and nerves beyond the finiteness of his body (McLuhan, 1964) allows man to immerse himself in the infosphere, to be Onlife (Floridi, 2015) and live a new dimension, further than the physical and virtual ones, in which to experiment with new ways of relating to the world, to others and to knowledge. One of the areas closest to the metaverse, to Virtual and Augmented Reality is that of gamification which uses aspects and potential of the game in learning contexts in order to impact motivation and attention, proposing environments that can take on the role of "bridge" between physical and virtual, guaranteeing the educational and didactic continuum necessary for learning (Accoto, 2022). Immersive technologies, protagonists of the new technological trend, envelop the user deeply on a sensorial level. For those who work in the teaching and training fields, the main question that arises is whether this greater perceptive involvement offered by virtual realities and the new paradigm of the Metaverse entails appreciable benefits in learning, without neglecting the ethical, legal, anthropological and social implications that will result from its use. In an attempt to participate in the answer, the contribution describes an experience of using the metaverse and gamification in a university setting.

2. Materials and Methods

Before carrying out the gamification experience, an initial questionnaire was administered to verify the students' initial starting point regarding the topic. When asked about their knowledge of the Metaverse, the majority responded that they did not have a clear idea of what it was about, a small portion of the students stated that they had consulted various sources to inform themselves independently, while a third of the sample subject to the questionnaire responded that they had no idea of the Metaverse at all (Figure 1).

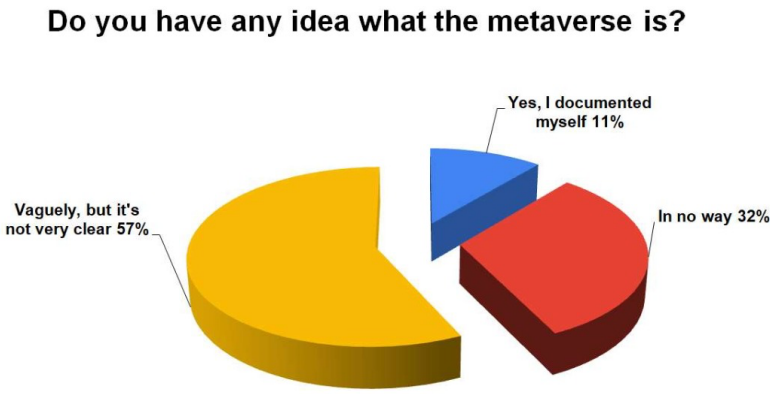


Figure 1 - Questionnaire, Metaverse knowledge question.

To a subsequent question, many of the students answered that they had never used a Virtual Reality headset, and only a small portion had had the opportunity to use them at school or in other contexts (Figure 2).

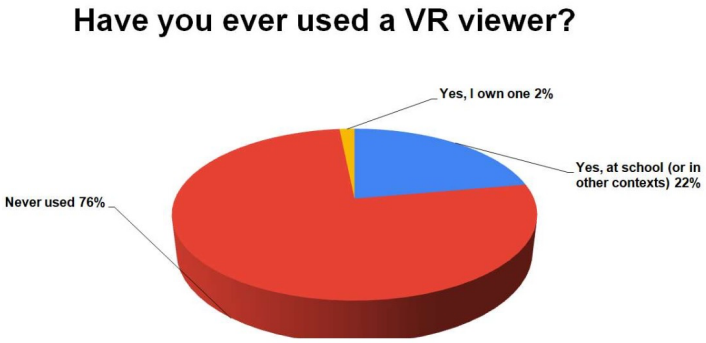


Figure 2 - Previous experiences with VR headsets.

A predominant part of the participants in the initial questionnaire expressed their appreciation for the use of immersive technologies in an educational context, despite not having the necessary skills to manage and manipulate them in order to create personalized content (Figure 3).

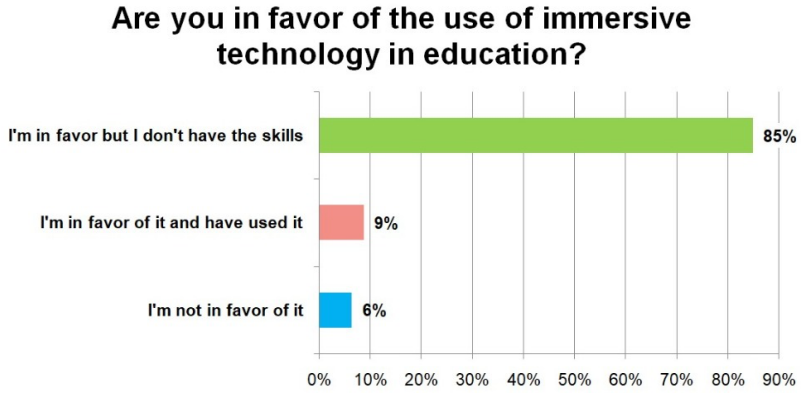


Figure 3 - Using immersive technologies in education.

When asked about the time spent playing video games, about 66% answered that they never play, almost 13% indicated that they play more than two hours a week, but not every day, while 5.56% answered that they play every day. Most of the students, almost 83%, answered that they had never used video games in a school or university context to learn and study. The experience described in this paragraph was started following some lessons on gamification and immersive technologies, to ensure that all students could acquire the necessary information on these two topics and participate in an informed manner. The gamification experience was created through an immersive environment containing teaching materials and a series of “serious games” (Figure 4). The experience was conducted as part of the "Laboratory of Educational Technologies I" course held at the University of Calabria. It is part of the courses activated for the first year of the Degree Course in Primary Education Sciences. For this reason, it is followed almost entirely by students who can be classified as digital natives both in terms of anagraphic characteristics and the learning and communication styles they possess. The environment allowed students to step into the shoes of another, an avatar, or a digital incarnation of themselves. The ability to interact with the environment and virtual objects can have a strong psychological impact on learning (Lombardi, 1997). The playful contents present in the environment have been divided into four sections, corresponding to the respective learning units into which the course program has been divided. The students were able to experiment with quizzes and games with various types of educational purposes created to reinforce the learning of the contents exposed by the teacher during the lessons. The games were designed first and then proposed according to a gradual criterion, with progressively involvement (Goehle, 2013).

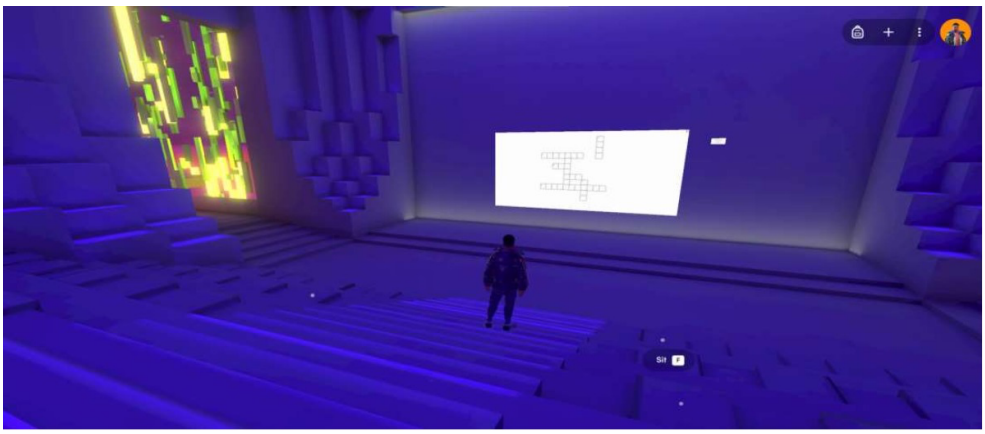


Figure 4 – One of the rooms in the immersive environment.

3. Results

The gamification activity in the metaverse stimulated the students' curiosity. They actively participated in the proposed experiences, motivated and rewarded by an innovative approach to the lessons. This approach has contributed to developing a better relational climate and to experiencing the moment of face-to-face teaching and individual study with greater awareness and serenity. The final prize for those first in the ranking, consisting of exemption from a part of the program during the exam, represented a further incentive for participation and interaction. The reward given at the end of the experience prevented a loss of interest and involvement during the activity, and led students to consider it as the result of their commitment: consequently, it was more rewarding. At the end of the experiment, a satisfaction questionnaire was administered online both on the gamification activity conducted and on the immersive environment used, in order to understand the students' opinion, their point of view and obtain useful feedback for future improvements. When asked about its usefulness in the educational field, 76% believe that an immersive environment like the one experienced could be quite useful, 18% consider it very useful, while the remaining 6% consider it not very useful (Figure 5).

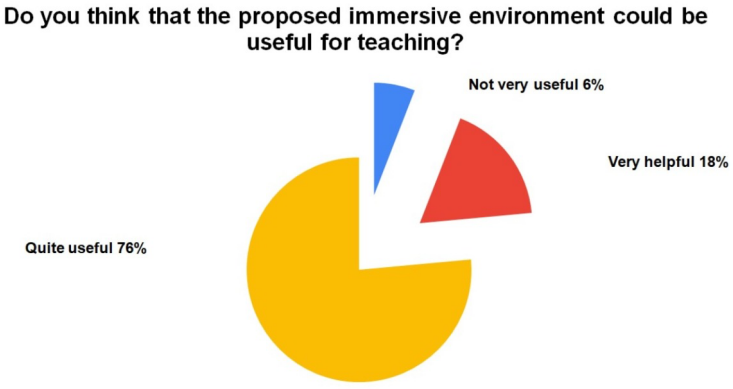


Figure 5 - Opinion on the usefulness of immersive environments in teaching.

In a rating scale from 1 to 5 regarding the feeling of being involved by the visual aspects of the virtual environment, 65% indicated values between 4 and 5, confirming how very realistic graphics and the possibility of moving 360 degrees have a significant impact on those who experience this type of experience.

88% of the students who ronded expressed themselves in favor of introducing Virtual Reality technologies into their educational curriculum, while all of them are of the opinion that the use of games and recreational activities in a university course makes the transmission of concepts and knowledge and the understanding of the topics better than a course taught in a traditional way.

When asked about the comparison between the experimented environment and the LMS platform used to support the teaching activities throughout the course, 53% of the students are of the opinion that they could use them together, 18% say they prefer the elearning platform, while 29% would like to use the immersive environment again to give an adequate judgment. Despite having recorded an overall satisfaction, it should be emphasized that none of the students declared themselves in favor of replacing the e-learning platform with the virtual environment. When asked how motivating and engaging the course was, conducted according to the dynamics described, on a scale of 1 to 5, approximately 82% of the students were divided between the highest answers (value 4 or 5).

4. Discussion

Coined in 1992 by Neal Stephenson in his science fiction novel (Stephenson, 1992), the term metaverse has now entered the pedagogical lexicon and is the subject of studies and research on the renewal of teaching and learning practices due to the growing interest in it by researchers and experts in the sector. The concept of metaverse today still seems vague (Di Tore, 2022) and there is no shared scientific definition. Indeed, according to some scholars, the true metaverse does not yet exist and will not see the light until certain technological requirements are met (Lee et al., 2021), while for others various metaverses are already present, identified by different experiences of Extended Reality (Suzuki et al., 2020). According to Matthew Ball, the metaverse can be defined as “a highly scalable and interoperable network of 3D virtual worlds redirected in real time, which can be experienced synchronously and persistently by an effectively unlimited number of users with an individual sense of presence within them, and which guarantee the continuity of data, relating to identity, history, rights, objects, communication and payments” (Ball, 2022). Based on this definition and the statements of Zuckerberg, founder of Meta and protagonist in the development of this “embodied Internet”, it can be deduced that the metaverse will be, or promises to be, the digital alter ego of the real world, with which it will be able to interact constantly, influencing each other so that every action in the real world has a reflection in the digital one and vice versa. A universe, therefore, not limited to the playful or social dimension, but capable of hybridizing and extending the spaces used in other contexts of everyday life. The existing literature currently identifies Augmented Reality (AR) and Virtual Reality (VR) among the fundamental components of the metaverse (Smart et al., 2007). While AR amplifies the real world with the superposition of digital contents, as if they were an integral part of the environment in which they are located, with which to interact via smartphone, tablet, PC or other devices, VR describes a 3D space that the user can explore in first person via ad hoc devices (visors, helmets, glasses), simulating a sense of presence and deluding themselves into thinking they are present in that place (Slater & Sanchez-Vives, 2016). These technologies, to date, are among the most effective for designing and creating experiences with the highest possible degree of immersion and presence and are an integral part of a hypothetical metaverse that reproduces aspects of the physical world to offer users participation in events of various kinds (Park & Kim, 2022). An environment is immersive to the extent that it can deceive a person's cognitive and perceptive system, making them believe they are in a different place than where they are physically located (Patrick et al., 2000). Considering Milgram's taxonomic scheme on virtual realities, we can identify different degrees of immersion that do not always completely exclude reality, as in the case of Augmented Reality where the real environment mixes with virtuality. And it is precisely the use of a virtual continuum, through the application of AR and VR (Krajčovič et al., 2022), one of the possible approaches to import these technologies, and the metaverse, into the educational context. These technologies are contributing to the redefinition of the traditional concept of learning environment, which gives way to hybrid environments in which the inclusive and didactic educational potential of physical spaces and digital environments can merge. Significant investments, represented by the National Plan for Digital Schools (PNSD) and the National Operational Program (PON) 2014-2020, have been launched in recent years to give impetus to the redesign of learning spaces in schools, up to the current School Plan 4.0, envisaged by the National Recovery and Resilience Plan (PNRR), which aims to strongly accelerate the process of

digitalization of Italian teaching. These new dimensions of hybrid learning configure the eduverse, or the application of the metaverse to learning contexts, a recent field of exploration that offers new spaces, tools and languages that must be understood and mastered. In order for teachers to be able to intentionally set up 3D environments consistent with the objectives to be achieved, it will be necessary to reflect and discuss the educational and didactic, technological and psychological aspects, keeping in mind that these "new places", which have points in common with social media and gamification, have the potential to define new ways of interacting and relating. This world opens the way to new forms of constructivism, as highlighted by a recent study that compares learning in the metaverse with learning in the classroom and that of traditional e-learning systems (Zhang et al., 2022). Students can experiment with activities for the acquisition of knowledge, skills and attitudes by manipulating three-dimensional objects, or by immersing themselves in three-dimensional educational scenarios that reproduce real contexts that are difficult to visit (universe, planets, marine environments, etc.) or historical settings that no longer exist. The visually vivid scenes enabled by the metaverse allow for STEM (Science, Technology, Engineering, Mathematics) experiments without worrying about the consequences of wrong actions that would occur in a real situation, inducing students to make independent decisions and increase interest in the discipline. Language teaching, medical training with simulated surgical interventions, the study of mechanics, professional training, flight simulation for pilots and astronauts, are some of the other endless applications of immersive technologies that characterize learning as experiential, authentic and situated (Rivoltella, 2016). The persistence that will characterize the metaverse makes it an almost omnipresent educational space (Dionisio et al., 2013): as it is always accessible, it promises to overcome the time and place limitations of traditional lessons and distance learning, offering great opportunities for the persistent implementation of education in the post-pandemic era. The new immersive world is also a new opportunity in an inclusive sense: the teacher can customize materials and the environment in order to personalize them to the individual needs of BES or disabled students (Rossi et al., 2023). The latter will be able to feel less excluded and more involved in the new immersive dimension, in which real physical disparities cease to exist, allowing movements and behaviors that are now impossible in traditional environments. Being represented by an avatar and being able to configure its physical characteristics, from a psychological point of view represents a relevant issue, as it gives disabled students the opportunity to configure a new identity and choose whether or not to represent their condition (something similar to what was already experienced in distance platforms during the lockdown). Some studies and experiments on the use of the metaverse and virtual reality for the learning of students with autism spectrum disorders (Zahabi & Razak, 2020; Cheung et al., 2022) have highlighted positive effects on the learning of social skills, acquired in the immersive environment and transferred to the real world. The potential, only outlined, are countered by a series of questions and problems that are no less challenging. The accessibility and affordability of the devices needed to connect, the management of privacy and the use of personal data, digital dependence and social exclusion, security, the absence of a shared standard protocol, represent open questions to which it will be necessary to provide answers.

5. Conclusions

Agencies operating in the world of education and all the interested parties are facing an unstoppable Copernican revolution, which affects culture and society globally. ICTs play a leading role as agents promoting a development that proceeds at an exponential rate. Institutional agents of education and training, consequently, are called upon to implement new actions, strategies and educational paths to promote in students creative and innovative skills, competence in the responsible and effective use of media, critical and reflective thinking and all those intangible skills and soft skills necessary for individual, professional and civil development. This entails the need to go beyond the closed approach typical of traditional educational and training systems, expanding spaces, times and training tools, promoting the interconnection between formal, non-formal and informal environments, also exploring new learning methods. The experience

described in this work should be considered positively both with regard to the direct feedback received from students in the satisfaction questionnaire, and the indirect feedback represented by the interactions and participation recorded during the activities. This confirms how it is necessary to undertake and continue on the path of a teaching that adopts more flexible strategies in terms of the methods of transmitting knowledge, more interactive and engaging, so as to be stimulating for the different intelligences and cognitive styles present in students, giving greater emphasis to the social, emotional, experiential dimensions of learning processes.

All this considering that a calibrated use of technologies, within well-designed training processes, helps subjects to reflect on the methods of building skills and knowledge, prefiguring a socio-cultural scenario in which to activate multiple and innovative teaching strategies, taking into account that it is not the tools themselves, but the methods and the "how" they are used that promote new learning. The immersive environment and gamification have made it possible to achieve the goal of involving students more than what happens in traditional university teaching, to offer significant and interesting learning opportunities by focusing attention on mechanisms that encourage participation and motivation. At the same time, metaverse and gamification have contributed to improving the quality of relationships between students and teachers and between students themselves.

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Balancing innovation and integrity: the dual role of Generative AI in transforming journalism. A Systematic Literature Review (2020-2024)

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Abstract

Artificial Intelligence has been part of journalism since the Associated Press embraced it in 2014, experiencing a significant surge with the advent of OpenAI's ChatGPT in late 2022. This period marks an era of exploration into generative AI's future role in journalism, as leading publishers like the BBC, Reuters, NYT, and Financial Times transparently initiate task forces to weave generative AI into news production processes. This paper presents a systematic literature review based on searches in Scopus including the terms "Generative AI and Journalism," "machine learning and journalism," "artificial intelligence and journalism," "automating news," and "bot + journalism." Additionally, over 300 articles published in global media from the first use of generative AI (January 2023) to the end of September 2024 were analyzed. The dual aspects of generative AI in journalism emerge distinctly. Ethical concerns and the potential for misinformation pose significant risks to democracy, complicating the distinction between authentic and AI-generated content, alongside issues like plagiarism, "hallucinations," opaque communication, and the threat to replace journalists. However, generative AI also holds the potential as a catalyst for creative news production and can enhance investigative journalism if applied with strict controls, reader-centric motivations, and adherence to the enduring principles of journalism: truth and transparency. The study underscores the need for an ethical framework guiding AI's journalistic use, arguing that, with conscientious human oversight, generative AI can significantly transform journalism, balancing technological innovation with journalistic integrity.

Keywords: Artificial Intelligence, Generative AI, Journalism Fake News, Ethics.

1. Introduction

In the post-media era (Eugeni, 2022), generative artificial intelligence promises to profoundly transform the role of journalists and global journalism practices. The crisis of traditional media, referring primarily to newspapers and, to a slightly lesser extent, television, has been steadily growing over the past 20 years, driven mainly by the rise and consolidation of digitalization. This digital revolution has led to significant media fragmentation and the rise of social media, expanding the availability of information while contributing to the spread of misinformation and disinformation (Das & Ahmed, 2022), which has undermined public trust in journalism worldwide. In this evolving context, media companies have been compelled to change their business models, and the processes of news production have undergone substantial shifts over the past two decades. The journalist's role has transitioned from that of a fieldbased observer to a newsroom-based professional focused on verifying and reworking information from various sources. Despite these changes, the journalist's role remains central to ensuring the credibility and balance of the information provided to the public (Martinez García & Capoano, 2023), which is essential for maintaining checks on political power in democratic societies. Technological innovation in journalism requires the ability to navigate ambiguity, a challenge anticipated in Plato's concept of *pharmakon,* which signifies both poison and remedy. The risks posed by digital technology – its "poison" – can turn into opportunities when applied carefully. Since the early 2000s, fields like digital journalism, data journalism, and computational journalism have emerged, each offering new ways to interpret and present information. These approaches, together with algorithmic journalism, provide valuable insights by integrating data science, computer science, mathematics,

statistics, and social sciences (Witschge et al., 2016). As Fridman et al. (2023) explain, "*Data journalism is a field that incorporates data analysis, visualization, and database use with traditional journalism practices to uncover and tell stories".* Data journalism continues to play a pivotal role in enhancing transparency, accountability, and informed decision-making (Bounegru & Grey, 2021). Similarly, the dual role of generative artificial intelligence in journalism presents both opportunities and challenges. Before the introduction of ChatGPT in November 2022, artificial intelligence had already been used in journalism for about a decade, primarily for automating routine tasks, such as producing content in sectors like finance, sports, and weather forecasting (Broussard et al., 2019). AI methods like machine learning and natural language processing (NLP) were employed to analyze large datasets and generate coherent texts without direct human intervention (Hossain & Wenger, 2024). Media organizations like The Associated Press, Bloomberg, and The New York Times adopted AI to increase the speed of news production and reduce operational costs (Fernández et al., 2024). The advent of ChatGPT, developed by OpenAI has expanded AI's potential in journalism even further: generative artificial intelligence systems are trained on large datasets to understand patterns and relationships. They use deep learning algorithms and neural networks to generate new content that resembles human-created work (Radford et al., 2019). After the ChatGpt release, other similar tools such as Copilot, Gemini, Midjourney, and Perplexity, have expanded beyond text, beginning to produce videos, images, and other complex multimedia formats. These tools utilize large language models (LLMs) to autonomously generate content, transforming journalism by automating news creation, streamlining workflows, and introducing new methods for storytelling and information dissemination (OpenAI, 2023). While generative AI offers promising opportunities, it also raises significant ethical concerns regarding its potential impact on journalistic integrity and professional standards. The challenge lies in balancing technological innovation with fundamental journalistic values, such as truth and transparency (Floridi, 2020). This article conducts a systematic literature review to explore two key research questions:

RQ1: How can the adoption of generative AI strike a balance between innovation and integrity in journalistic practices?

RQ2: What is the current level of AI literacy among journalists, and how can it be improved to promote the responsible use of AI technologies in journalism?

2. Materials and Methods

The primary objective of this study is to investigate whether journalists' digital and AI-related competencies are evolving in line with the rapid development of new technologies, which are often perceived as irrelevant to their work, especially by older generations, or viewed solely as tools for task automation. This research aims to provide a comprehensive, multidisciplinary, and cross-cultural overview of the rapidly changing global media landscape. It seeks to identify key issues related to the use of AI in journalism, focus on the most controversial and significant topics in news production, outline future challenges, and suggest further areas for research. The methodology of this study follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and rigor in the process of identifying, selecting, and analyzing the relevant literature. Using the digital academic database Scopus, scientific articles published between 2020, and September 2024 were collected and cataloged. The Scopus database was chosen because it is commonly regarded as one of the most comprehensive in scientific literature. Data were extracted into an Excel file, including the author, article title, year of publication, journal, citations received, abstract, and keywords. Articles published in both English and Spanish were considered, given the active scientific production in the Iberian and South American regions. The Excel file was generated for the quantitative analysis of the contents. The search terms included "Generative AI and Journalism," "artificial intelligence and journalism," "automating news," and "robot journalism." The final query was structured using the following Boolean logic: (journalism AND artificial AND intelligence OR ChatGPT OR disinformation OR AI OR generative AI). Over 300 articles encompassing various disciplinary fields such as communication, data science, sociology, and others, were initially retrieved and

subsequently reviewed based on specific exclusion criteria: all selected papers had to be peer-reviewed. Articles focusing on specific historical periods, such as the COVID-19 pandemic, or those dealing with overly specific case studies in specialized fields (science communication, medicine, law), were excluded. Additionally, studies that did not represent general trends or focused on a single country with very limited research samples were omitted. After applying these criteria, a dataset of 202 articles was created, of which 175 were from scientific journals. Other sources, such as book chapters, were excluded from the systematic literature review but considered for a theoretical framework only. The results of the selection and inclusion process are visually represented in a PRISMA flow diagram, in Figure 1, which outlines the identification, screening, eligibility, and inclusion of articles for this review. The 175 papers included in the systematic literature review were grouped by thematic areas and divided into the following categories:

1. Automating: transformations in the process and product of news creation.
2. Sentiment: perception, and attitudes of journalists and readers towards AI and Generative AI.
3. Disinformation and Fact-Checking: the production of fake news, photos, and videos, as well as potential tools and applications for verifying news accuracy.
4. Ethics and Regulation, topics such as transparency, accountability, guidelines, and the need for regulation.
5. Data and Digital Journalism, the role of datafication and AI in news production.
6. Training: the need for AI literacy among current and future journalists, especially given the rapid pace of technological change that outstrips traditional learning timelines.
7. Strategy and Tools: the development of Generative AI tools, with a focus on case studies deemed particularly relevant.
8. Systematic Review: an overview of previous research in the field, 9) Others. See in Table 1.

Additionally, a database containing over 300 articles published in international media from late 2022 to September 2024 was analyzed to understand the practical application and use of generative AI in newsrooms. This database is available on the Slack platform of “Journalist AI Connect”, a community of over 1,400 journalists supported by the London School of Economics and Political Science. Within this community, professionals exchange ideas and best practices concerning AI and the development of Generative AI in journalism.

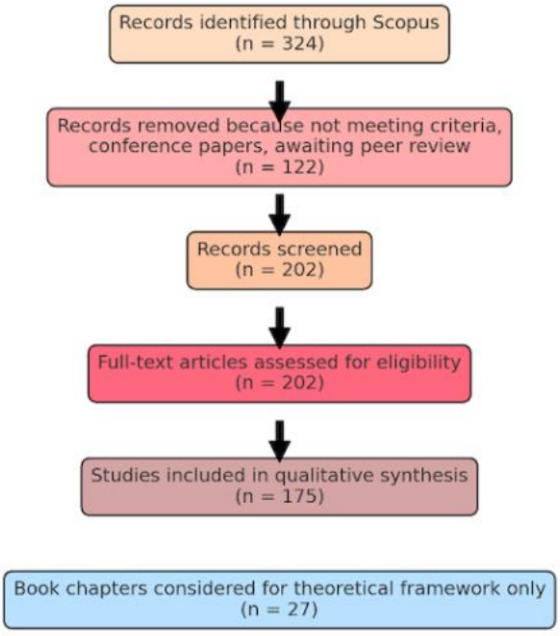


Figure 1 - Prisma Flow Diagram.

Table 1 - Paper's categories.

Category	*Articles*	*%*
Automating	46	26
Sentiment	39	22
Fact checking and disinformation	26	15
Ethics and Regulations	21	12
Strategy and Tools	13	7
Data and Digital Journalism	10	6
Training	9	5
Systematic Review	8	5
Others	3	2

The Data Analyst tool in ChatGPT was utilized to assist in the data analysis and categorization process, aiding in the identification of patterns and recurring themes across the selected literature, as well as in generating graphs. The remainder of the analysis was conducted manually and independently, without the use of specialized reference management tools or quantitative and qualitative analysis software. This manual approach ensured meticulous attention to the selection and organization of the articles, thereby enhancing the relevance and accuracy of the categorization process.

3. Results and Discussion

The dual role of generative AI in journalism, as suggested by the title of this article, has been confirmed by both the quantitative and qualitative analysis of the papers considered. On one hand, AI brings innovation by improving efficiency, automating repetitive tasks, and freeing journalists for more complex work (Peña-Fernández et alt., 2023). On the other hand, AI raises concerns about integrity, such as the potential for spreading bias or disinformative content, which requires strict human supervision and monitoring, offering also possible solutions through the implementation of ethical guidelines and robust editorial oversight (Trapova & Mezei, 2022). The quantitative analysis of the papers reveals the significant impact that the emergence of generative AI has had on research since the release of ChatGPT in November 2022. Academic interest has grown globally, with an exponential increase in scientific output, as illustrated in Figure 2. This growth peaked in 2023 and continued throughout 2024, though the data for 2024 is partial, as the database consulted for this study extends only until September 2024. According to Scopus, as of that date, approximately 40 additional articles were awaiting peer review. Before the release of ChatGPT, research on the relationship between artificial intelligence and journalism was predominantly centered in the United States (Sonni et alt., 2024). However, since late 2022, researchers from the Iberian Peninsula and South America have shown a marked increase in interest, with over 50 articles published, accounting for 28% of the total analyzed in this dataset.

The keyword analysis confirms the research interest and focuses on artificial intelligence, as illustrated in the graph, with two key terms: "artificial intelligence" and "AI." These terms reflect the dominant themes and highlight emerging trends. The identification of these keywords aligns with the objective of this review, which seeks to understand how artificial intelligence and generative AI are being integrated into the processes of journalistic production, distribution, and personalization of news. Additionally, other terms such as "automated journalism," "automation," "machine learning," and "digital journalism" further demonstrate how news automation has become an established field of research, as shown in Figure 3.

The data also reveals another trend of significant interest, which is confirmed by the analysis of themes related to the automation of journalistic work. This trend will be explored in more detail in the following sections, where we will examine emerging dynamics, concerns, and phenomena that the impact of generative AI is causing in content and news production. This term is used to refer to generative AI tools' ability to generate not only text but also audio and video, often

indistinguishable from real-life events. The increase in articles under the "Automating" category runs parallel to the rise in the "FactChecking and "Disinformation" category, as well as, to some extent, the "Ethics and Regulation" category. This trend has accelerated since 2022, driven by growing interest in the subject, particularly following the release of ChatGPT as in Figure 4.

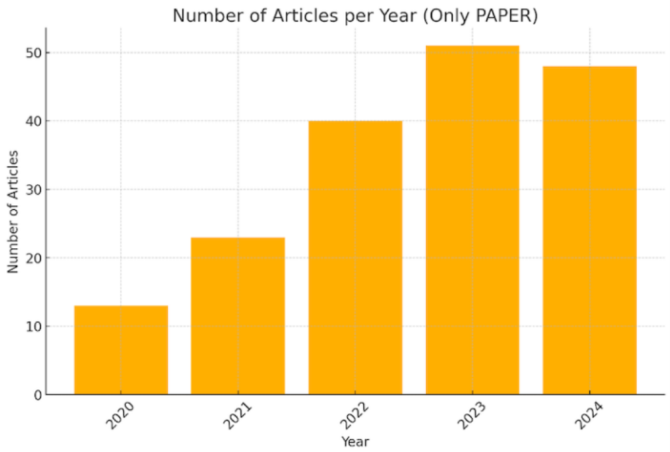


Figure 2 - Distribution of Articles by Year**.**

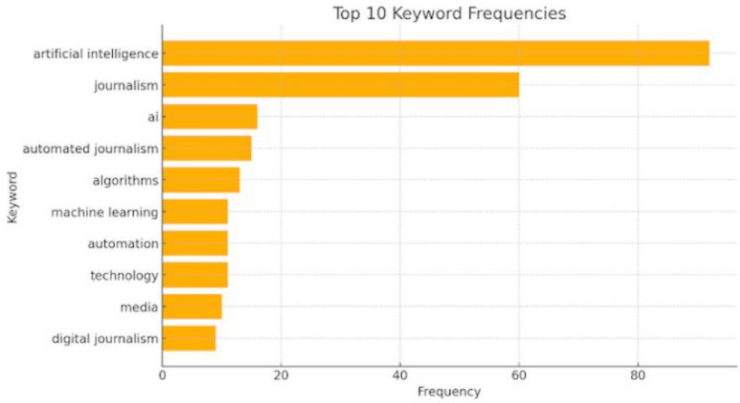


Figure 3 - Keyword frequencies**.**

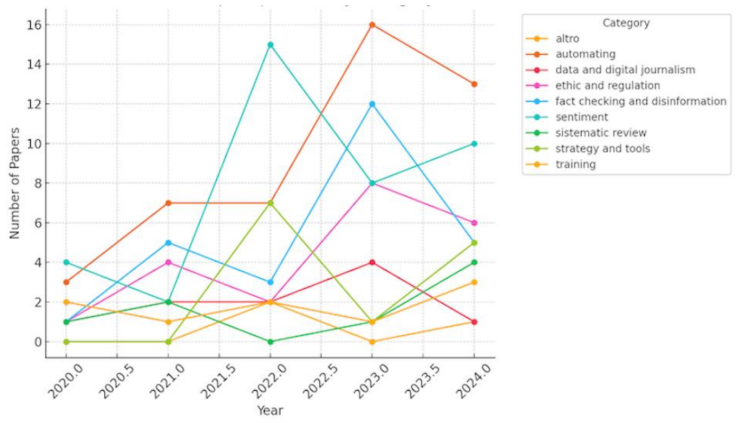


Figure 4 - Papers per Year by Category.

The AI and Generative AI tools available to journalists are useful for summarizing texts, retrieving information, understanding data, and creating structures, as well as transcribing interviews and generating catchy headlines, as highlighted by the qualitative analysis of articles in the

“automating” category. These tools aim to accelerate and improve efficiency in both news production and distribution. Another emerging trend is the personalization of content based on readers' interests, allowing for the creation of tailored news for individual users or audience groups. Automation in news production can reduce costs, especially for small outlets or start-ups, as it can create value (Rinheart & Kung, 2022) by allocating human resources to activities beyond routine tasks, enabling smaller organizations to compete with larger ones that have more extensive editorial resources (Vogler et al., 2023). Major media companies are also developing their models for using Generative AI. For instance, Reuters set a benchmark with its News Tracer, which, since 2018, has used AI to extract and verify news from social networks. In the financial sector, Bloomberg has developed its language model and platform (Quinonez & Meij, 2024). AI is used to accelerate production, improve accuracy, and provide real-time complex analysis, though always under the supervision of human editors. Other outlets, such as the Financial Times, have entered into agreements with OpenAI to train ChatGPT in the historical style of the financial newspaper, thereby consolidating their readers’ trust and enhancing their reputation. We are likely still in an experimental phase, as media organizations like Aftonbladet (Sweden), Verdens Gang (Norway), and Helsingin Sanomat (Finland) have begun adding bullet points at the top of their articles. Aftonbladet, along with the Argentine El Clarin, has introduced short summaries of articles written by journalists, which have increased overall engagement. Younger readers are more likely to click for additional information (Newman, 2024). Although other mainstream media outlets like the BBC and the New York Times are deepening their use of Generative AI, these tools are still rarely used to write longer, more complex texts intended for direct publication. Where they are used (especially in local media), the limitations of the technology – prone to frequent hallucinations—have been highlighted (Pavlik, 2023). Spanish television RTVE even conducted a pilot project during the 2023 municipal elections using automated writing, transforming election results into news without human intervention (Aramburù & Moncada, 2023). The adoption of AI and Generative AI has been slower in traditional media, which tend to have a more balanced approach compared to digital media, due to their established infrastructures and less flexible corporate cultures (Quinonez & Meij, 2024). Analyzing the Sentiment category, journalists' attitudes and perceptions of Generative AI technologies are mixed. On one hand, the benefits are recognized when the tools are harmonized with traditional journalistic practices. On the other hand, skepticism persists regarding the future impact of automation on job security: many professionals fear increased unemployment and reduced opportunities for creative and investigative journalism, worrying about losing the profession's identity (Lewis et al., 2019). Some researchers argue that Generative AI can undermine journalistic professionalism, asserting that "Without journalists, there is no journalism" and that automated news could lead to a decline in quality (Fernández et al., 2023). Nevertheless, by automating routine processes, Generative AI frees editors to engage in more creative tasks, enabling them to identify and pursue more exclusive stories. The public also seems to have more trust in news written by journalists rather than AI (Newman, 2024). From a theoretical perspective, while it may be anachronistic in the post-media era to base journalism on the concept of truth, Moriggi et al. (2023) values such as credibility, reliability, and authority remain key ethical principles that characterize the profession. The integration of artificial intelligence in journalism challenges existing ethical frameworks, requiring a reassessment of how we ensure accuracy, fairness, and accountability in an increasingly automated world (Ess, 2009). Journalists have a deontological obligation to verify their sources – something that does not occur, for instance, on social media, which is one of the main vehicles for spreading fake news. UNESCO, in its Handbook for Journalism Education and Training, uses three terms to categorize misinformation:

> *“Misinformation is false information, but the person disseminating it believes that it is true. Disinformation is false information, and the person disseminating it knows it is false. It is a deliberate, intentional lie and points to people being actively disinformed by malicious actors. A third category could be termed mal information: information that is based on reality but used to inflict harm on a person, organization, or country”.*

AI and Generative AI have an immense capacity to construct and disseminate false and synthetic content, not only text but also audio and video, often creating a dangerous echo chamber effect, promoting propaganda, and posing serious challenges to democracy. This can be seen, for example, in events like Brexit or the recent Capitol Hill riots in the United States. Additionally, this type of disinformation can be particularly damaging during election periods, influencing voters' opinions on candidates, parties, and key issues (Peña-Fernández, MesoAyerdi & Larrondo-Urkizu, 2023). At the same time, AI has long been employed to combat disinformation, with many news organizations developing increasingly sophisticated fact-checking tools. An example is the New York Times' AI-guided analysis of Gaza bomb craters, which contradicted the official version of the Israeli army, coordinated by expert journalists. The main issues emerging from this research concern ethical and legal questions and the risk of weakening democratic processes due to a lack of transparency and potential bias. Transparency in the use of AI, along with the requirement to disclose its use, stands as the primary ethical standard, as does human oversight of all content and attention to algorithmic biases. The AI models, learning from the data on which they are trained, can reproduce or amplify biases already present in the original information (Brown, 2023). The discussions emphasize the need for regulation to prevent the misuse of AI and Generative AI. AI and Generative AI can provide valuable support for journalists, contributing to a more robust information ecosystem. However, this requires the critical application of technology, adherence to specific ethical guidelines, and, above all, adequate AI literacy and training for journalists to increase their digital competencies. A recurring theme in this review is the need for continuous, accessible training for journalists, enabling them to develop technical skills in using AI and Generative AI and fully understand their ethical implications (Lopezosa et al.,2024). The current gaps in AI literacy make it essential to promote training programs that teach not only how to use the tools but also how algorithms work, and the risks associated with bias. Ensuring the responsible integration of AI in journalism is a more significant challenge than merely using various tools. Moreover, continuous monitoring of AI's impact on journalistic practices and democratic processes, as well as exploring new AI applications in news production, remains critical.

4. Conclusion

The growing adoption of Generative AI in journalism presents a crucial challenge: balancing technological innovation with professional integrity. Tools based on advanced language models, such as ChatGPT and similar systems, not only relieve journalists from repetitive, less creative tasks but can also increase productivity by up to 50% in specific areas like tagging, transcription, and editing (Diakopoulos, 2024). However, these tools require constant human supervision, as so-called "hallucinations" – inaccurate responses generated by AI – are frequent and require verification. The relationship between journalists and AI can evolve towards more personalized forms, where generative AI becomes a continuous interlocutor, capable of providing insights and deeper analysis. With proper training, each journalist could, over time, develop their own "Small Language Model" (De Kerckhove, 2024), adapting it to their writing and research style. The findings of this review suggest that the future of journalism will take the form of a hybrid model, where AI offers technical support, but the final editorial responsibility remains in the hands of human professionals, who must always curate the AI-generated content to ensure its integrity. Generative AI should not be seen by media companies as a replacement for journalistic work, despite the strong temptation, particularly among smaller publishers. Critical judgment and human interpretation remain the best guarantees of quality and ethics, a point reiterated throughout this analysis (Floridi, 2022). Ethical challenges emerge as a recurring theme across all categories covered, going beyond the internal guidelines adopted by individual media companies, which are often not fully integrated or co-created with the journalists themselves. Continuous monitoring to prevent bias, transparency in the use of AI tools, and the need to balance training with respect for citizens' privacy remain central ethical concerns. The issue of copyright also remains highly controversial: content produced by Generative AI, despite being based on pre-existing knowledge, may constitute an original product that should be protected. In conclusion,

the integration of Generative AI in journalism requires a conscious balance between technological innovation and the preservation of editorial integrity. While AI represents a powerful tool for automation and analysis, constant vigilance is necessary to prevent the risks of misinformation, bias, and superficiality in content. Paradoxically, while AI's ability to generate images and videos may increase the spread of fake news, it could also become the best antidote to disinformation, supporting journalists in fact-checking. The future of journalism will depend not only on the adoption of new technologies but on how these technologies are integrated while preserving human judgment and professional ethics. In this regard, improving AI literacy among journalists is essential, not only for using the tools but also for understanding the underlying algorithms and the risks of bias. Continuous, accessible training for journalists remains critical to ensure the responsible integration of AI. A personal reflection concerns the future role of the journalist. Who will the journalist of tomorrow be, and what identity is being shaped? The pace of technological evolution far exceeds the time needed for learning. While digital tools enable rapid information processing, it is unreasonable to expect journalists to constantly update their IT and computational skills or to adapt to every new AI tool. As is already the case in some countries, it might be beneficial, if not essential, to introduce a support figure alongside journalists, acting as a bridge between innovation, production, verification, and the personalization of news. Perhaps we could reach a common epistemological approach between journalism, data sciences, and computer science, precisely to integrate AI systems with the values of transparency, verification, reliability, and the tendency toward objectivity, which are inherent to journalism, a field with social responsibility. (Dierickx & Linden, 2023) Finally, a further consideration concerns the Italian context. While Spain has experienced immediate research development in this field, the database considered in this review contains no articles referencing how Italian media companies are engaging with Generative AI, apart from the agreement between Gedi (Italy's second-largest media group) and OpenAI. The topic seems almost taboo, especially in a heavily unionized context like Italy, indicating the need for further research and implementation in the national context.

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Soft Skills for Green Transition

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Abstract

Climate change is progressively changing the nature of work in various occupations and the skills required of many workers even in the STEM fields. Education at all levels, including higher education, should face these changes, adapt to new challenges and conditions, and change its approach to teaching. Traditionally, hard skills have been considered essential, yet several studies highlight the crucial role of soft skills in rapidly changing working environments. Therefore, developing these skills as part of a holistic approach to the 'greening' of the economy is essential for educators, as their students are future workers and potential change agents in the green industry. At the same time, more knowledge about the context in which soft skills are used is of great interest.
The findings of this research provide some interesting insights for STEM educators: soft skills are widely recognised, but some of them, such as communication, empathy, problem-solving, and metacognition are particularly useful as the green transition essentially involves changing mindsets, working in multidisciplinary environments and influencing employees and customers. The connection with industry stakeholders as co-designers or simply contributors to the learning experience, and collaboration between faculties, fostering transdisciplinarity, can be a leverage to develop such skills.

Keywords: Green Transition Skills, STEM Education, Soft Skills in Green Transition, Green Transition Skills Gaps, Sustainable Development.

1. Introduction

The research conducted within the SOFTEN project ('Embedding SOFt skills in sTem academic curricula for the transition to sustainable grEeN economy' www.softenproject.eu – an international educational project co-funded by the European Union under the ERASMUS+) – recognized that one of the major challenges our society must face is to adapt to climate change. The 'green transformation' is the transition of the economy and society towards achieving climate and environmental goals, primarily through policies and investments, and striving to develop the so-called 'green economy', described as management that helps improve human well-being and reach social equality while reducing or eliminating environmental risks and ecological deficiencies.

In such conditions, 'green jobs' are created, which include occupations that facilitate the achievement of net zero emissions goals and other environmental goals (e.g. restoring the balance in nature, adapting to climate change, caring for biodiversity etc.). In this context, the concept of "green soft skills" becomes relevant, covering knowledge, skills, values, and attitudes important for human existence and social development, consistent with sustainable development (Galani et al., 2023; Rieckmann, 2018). This is not about special new soft skills, but rather about their adaptation and "interpretation" in a direction useful for implementing the principles of sustainable development in practice and building a greener economy.

In order for new graduates to enter the world of work, "equipped" with all the skills to face local and global challenges, it is necessary for them to acquire soft skills throughout their studies. Academic institutions must therefore consider the possibility of integrating them into their curricula, training teaching staff.

2. Materials and Methods

The research at the basis of this paper has been addressed to STEM educators and companies in the green sector in six European countries: it aimed at highlighting the status and teaching practices of soft skills in STEM higher education, as well as the barriers experienced by educators. Secondly, the research explored how soft skills and their role in the green transition are perceived in the green industry and in which specific situations are essential.

Given the lack of soft skills among STEM graduates reported in previous studies, the perception of different stakeholders about soft skills development in STEM faculties and their incorporation within current curricula has been investigated. In addition, pedagogical practices for their development have been examined. Third, the challenges and barriers to effectively integrating these skills were also explored.

To investigate, map, and identify in-depth current trends, opportunities, needs, and gaps, a mixed methodology was applied through a series of three interconnected research activities within six European countries (Greece, Italy, Finland, Poland, Portugal, Lithuania) during the spring and summer 2023. Three target groups were reached out to participate in the research activities, more specifically STEM educational providers (professors, assistant professors, lecturers, etc.) STEM students from different departments and schools, and green industry stakeholders (e.g., CEOs, employees, employers, directors, etc.), again through a variety of green economy fields (e.g., circular economy, eco-entrepreneurship, clean energy, etc.).

A mixed-methods approach was selected to ensure a good representation of all targeted stakeholders, increase their engagement, and enrich the research findings with as much significant information and insights as possible, about their needs and level of awareness of the examined issue.

The implemented research activities included:

1. A desk research activity in each of the six countries, with the aim to identify and map trends, opportunities, limitations, and good practices regarding soft skills' integration in several STEM university study programs in each country.
2. The application of a qualitative method, through the organization and implementation of semistructured interviews for educational providers and academic staff from STEM faculties, and professionals from green industries. The main objectives of the interviews were the following ones: (1) to understand the level of awareness of the two previous target groups about soft skills and their perception of the importance of these skills for green transition; (2) to identify barriers and obstacles regarding the integration of soft skills in their STEM departments and gaps that impact negatively on the adaptability of employees to sustainability & green processes; (3) to capture their opinion about the driving factors for soft skills development, in relation to the green transition, within STEM curricula and identify any existing initiatives and benefits of soft skills from green professionals towards the cultivation of a more inclusive green mindset.
3. The application of a quantitative method, through the development of two online surveys, distributed to STEM educators and students from different technical departments and fields. Through online questionnaires these two groups were given the chance to assess the level of knowledge on soft skills' incorporation and development in their studies – field of expertise and highlight their needs and existing gaps about the embeddedness of soft skills in green education in STEM curricula. In addition, both groups were asked to rate their preference about possible pathways, educational tools and training methods that could enable the effective integration of soft skills in STEM curricula for improving their green thinking under an interdisciplinary and more holistic approach.

The collection of primary data offered a direct opportunity to understand the needs and preferences of targeted participants on soft skills' integration, the level of their familiarization with soft skills, and their connection with the green transition and green economy, mainly in relation to STEM graduates' future career.

For the selection of participants for interviews and surveys, a combination of invitations and snowball technique (Robson & McCartan, 2016) were deployed, in order to capture gaps and needs in soft skills and successfully perform the planned research tasks. The involvement of private sector stakeholders from green companies was proven essential in the project for gaining insight into the green soft skills demanded by green businesses.

All collected results were analyzed and included in a framework report (SOFTEN framework), developed as the final product of all research activities and subsequent findings. It describes the state of the art, gaps, limitations, and existing practices from all targeted stakeholders in six European countries.

3. Results

The research offers some main findings, highlighting the role of soft skills in STEM education and green industries. Despite the recognition of soft skills, as complementary to other field-related skills, the research indicates that approaches in the participating countries differ in many aspects.

3.1 Recognition of soft skills in Higher Education Institutions

The 26 interviews conducted with the academic staff revealed a quite high level of familiarity with soft skills, with no significant differences between countries (Table 1). The majority of educators also agreed that students consider soft skills to be very important to acquire during their studies. Despite this consideration and students' expectations, there were differences in all countries in terms of how universities were taking concrete systemic action to integrate the development of these skills into their school and departmental curricula. Only in Finland and Italy does it seem that soft skills have been quite well integrated through a systemic action involving the whole institution. In other countries, despite the general agreement that soft skills are important for the development of a STEM professional, their integration into curricula often occurred as isolated initiatives, by single departments or faculty members in specific courses.

The lack of support of top management is one of the major barriers that slow down an effective student's soft skills development process: it has been indicated by all educators interviewed in all countries. Pavlova (2018), for the VET sector, refers to “factors at the system level" that delay or hamper soft skills development: assessment mechanisms not in place, low demand (or none at all) for such skills, no commitment by academic staff and by administrations.

Table 1 - Rating of academic participants on introductory interview questions.

Target groups	Level of familiarity with soft skills
STEM educational providers	FI: 4.4 EL: 4.3 IT: 4.8 LT: 4.1 PL: 4.2 PT: 4.0

Further, the research reveals that small-scale initiatives have flourished in all six countries regarding the advancement of soft skills in STEM departments’ curricula. This is a positive sign indicating that the transition towards more integrated academic programs in STEM schools has kicked off. However, it is worth stressing that in these initiatives, the explicit linkage of soft skills with a sustainable green transition is often missing, or at least it is not straightforward enough.

Overall, the results confirmed previous findings (Bonwell & al., 1991; Felder, 2000; Prince, 2004; Freeman et al., 2014) in the sense that the development of soft skills is usually effective when integrated into a technical course, through the implementation of new collaborative and interdisciplinary methods that can engage students in practicing these skills. This suggests that

the achievement of soft skills should be included in the curriculum and among the intended learning outcomes of the courses, and should be assessed in the same way as hard skills.

3.2 Recognition of soft skills in Green Industry

In industries, the perception of soft skills shows a rather high variety, which can be seen as natural due to cultural and historical differences. However, the familiarity with soft skills varies from country to country and seems to be in line with the perceived importance of soft skills in relation to the green transition. It is noticeable that in all countries, except for Portugal, this received values exceeding 4.0.

With respect to this, it is somewhat concerning that the green industry confirmed the lack of soft skills in graduates and younger professionals, a finding already reported earlier (e.g., Mourshed et al., 2014; Karimi & Piña, 2021; Singh Dubey et al., 2022). In the presence of this skills shortage, it seems evident that besides educational institutions, also employers have to share this responsibility for their employees' soft skills gaps and to be ready to contribute with actions to the solution of this problem.

As for the practical role and importance of soft skills, the research offers various indications of novelty. First, engaging in the realm of green transition typically entails interdisciplinary collaboration, necessitating communication with individuals from diverse fields of expertise and consequently, different professional mindsets. Besides communication skills, empathy, problem solving, goal-orientation and other non-technical skills are needed in order to succeed. Second, given that green transition involves perpetually shifting parameters within work environments, it requires intrapersonal skills that facilitate the ability to alter one's mindset and adapt to these changes. Based on this research, green soft skills include teamwork, adaptability, communication, collaboration, metacognition, open-mindedness, empathy, critical thinking, and problem-solving complementary to environmental awareness and social consciousness. The evidence obtained from the green industry shows that in various practical contexts, soft skills have a potential leverage effect, proposing them as an element of success in green transition (Table 2). They enhance the ability to communicate, collaborate, innovate, and lead effectively in the pursuit of a more sustainable future. As the world increasingly recognizes the importance of environmental sustainability, the value of these skills will continue to grow.

Table 2 - Rating of green industry participants on introductory interview questions.

Target groups	Level of familiarity with soft skills	How critical are soft skills considered for green transition and green companies?
Green Industry stakeholders	FI: 4.6 GR: 4.6 IT: 4.6 LT: 3.3 PL: 3.5 PT: 3.8	FI: 4.6 GR: 4.0 IT: 4.7 LT: 4.2 PL: 4.0 PT: 3.6

However, the relatively small number of organisations (30) cannot objectively represent the views of the participating countries.

3.3 Self-Awarness - Awareness - Knowledge - Action …and Gen AI

In the frame of the project, a university teacher-centered strategy has been formulated to address all the obstacles to the widespread adoption of green soft skills, such as the low importance attributed to soft skills by STEM university students, the reluctance of STEM university teachers to include these skills in their courses, and the lack of those skills among new young employees. One of the pillars of this strategy is teacher training.

“Green Soft Skills for transitioning towards a Sustainable Future” is a Massive Online Open Course for STEM university teachers and educators. It aims at creating awareness of the importance of soft skills for students, not only during university years but, in particular, when they start working. It offers an overview of those skills that can be useful in green industries or in green processes and describes techniques and methodologies that teachers can adopt in their courses, to let students develop soft skills.

The adopted soft skills classification is that elaborated by Schleutker (2016), so the MOOC is organised in 6 weeks: the first one is a general introduction to soft skills for the green transition, then self-management, creativity, communication, and teamwork are presented through methodologies and techniques that teachers can adopt during their lessons, to engage students and let them also acquire transversal skills. The last section is dedicated to innovative pedagogies to foster soft skills, in particular Service Learning and Design Thinking.

Accordingly, the general objective of the MOOC is to present a set of tips and tools, applicable both in large and small classrooms, both with students in 1st university year and with students at the end of their curriculum, both in traditional context with static tables and chairs and with movable furniture. As such, the MOOC represents a long overdue endeavor to find solutions to develop these skills, rather than reflecting on the character of soft skills and, in particular, green soft skills.

To create the videos for this MOOC, some artificial intelligence tools have been experimented with: the content was entirely written by the authors, as were texts, tables, infographics, and reading suggestion lists. Generative Artificial Intelligence has been “engaged” to create the avatars to be used as speakers for video-clips, i.e. those who illustrate some of the teaching techniques proposed in the course. So, in the MOOC videos, the avatars Anna and Justin lead the participants to discover some straightforward and intuitive tools that can involve students in active learning.

For each of the techniques proposed in the MOOC videos, a Methodology card is available, i.e. a downloadable template in an editable format that proposes the presented technique with more details, offering some suggestions on how to prepare and manage it in the classroom.

The secret ingredient of “Green Soft Skills for transitioning towards a Sustainable Future” is metacognition: starting from the beginning of the learning path, MOOC participants are involved in activities that gradually make them reflect about their learning choices, their learning styles, and the level of comprehension of the topics.

For each skill, participants pass through:

1. a level of self-awareness, because talking about soft skills concerns everyone and sometimes one is very condescending towards oneself, convinced that it is not necessary to be trained;
2. a level of awareness, about the real willingness to putting into practice and experimenting but also about the specific context assets;
3. a level of knowledge, with the possibility to go deeper if they prefer to read some detailed explanations, and
4. a level of action, thanks to some activities oriented to let instructors apply the concept in their specific context and design their new courses.

5. Conclusions

Despite the recognized acknowledgment of soft skills, fluctuations in the overall level of awareness between countries are observed. In some countries the role of soft skills is perceived clearly higher by both educators and the green industry, whereas they seem less acknowledged in other countries. This calls for customized awareness when raising campaigns and initiatives, always with respect to the historic and cultural backgrounds of each nation.

On the basis of this research, green soft skills include teamwork, adaptability, communication, collaboration, metacognition, open-mindedness, empathy, critical thinking, and problem-solving

complementary to environmental awareness and social consciousness. The evidence obtained from the green industry shows that in many contexts, soft skills have a potential leverage effect, proposing the industry an element of success in the green transition. It is evident that green soft skills enhance managers' and professionals' ability to communicate, collaborate, innovate, and lead effectively in the pursuit of a more sustainable future. As the world increasingly recognizes the importance of environmental sustainability, the value of these skills will continue to grow.

So, integrating the development of green soft skills into school and university curricula is essential for preparing students to meet the challenges of a sustainable future. Such integration should be not only in charge of the teachers but also of the institutions. MOOC running (by the end of 2024) and the development of the other tools scheduled by the project to support STEM educators, could add further inputs to the research.

Acknowledgements

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In the production of this MOOC some "green" practices have been adopted to limit the impact on the environment:

1. the number of videos has been limited to the necessary: in fact, these require a long production process (recording, editing, publishing), and much more energy is required to watch a video than to read a text;
2. the document has been shared online instead of being sent by email or printed;
3. a Generative AI tool has been used to create avatars to represent the content experts, thus eliminating the travel required to record the videos at the studios of the team in charge of this activity;
4. existing online resources have been shared, after carefully selecting videos, articles, websites, and tools, instead of creating all the content from scratch.

Among the Green Soft Skills, the team experimented with were creativity, team management, and collaboration

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Exploring the relationship between Self-Reported Feedback and students' achievement in Video-Based Learning

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Abstract

This study explores the relationship between self-reported feedback and learning outcomes in video-based learning (VBL) environments. We analyzed data from 32 university students who engaged with a video on machine learning using the Evoli video annotation tool. Participants provided self-reported feedback on their prior knowledge, understanding, and perceived difficulty of the subject matter, while video interaction logs tracked their behaviour. Correlation analysis revealed a strong relationship between self-reported prior knowledge and pre-test scores (0.67) and a moderate relationship between perceived difficulty and mental effort (0.58). However, a weaker correlation was found between self-reported understanding and post-test scores (0.37), suggesting that confidence in understanding does not always correspond to better achievement. K-means clustering identified three distinct learner profiles: "Careful Viewers", who demonstrated significant improvement despite low initial knowledge; "Superficial Viewers", who showed no improvement despite high self-reported understanding; and "Regular Viewers", who exhibited steady progress with moderate effort. These findings highlight the complexity of the learning process, showing that while self-reported feedback provides valuable insights into student engagement, it may not fully predict learning outcomes. The study emphasizes the need to consider multiple dimensions of engagement when evaluating VBL effectiveness and suggests avenues for future research to improve instructional design in digital learning environments.

Keywords: Teacher Awareness, Video-Annotation Tools, Video-Based Learning, Learning Analytics, Learning Engagement.

1. Introduction

The popularity of video-based learning (VBL), exemplified by pedagogical strategies such as the flipped classroom approach, has become increasingly pervasive (Sablić et al., 2021). However, this surge presents inherent challenges stemming from the spatial and temporal separation between learners and instructors. In traditional classrooms, instructors can observe physical and non-verbal cues to gauge engagement. Yet, in the digital landscape of VBL, especially within asynchronous formats, these cues are replaced by a complex array of data, mainly coming from video interaction logs, making it difficult to discern meaningful indicators of student engagement (Wang et al., 2022).

1.1 Learning Engagement in Video-Based Learning

Learning engagement is a concept without a universally agreed-upon definition, as noted by Bond (2020) and Henrie et al. (2015). However, there is broad consensus on its multidimensional nature. The most accepted definition divides engagement into three dimensions (Fredricks et al., 2004):

- *Behavioral* engagement refers to actions like persistence, active participation, and positive conduct. It includes attending class, completing assignments, and participating in discussions or school activities. This is the most visible and measurable form of engagement.
- *Cognitive* engagement involves the mental processes used in learning. It includes understanding, using strategic learning methods, self-regulation, and the willingness to put in effort to grasp complex ideas and develop challenging skills.

- *Emotional* engagement, often referred to as “affective” engagement, involves students' emotional responses in a learning environment, including feelings of interest, happiness, and positive attitudes toward teachers, peers, and the overall learning setting.

These dimensions are closely linked and often overlap, making them hard to distinguish. For example, Joshi et al. (2022) pointed out the potential for confusion between cognitive and behavioral engagement. Nonetheless, they remain distinct aspects of an individual's involvement in educational activities.

In the context of VBL, engagement indicators can be identified across different dimensions. For behavioral engagement, the three main indicators are effort (defined as task completion, e.g., Hildebrand & Ahn, 2018, Costley et al., 2017), and participation/interaction (e.g., Dimitrova & Mitrovic, 2022). These are measured using log data, which provides precise insights into student actions such as access, viewing time, rewinding, and pausing. For cognitive engagement, the most commonly considered indicator is cognitive load (e.g., Wang et al., 2020), followed by concentration/focus (e.g., Chen & Thomas, 2020) and content comprehension (e.g., Hefter et al., 2023). As for emotional engagement, the top three indicators are satisfaction (e.g., Colasante & Douglas, 2016), interest (e.g., Fiorella et al., 2019), and positive interaction with the instructor (e.g., Kim & Thayne, 2015).

1.2 Research aim

In this research, we aim to investigate the relationship between various types of data related to learning engagement, including students' self-reported feedback on prior knowledge, understanding, and difficulty, as well as video viewing logs, and their learning outcomes in VBL. These logs capture the actions a learner takes during video watching, such as play, pause, seek backward, and seek forward events.

We address the following research questions:

RQ1: What is the relationship between self-reported feedback and learning achievement?

RQ2: How can the learners be classified in different clusters according to their video viewing logs?

RQ3: What difference is present in the identified clusters in terms of learning achievement?

2. Materials and Methods

2.1 Study Settings

This study took place in an experimental setting, where a group of university students were asked to engage in a higher-education subject, namely “machine learning”. The process involved several steps: first, students completed a pre-test on the subject. Then, they watched a video using a video annotation tool called Evoli (Cassano & Di Blas, 2024). After watching, they provided self-reported feedback on their prior knowledge, understanding, and perceived difficulty with the material. Finally, they completed a post-test, which was identical to the pretest, and a NASA-TLX questionnaire to report their level of mental effort.

2.2 Participants and Context

This study involved a diverse sample of 32 university students, comprising 22 males and 10 females, with an average age of 24.1 years (SD = 2.98 years). Participants came from various academic institutions, allowing us to explore how educational background influences engagement with complex topics, specifically machine learning, a field at the intersection of computer science and mathematics. While there was a noticeable gender imbalance, recent research by Yoon et al. (2021) suggests that gender may not significantly affect interaction patterns in video-based learning. Based on these findings, we assume that gender distribution will not substantially influence the engagement outcomes in our study.

For the study, we selected a challenging technical-scientific topic, machine learning, along with a group of university students from both STEM and non-STEM disciplines. This choice allowed for a

diverse range of prior knowledge among participants, enabling a more comprehensive analysis of how these differences influence engagement and learning outcomes in a virtual-based learning (VBL) environment. We deliberately restricted our selection to university students to ensure a cohort capable of managing the complexity of the subject matter, thereby maximizing the potential for insightful observations regarding the relationship between academic background and learning effectiveness.

Nearly 44% of participants were from Politecnico di Milano, Italy's leading technical university, while others represented a broad spectrum of academic fields. Specifically, the group included students majoring in computer science (n = 12), engineering (n = 4), economics (n = 8), law (n = 3), humanities (n = 3), and sciences (n = 1), providing a diverse mix of expertise and perspectives.

The study was conducted in a controlled educational environment, where students watched an 8-minute, 39-second introductory video on machine learning (https://www.youtube.com/watch?v=sPHucMK6Ev4), selected from Politecnico di Milano's Open Knowledge platform, known for its high-quality educational content. The video's length was intentionally short, based on insights from Guo et al. (2014), who found that shorter videos tend to promote higher viewer engagement.

2.3. The Evoli platform

Evoli is a video-based learning platform developed by Politecnico di Milano (Cassano & Di Blas, 2024). It allows teachers to create courses by uploading and sharing videos with their students. Through Evoli, students can watch these videos and ask questions that are tagged at the specific moment that triggered their doubt, allowing the instructor to identify the precise topic that challenged them. The platform records all actions taken by the viewer, such as play, pause, and seeking backward or forward, enabling a detailed reconstruction of the student's video viewing experience. After watching the video, learners are prompted to provide self-reported feedback on their prior knowledge, understanding, and the difficulty of the lesson (see Figure 1). In this study, we use Evoli to collect both self-reported feedback and video-viewing logs from each participant.

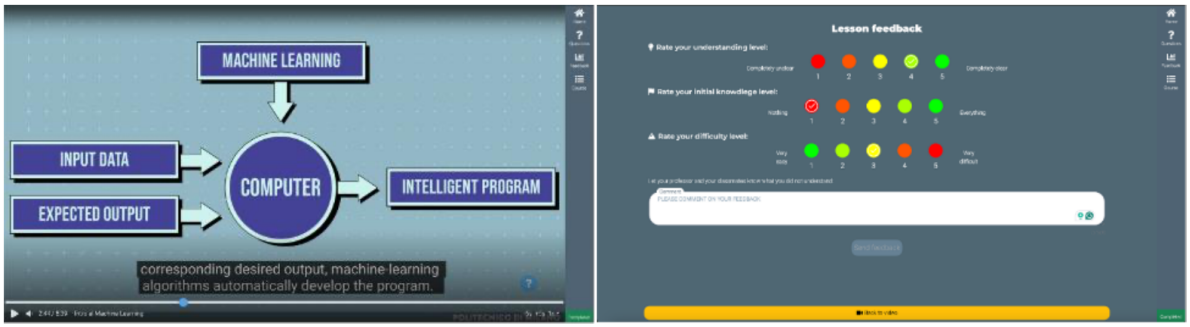


Figure 1 - Student's lesson page interface with the video player (a);
The student is asked to insert her self-reported feedback about her prior knowledge, understanding, difficulty and an additional comment.

2.4 Data Analysis

The data analysis for our study was carried out in a Jupyter Notebook environment using Google Colab. After gathering data through the Evoli platform, we compiled a dataset that included participants' video interaction logs and self-reported feedback. Our initial dataset contained a broad range of features designed to model student engagement, drawing from both previous research and our own insights. To refine the dataset, we focused on identifying key features and examined their correlations, looking for strong linear relationships with correlation coefficients of 0.80 or higher. This analysis allowed us to remove redundant features, simplifying our model for better clarity and interpretability. The features selected for the starting dataset are listed below in Table 1.

After constructing the dataset, we conducted a correlation analysis to investigate the relationship between learners' self-reported data and their academic performance, as measured by quiz

scores. The goal was to determine if self-reported measures could serve as proxies for various aspects of learning achievement: prior knowledge as a proxy for pre-test performance, perceived difficulty for mental effort, and self-reported understanding for post-test outcomes.

Table 1 - Comprehensive list of features of the final dataset to model the behavioral engagement.

Feature	*Type*	*Description*
completion	Video log	The percentage of the video content that the participant completed
watched seconds	Video log	The total time in seconds that the participant spent watching the video, including any time spent rewatching portions of the content.
rewatched seconds	Video log	The cumulative time in seconds that the participant spent rewatching specific segments of the video.
avg playback rate	Video log	The average speed at which the participant watched the video, with rates such as 1x (normal speed), 1.5x, or 2x.
watched seconds <= 3 times	Video log	The count of distinct intervals within the video that the participant watched three or more times.
total pause time	Video log	Time spent by the user pausing the video (in seconds).
# pauses	Video log	Count of how many times the user paused the video.
#backward seeks	Video log	Count of backward seeks.
# forward seeks	Video log	Count of forward seeks.
pre-test score	Score	The participant's score on a pre-quiz before watching the video, ranging from 0 to 24
post-test score	Score	The participant's score on a post-assessment quiz after watching the video, ranging from 0 to 24.
mental effort score	Score	The participant's self-reported mental effort while watching the video, measured on a scale from 0 to 7
understanding	Self-report	The participant's self-reported level of understanding of the video content, ranging from 1 to 5.
difficulty	Self-report	The participant's self-reported level of difficulty of the video content, ranging from 1 to 5.
prior knowledge	Self-report	The participant's self-reported level of prior knowledge of the video content, ranging from 1 to 5.

Following the correlation analysis, we applied a clustering algorithm. To identify the optimal number of clusters, we used the Elbow method combined with Knee point detection. Once the clusters were established, we labeled them based on their defining features and analyzed the differences in academic achievement across clusters.

3. Results

3.1 RQ1: What is the relationship between self-reported feedback and learning achievement?

The correlation analysis between learners' self-reported feedback and their quiz scores has provided valuable insights into how well students' self-assessments align with their actual academic performance. As shown in the correlation matrix in Figure 2, the analysis revealed several noteworthy relationships. Most striking is the strong positive correlation (0.67) between self-reported prior knowledge and pre-test scores, indicating that students have a fairly accurate sense of their existing knowledge and how it will reflect in their initial performance. Similarly, the correlation of 0.58 between perceived difficulty and the NASA-TLX mental effort score shows that students recognize the challenges of the content, with those perceiving greater difficulty also reporting higher levels of mental effort. This aligns with the intuitive understanding that more challenging content demands greater cognitive engagement (Fredricks et al., 2004).

However, the relationship between self-reported understanding and post-test scores is less clear, as evidenced by a weaker correlation of 0.37. This suggests that learners' confidence in their comprehension doesn't consistently lead to better performance in post-assessments. While students seem to accurately gauge their prior knowledge and the effort needed to tackle difficult content, these factors do not entirely predict how well they can apply this knowledge in a testing scenario.

The weak correlation between understanding and post-test performance underscores the complexity of the learning process. It suggests that understanding is just one of many factors influencing a learner's overall performance. Therefore, relying solely on self-assessments of understanding to predict final outcomes may be an oversimplification of the nuanced dynamics at play in academic achievement.

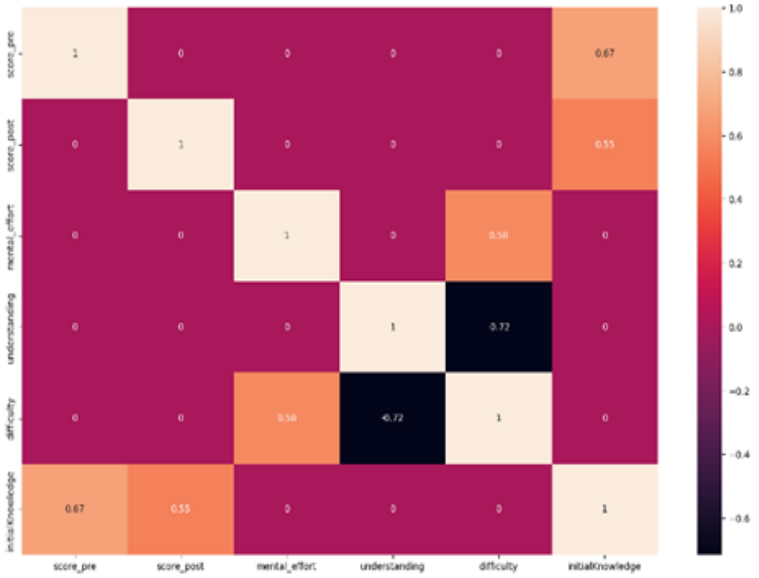


Figure 2 - Correlation matrix between explicit feedback and test scores with a threshold mask = 0.5.

3.2 RQ2: How can the learners be classified in different clusters according to their video viewing logs?

The optimal number of clusters was identified using the "elbow method", with both 3 and 4 clusters emerging as viable options for segmentation. We opted to proceed with 3 clusters for clarity and analysis.

Through K-Means clustering (see Table 2 for details), we identified three distinct profiles within the dataset:

- Careful Viewers (Cluster 0): Comprising 8 participants, these viewers displayed a much deeper level of engagement. They had a completion rate of 0.99 and spent significant time rewatching content (105.00 seconds on average). They also paused frequently (15.25 times) and made numerous backward seeks (20.25 times), indicating a thoughtful and in-depth approach to consuming the material.
- Superficial Viewers (Cluster 1): This small group of 2 participants showed a very different engagement style, characterized by a rapid review of content. They had a high playback rate (1.23) and frequently navigated forward through the videos (9.00 times), suggesting a more exploratory but less thorough interaction with the material.
- Regular Viewers (Cluster 2): This group, consisting of 22 participants, showed a moderate yet consistent interaction pattern. They exhibited a near-average playback rate of 1.09 and moderate engagement metrics, such as pausing 2.14 times on average and seeking behavior with 2.77 backward seeks and 0.18 forward seeks. Their interaction suggests a standard approach to learning.

An interesting pattern emerged regarding the distribution of STEM and non-STEM students across these clusters. The majority of STEM students (86.36%) fell into the Regular Viewers category. In contrast, the Careful Viewers group had a mix of 25% STEM and 75% non-STEM students, while the Superficial Viewers group had an even split of 50% STEM and 50% nonSTEM participants.

Table 1 - Clusters characteristics.

Cluster	*Completion*	*Rew. Seconds*	*Watched Seconds*	*Avg Playback Rate*	*Secswatched <= 3 times*	*Total pause time*	*# pauses*	*# back seeks*	*# forw seeks*
0	0.99	105.00	620.13	1.00	6.25	195.88	15.25	20.25	4.00
1	0.84	8.50	442.50	1.23	0.00	7.00	2.00	3.50	9.00
2	0.99	19.86	538.50	1.09	0.91	38.41	2.14	2.77	0.18

3.3 RQ3: What difference is present in the identified clusters in terms of learning achievement?

Cluster 0 (Careful Viewers) consists of 8 individuals who showed significant dedication to learning despite starting with the lowest initial knowledge score (2.00 out of 5). Their pre-test average of 12.50 was the lowest, yet they achieved a notable post-test score of 19.88, marking a substantial improvement (delta of 7.38). Although their final score was slightly below that of the "Regular" group, their learning progress stands out. They reported the highest mental effort (5.88 out of 9) and perceived the material as the most difficult (2.50 out of 5), yet their understanding (4.38 out of 5) was almost on par with other clusters. Their strong effort highlights the importance of perseverance in overcoming initial disadvantages.

Cluster 1 (Superficial Viewers) is the smallest group with only 2 individuals, and it exhibited static performance, with both pre- and post-test scores averaging 16.00, indicating no improvement. Despite this, they reported a high mental effort (6.00 out of 9) and a perfect selfassessed understanding (5.00 out of 5), though this confidence did not translate into measurable learning gains. They found the material relatively easy (difficulty rating of 1.50 out of 5) and had a moderate initial knowledge level (3.50 out of 5), suggesting a disconnect between perceived and actual learning outcomes.

With 22 individuals, *cluster 2 (Regular Viewers)* represents the most common experience in the dataset. They showed steady improvement, with an average pre-test score of 15.77 increasing to 20.18 post-test (delta of 4.41). Their mental effort was moderate (5.27 out of 9), indicating an efficient learning process. Their understanding (4.41 out of 5) and perceived difficulty (1.95 out of 5) suggest a balanced approach, with a good grasp of the material and moderate challenges. This cluster represents a typical learning trajectory with moderate effort and solid improvement.

The summary of the statistics for each cluster can be found in Table 3.

Table 3 - Cluster characteristics, including size, pre- and post-test scores, mental effort, understanding, difficulty, and initial knowledge for the 3 clusters.

Cluster	*#*	*PreTest*	*PostTest*	*Effort*	*Underst.*	*Difficulty*	*PriorKnow.*
0 (Careful)	8	12.5	19.88	5.88	4.38	2.50	2.00
1 (Superficial)	2	16	16.00	6.00	5.00	1.50	3.50
2 (Regular)	22	15.77	20.18	5.27	4.41	1.95	3.05

4. Conclusions

This study highlights the complex relationship between learners' self-reported feedback and their actual performance in a video-based learning environment. The correlation analysis revealed that learners generally have a good sense of their prior knowledge, which strongly predicts pre-test

performance. However, perceived difficulty and mental effort also played crucial roles in understanding the cognitive demands of the content, showing that students who reported greater difficulty were more engaged cognitively.

The clustering analysis further demonstrated distinct learning profiles. The "Careful Viewers" group exhibited the most substantial improvement despite starting with the lowest prior knowledge, reflecting their perseverance and high cognitive effort. In contrast, the "Superficial Viewers" showed no improvement, despite high self-reported understanding, suggesting a disconnect between perceived and actual learning outcomes. The "Regular Viewers," representing the largest cluster, showed moderate improvement with a balanced approach to engagement and effort.

These findings underscore the importance of considering multiple dimensions of engagement when analyzing learning behavior. While self-reported measures provide useful insights, they alone are not sufficient to predict learning outcomes. Understanding the nuances between perceived and actual performance is critical for designing more effective video-based learning interventions. Further research could explore additional factors that contribute to the discrepancies observed between self-assessment and actual achievement.

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Innovation at school: gamification, artificial intelligence and emotional skills. How to prepare students to the next future

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Abstract

The future is continuously changing, and the world our children will inherit will most likely be significantly different from what we know today. The educational system needs to be innovative to educate students for success, promoting practical skills in addition to traditional knowledge. Gamification (Bennani et al., 2022), artificial intelligence (AI) (Chen et al, 2023), and emotional intelligence (EQ) (Sanchez et al., 2023) are three major fields with enormous potential. Applying game elements to non-gaming environments, or gamification, has the potential to make learning more enjoyable. AI is another revolutionary tool that may personalize the learning experience and respond to individual needs. But educating pupils for the future entails more than just academic content. The capacity to comprehend and regulate one's own emotions as well as those of others is known as emotional intelligence (EQ), and it is essential for surviving in the complex modern world. Schools must provide time to develop social-emotional learning (SEL) abilities, allowing children to form healthy relationships, handle stress, and make responsible decisions. Collaborative initiatives, mindfulness training, and candid conversations about emotional health can help achieve this. Overcoming obstacles is necessary for putting these creative strategies into practice. Schools can provide students with the knowledge and abilities they need to succeed in the rapidly changing world (Vecchiarini & Somià, 2023) by integrating gamification, artificial intelligence, and self-empowerment (SEL) into the curriculum. This will enable students to become not only academically well-rounded individuals but also flexible, emotionally intelligent, and responsible citizens.

Keywords: Innovation, Gamification, Emotional Skills, Artificial Intelligence, Education.

1. Introduction

In the rapidly evolving landscape of education, institutions must adapt by integrating practical skills into their conventional teaching methods. This transformation is driven by emerging technologies and a growing understanding of the importance of holistic student development. Among the key trends shaping this shift are gamification, artificial intelligence (AI), and emotional intelligence (EQ), each playing a vital role in preparing students for the complexities of the modern world. These innovations are not only enhancing the learning experience but also addressing the need for adaptability and emotional resilience in today's increasingly dynamic and interconnected society.

Gamification, in particular, is reshaping traditional educational approaches by creating interactive, game-like environments that engage students more actively. By incorporating elements such as point scoring, badges, and leaderboards, gamification fosters a competitive yet collaborative atmosphere, motivating students to stay engaged while cultivating skills like perseverance and teamwork. According to Bennani, Maalel, and Ben Ghezala (2022), adaptive gamification strategies in e-learning environments have shown promising results in maintaining student engagement and improving learning outcomes, though they also present challenges such as ensuring inclusivity and accessibility.

Meanwhile, AI is revolutionizing personalized learning. Through data analysis, AI enables educators to tailor content to individual students' needs, offering real-time feedback and adjusting

instruction based on a learner's progress and challenges. This approach ensures that students receive a customized learning experience, optimizing their potential for success. As Baker and Smith (2019) point out, the future of AI in education holds great promise for creating more equitable and efficient learning environments. However, as these systems become more integrated, there are ethical concerns to address, particularly regarding data privacy and the potential for bias in AI algorithms.

In addition to technological advancements, emotional intelligence (EQ) has emerged as a crucial component of education. As the world becomes more complex, with challenges ranging from global crises to personal stress, students need to develop strong emotional competencies to navigate these demands effectively. Emotional intelligence, encompassing skills such as empathy, self-regulation, and social awareness, is increasingly valued alongside academic knowledge. Schools are thus placing greater emphasis on social-emotional learning (SEL) to equip students with the tools to manage their emotions, build healthy relationships, and foster a positive learning environment. As Bimbrahw, Boger, and Mihailidis (2012) suggest, the use of assistive technologies in developing emotional and social skills is gaining traction, especially for students with specific. needs.

However, the integration of these innovations into the educational system brings about certain challenges. Educators need continuous professional development to keep pace with technological advances, ensuring they can effectively implement AI-driven solutions and SEL frameworks. Moreover, the ethical implications of AI applications, such as the potential misuse of student data, necessitate careful consideration. Addressing these issues will require a balanced approach, where the benefits of emerging technologies are maximized while safeguarding students' rights and well-being.

Ultimately, by incorporating gamification, AI, and emotional intelligence into their curricula, educational institutions can foster greater flexibility, empathy, and responsible citizenship. These tools empower students not only to succeed academically but also to navigate the emotional and social complexities of life in the 21st century. As the future of education continues to unfold, a comprehensive approach that blends technology with emotional learning will be key to preparing the next generation for the challenges and opportunities that lie ahead.

2. Summary Analysis of the Literature

In recent years, the integration of innovative technologies such as artificial intelligence (AI) and gamification in educational contexts has garnered significant attention. This shift reflects the need to adapt teaching methods to the evolving demands of the 21st century, promoting not only academic achievement but also the development of essential skills such as creativity, collaboration, and emotional intelligence (EI). In light of this, the present content analysis extends over a decade (2012–2023), examining the use of AI and gamification in educational environments. The analysis sheds light on the emerging trends, challenges, and potential of these technologies in enhancing both cognitive and non-cognitive learning outcomes, as well as their impact on students' motivation, performance, and emotional well-being.

AI technologies have transformed traditional pedagogical practices, with their application in education being widely studied. The analysis of 68 research articles revealed a strong focus on how AI can improve student engagement, motivation, and academic performance across different educational settings and subjects, including physical education, computer science, and mathematics (Chiu, 2021; Chiu et al., 2022; Xia et al., 2022; Kuleto et al., 2021). The reviewed studies consistently report that AI, particularly through robotic systems and personalized learning environments, significantly enhances student motivation and engagement. This finding aligns with the work of Baker and Smith (2019), who argue that AI systems enable more interactive and student-centered learning experiences, thus fostering greater student involvement.

Furthermore, the integration of AI technologies has demonstrated notable improvements in academic performance, especially when applied to personalized learning environments. Research suggests that AI is particularly effective in supporting diverse learner populations, including those

with special educational needs (Bimbrahw et al., 2012; Garg & Sharma, 2020). For example, AI-driven prompting devices have shown efficacy in assisting children with autism spectrum disorder in performing activities of daily living, reflecting the adaptability and inclusiveness of AI in education (Bimbrahw, Boger & Mihailidis, 2012). However, it is important to acknowledge the limitations of AI, as not all students benefit equally from these technologies. Bonneton-Botte et al. (2020) found that AI's effectiveness is contingent upon students' existing skill levels, with higher-achieving students benefiting more than their peers with lower proficiency. This raises concerns about the equitable distribution of AI's benefits and the need for more tailored interventions to ensure all learners can thrive.

In addition to cognitive outcomes, AI has also been shown to influence the development of non-cognitive skills. The reviewed literature indicates that 12% of studies examined the role of AI in enhancing students' confidence, self-directed learning, and social interaction skills (Hsieh et al., 2020; Kim et al., 2021; Rodriguez et al., 2021; Soong et al., 2020). These findings highlight the importance of AI in creating supportive learning environments where students can build not only academic competence but also emotional resilience and collaborative abilities. In language learning contexts, AI-driven chatbots have proven particularly useful in reducing anxiety and boosting learners' confidence by providing immediate, non-judgmental feedback (Kim et al., 2021). Nevertheless, as Terzi (2020) and Wang & Wang (2022) note, the widespread adoption of AI has also led to increased concerns among students about the future job market, with some expressing anxiety about the potential displacement of human workers by AI technologies.

Parallel to the integration of AI, gamification has emerged as a powerful pedagogical tool, particularly in fostering creativity, motivation, and engagement among students. Gamification involves the application of game-like elements – such as point scoring, leaderboards, and badges – to educational contexts, creating a dynamic and interactive learning environment. Studies have shown that gamification can significantly enhance students' intrinsic motivation and promote active learning across different educational levels and disciplines (Bennani, Maalel & Ben Ghezala, 2022; Jamalulail et al., 2022). For instance, in a study on elementary school students, Al Ghozali, Mustoip, and Sulkhah (2024) found that gamification methods effectively increased creativity and innovation, helping students develop problem-solving skills in the digital era.

At the university level, gamification has been widely adopted to facilitate collaborative learning and critical thinking. Patricio, Moreira, and Zurlo (2022) explored the use of gamification in innovation teams, revealing that game-based approaches foster a sense of teamwork, allowing students to engage in more innovative and creative problem-solving processes. Similarly, Aibar-Almazán et al. (2024) examined the use of the gamified learning tool Kahoot! in university settings, reporting that it not only increased student motivation but also improved academic outcomes by making learning more engaging and accessible. These results are consistent with the findings of Mårell-Olsson (2022), who highlighted that teachers perceive gamification as an effective teaching strategy, particularly for designing interactive and student-centered learning experiences.

Despite the evident benefits of gamification, challenges remain in its implementation. For instance, Guerrero et al. (2022) pointed out that while gamification can make subjects like nutrition education more engaging for high school students, its effectiveness is dependent on careful design and the alignment of game elements with educational objectives. Moreover, Sotos-Martínez et al. (2024) underscored the importance of addressing students' basic psychological needs – autonomy, competence, and relatedness – when designing gamified learning environments in physical education. Failure to do so may result in superficial engagement without meaningful learning gains.

In conclusion, both AI and gamification offer promising avenues for enhancing student engagement, performance, and skill development. AI has demonstrated its capacity to create personalized learning experiences and foster 21st-century skills such as collaboration and self-regulation, while gamification has proven effective in motivating students and making learning more interactive.

However, the implementation of these technologies is not without challenges, particularly regarding equity and the ethical implications of AI in education.

Future research should continue to explore how AI and gamification can be effectively integrated into educational curricula, ensuring that these innovations benefit all learners and support the development of both cognitive and emotional competencies.

3. Conclusions

In summary, this research seems to be tilting towards a middle ground of combining AI tools with traditional teaching and human interactions in order to effectively nurture and control Emotional Intelligence (EI). AI's potential to expand each part of Goleman's EI model (1998) is very hopeful. These include empathy, social skills, self-awareness, self-regulation, and motivation. Priority is given to AI-driven applications that help individuals in emotion identification and regulation; understanding what others go through; and making customized educational materials for motivating learners. Also, it should be noted that there are some vital concerns around this issue. In other words, strict attention should be paid to ethical and privacy considerations when collecting data in terms of student information security. Moreover, there has been a need to examine whether algorithms present any biases in machine-based learning outcomes as well as ensure fairness in education access by all stakeholders irrespective of their background using such technologies. Another problem regards the possibility that people will rely on AI too much thus emphasizing the significance of a personal aspect within education. Thus we advise a comprehensive strategy which integrates the inventiveness of AI with the irreplaceable worthiness of conventional teaching including physical presence. Hence, both academic performance and emotional development can be enhanced with an eye on these two methods so that pupils can better cope with future challenges.

In this scenario, a central role is played by teachers and, in particular, pioneer teachers who have played and continue to play a key role in school innovation. The school of the digital and knowledge society is a different school centered on students and digital literacy. It is a 'liquid' school, as Bauman would say, able to adapt to the dynamics of society and even, in a sense, to determine them. In other words, the digital school constitutes, in itself, a fluid construction between pedagogy and didactics, curriculum and contents, organization, technologies, professional development and innovation. The Internet makes it possible to communicate, acquire information and play, and thus to learn in a different way. When you access the Internet via your computer, you can receive texts, pictures, videos and music, access educational programs, find information for research for school or work, shop and communicate with people all over the world. The strong expansion of mobility in the use of the Internet and the web allows us to foresee how access to information will be in the future: great mobility and the possibility of maintaining the ubiquity of the web presence thanks to mobile devices such as mobile phones, iPads, smartphones, consoles, but also more personal items such as watches, and soon glasses and clothing. What is missing in today's schools is a pedagogical reference to improve the learning of 'digital natives' with this new way of understanding and practicing school. In compulsory schooling, these assumptions often only find space as an integral part of traditional disciplines, or in the implementation of a few sporadic projects, but it would be really useful to find ways to make them part of a systematic programme of transversal and interdisciplinary media education in all schools of all levels. In recent years, the European Union has repeatedly drawn attention to the need to promote media education in the Member States and to foster through specific actions at national and European level the exchange and sharing of good practices.

The challenge of education in the digital age starts with defining the skills our students need: a much broader and more structured challenge than what is commonly summarized as the critical use of the Net, or information technology. We must tackle it from an idea of competences in line with the 21st century: made up of new literacy skills, but also and above all of transversal skills to be developed. In particular, there is a need to strengthen skills relating to the understanding and production of complex and articulated content, even within the digital communication universe, where granularity and fragmentation sometimes prevail. It is in this context that we need to look at openness to the territory, the relationship between public and private, the relationship between

digital creativity and craftsmanship, and between digital entrepreneurship, manufacturing, labour and Industry 4.0.

In conclusion, the digital school can be a starting point to comprehend the definition of a laboratory of a new democratic school that is defined as a school of the life project of each student, of a project broader and more meaningful than the personalisation of learning, devoted to building critical thinking through the use of digital technologies to develop the learning creativity of 'digital natives'. The digital school must be seen as an opportunity to build a quality school for each and every one, a school that orients each student through digital competences to find meaning in his or her school learning linked to his or her living environment. In order to guide the student towards a conscious citizenship, it is appropriate that the digital culture enters into teaching, into the contents, into the training of teachers and managers as a heritage of ideas and fundamental values to build a better democracy in the school and in society.

In addition to developing the appropriate skills to be able to dialogue with the sphere of artificial intelligence, it is also necessary to deal with the pedagogical challenges that the new technological era entails. One of the greatest challenges that the pedagogical world will face, with respect to technological innovation, will most likely be related to the emotional and relational dimension. It was once thought, in fact, that the field of human freedom could rely on the impenetrability of one's thoughts and emotions. The ability, however, of algorithms to recognise and manipulate states of mind, represent a new frontier of artificial intelligence, and raise rather complex ethical, pedagogical and organizational issues. According to historian Yuval Noah Harari (2015), artificial intelligence is, in fact, destined to exert a primary influence not only on the way people consume and work, but even on the way they think. Yuval, in this regard, goes so far as to argue, that the dominance of algorithms could go so far as to undermine the very concept of individual freedom and self-determination of the individual, and to address this problem, he has long been calling on world leaders to regulate the use of data with regard to artificial intelligence. Today, machine learning systems, but above all 'affective computing' systems, which make use to a large extent of mechanisms defined as deep learning, make it possible to cross the threshold of our emotions, making them intelligible. Not only is it now possible to know what is going on behind the screen of our emotions, but it is also possible to interact with them, modifying and influencing them according to functional criteria (Huyskes, 2021). According to Huyskes, the use of affective computing could, for example, improve the performance of one's employees, but make them feel dehumanized because they are at least partially deprived of their emotional intelligence. Moreover, by disrupting the structures of normal communication and interaction in such a disruptive way, emotional AI can only have an enormous impact on organizational structures and educational relationships, of which empathy and otherness are the cornerstones. Indeed, the international scientific literature highlights artificial intelligence in education as a particularly emerging field (Baker & Smith, 2019).

Authors' contributions

This paper is the result of the shared work of the authors; however, for the purposes of the attributions of its individual parts it is divided as follows: Maria Concetta Carruba: abstract and Summary Analysis of the Literature; Alessandro Barca: Introduction; Valentina Paola Cesarano: Conclusion.

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Reality vs. perception: exploring the Dunning-Kruger Effect on literacy and numeracy skills in university students

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Abstract

The present research aims to explore the Dunning-Kruger (DKE) effect on literacy and numeracy skills among university students just enrolled in the first year of the Digital Education degree course at the University of Modena and Reggio Emilia (a.y. 2023/2024).
Also called by the authors "unskilled and unaware", the DKE shows that incompetent individuals have more difficulty recognizing their true level of ability than more competent individuals, generating estimation errors in performance by both.
We explore these effects in our study, investigating a sample of students who assessed their ability in literacy and numeracy skills, according to ISFOL definition (2014), through an incoming skills assessment tests on basic knowledge to verify that there are no significant deficiencies in particular disciplines. In line with DKE, it has been hypothesized that students with lower performance may show a tendency to overestimate their abilities, while those with higher performance may have a more accurate perception of their skills.
Statistical methods of analysis processed the results of a questionnaire on Metacognition Awareness (MAI) and put in relation literacy and numeracy tests results to the student's perception of performance, expressed through a range of choice from -10 to 30 (literacy test) and 10 e 30 (numeracy test).
The results of this research aim to contribute to the lack of research studies on the impact of the Dunning-Kruger effect on literacy and numeracy skills, besides having important implications for the educational practice and skill development of university students.

Keywords: Dunning-Kruger Effect, University Students, Literacy, Numeracy, Skills.

1. Introduction

The Dunning-Kruger Effect (DKE) is a cognitive bias that describes the tendency of less competent individuals to overestimate their abilities while more competent individuals more accurately assess their performance (Kruger & Dunning, 2009).

The study demonstrates that individuals with lower abilities in specific areas tend to overestimate their performance and skills. This cognitive bias occurs because these individuals lack the metacognitive ability to assess their limitations, leading to inflated self-assessments. To demonstrate, the authors conducted four experiments across domains, including humor recognition, logical reasoning, and grammar, assuming that incompetent individuals overestimate their abilities because they lack the self-awareness or the necessary metacognitive skills to recognize their deficiencies. In each study, participants in the lowest quartile of performance greatly overestimated their competence. Conversely, participants with higher competence were more accurate in their self-assessments, though they sometimes underestimated their abilities relative to others. In one of the four experiments, after training to improve their logical reasoning, low-performing participants were better able to assess their competence and reduced their overestimated abilities. This supports the idea that competence and self-awareness are linked.

This phenomenon is widely recognized in cognitive psychology and has implications for various domains, including higher education.

In the study of Howard and colleagues, for example, the Dunning-Kruger Effect is explored as a potential explanation for discrepancies between university students' self-perceptions and their actual reading proficiency. The study found that many students rated their competence in academic reading, particularly in understanding scholarly articles, much higher than faculty did. For instance, 59% of students believed they were competent in reading literary journals, while only 11.1% of faculty agreed. This overconfidence aligns with the DKE, as students overestimated their abilities compared to faculty perceptions and actual performance (Howard et al., 2018). In another study by de Brain and colleagues, the authors focus on the manifestation of the DKE in students enrolled in university-level introductory chemistry courses. The study confirmed the DKE's presence by showing that students in the lowest quartile of performance significantly overestimated their understanding and exam results. On average, students who ranked around the 15th percentile perceived themselves as being in the 40th percentile. Illusions of competence are robust and persistent in STEM education, highlighting the need for interventions that target low-performing students' overestimation and high-performing students' underestimation of their abilities (de Bruin et al., 2017).

Our study explores how this effect manifests in university students' literacy and numeracy skills in the first year of a degree in Digital Education at the University of Modena and Reggio Emilia. Literacy and numeracy are essential competencies in higher education. Using ISFOL definitions, literacy involves reading comprehension, writing, and communication skills, while numeracy refers to the ability to interpret and work with numerical information (2014). These basic skills are the foundation for more advanced learning, and accurate self-assessment of these skills is essential for academic success. Metacognitive awareness, the ability to reflect on one's cognitive processes and assess one's knowledge, plays a crucial role in learning (De Santis et al., 2021). Individuals with high metacognitive awareness are more likely to make accurate self-assessments and recognize areas for improvement. In the context of the DKE, poor metacognitive skills may exacerbate overconfidence in low-performing individuals, as they cannot acknowledge their knowledge gaps.

Despite the importance of numeracy and literacy, very few studies have been found on major scientific databases (Scopus). The research using the string “Dunning” AND “Kruger” AND “effect” AND “Literacy” shows 17 results, and just 2 results using “Numeracy”.

For this reason, our study wants to contribute to scientific evidence in this field, so aims to investigate whether students, mainly those newly enrolled in university, are prone to the DKE when assessing their literacy and numeracy skills. The focus is on students enrolled in the first year of the Digital Education degree at the University of Modena and Reggio Emilia. This research examines how students' self-assessed abilities compare to their actual performance and explores the role of metacognitive awareness in moderating these judgments.

2. Method

We administered three questionnaires to the first-year students of the Digital Education degree course at the University of Modena and Reggio Emilia (Italy).

The first two questionnaires regard literacy and numeracy. In addition, to detect data on metacognition, we administered Metacognitive Awareness Inventory (Schraw & Dennison, 1994) to students.

The literacy questionnaire, which focuses on reading comprehension, is scored on a scale of -10 to 30. Each of the 10 questions carries a penalty of 33% for incorrect answers, allowing students to obtain a final score within this range.

The numeracy test, which mirrors the structure of the Professional Skills Tests used in England to obtain Qualified Teacher Status, QTS, is an assessment of the students' numerical abilities. It is made up of two parts: The mental Section (12 questions) and the Written Section (16 questions), and the score that students can obtain is between 0 and 30 (no penalties).

For both the tests, the passing grade is 18.

Before completing the tests, students rated their perceived performance on a scale from -10 to 30 for the literacy test and from 0 to 30 for the numeracy test. They replayed the questions:

- "How competent do you think you are in text comprehension? Indicate the grade you will get on the literacy test".
- "How competent do you think you are in numeracy? Indicate the grade you will get in the numeracy test".

Therefore, two variables were available for literacy and numeracy: the score obtained during the test and the score declared by students in the self assessment.

For the analysis, the authors introduce an index calculated as the ratio between Self Assessment Score (SA) and Achieved Score (L or N).

As in Figure 1, the index called SAI (Self Awareness Index) is equal to 1 when the achieved score coincides with the self assessment score; the perceived and obtained results overlap.

SAI is higher than 1 when self assessment scores are higher than the test scores; students overestimate their abilities.

SAI is lower than 1 when self assessment scores are lower than the real ones; students underestimate their performance.

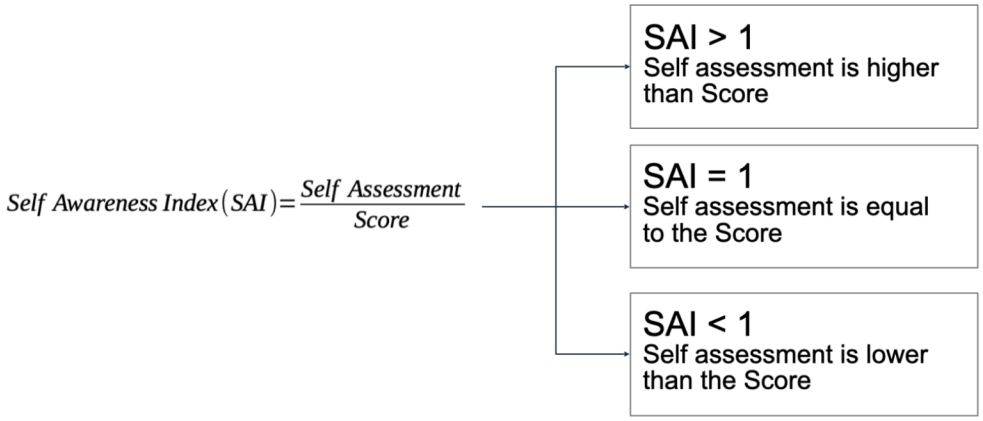


Figure 1 - Self Awareness Index.

3. Results

89 students in the Digital Educationdegree course participated in the investigation.

After removing incomplete answers, our sample was composed of 67 units for the literacy test and 70 units for the numeracy test.

76% of the sample are women. Median age was 21 (range 18-57). 87% of the participants declared that they were attending a degree course for the first time.

Figures 2 and 3 show the distribution of the score for the two questionnaires. In both cases, the range of self assessment scores is wider than the achieved score.

For literacy (Figure 2), students choose their perceived grade (SA) between -10 and 30. Their test grade (L) is between 0 and 30; no negative score has been obtained. In students' perception, the scores (SA) more frequently chosen are between 15 and 25; the real scores (L) are higher than 20. The median score for SA is 20, and for L is 22.

For numeracy (Figure 3), students choose their perceived grades (SA) in a range between 0 and 30. Their test scores (N) are distributed with similar frequencies from 10 to 27. Students' most frequently perceived scores are between 15 and 25 (with a peak of 18). The median score for SA is 18, and for N is 20.25. We observed a high correlation (0.82) among the perceived scores for numeracy and literacy: the variables follow the same trend in both tests, and students have similar

perceptions of their performance in the two tests regardless of ability. There is no high correlation between SA and L (0.06) for literacy and between SA and N for numeracy (0.23).

We calculated the correlation between the score obtained in the Metacognitive Awareness Inventory and the difference between the grades of SA and test score for literacy and numeracy. The correlation value is low in both cases. In detail, *r* is 0.11 between SA and L; 0.01 between SA and N.

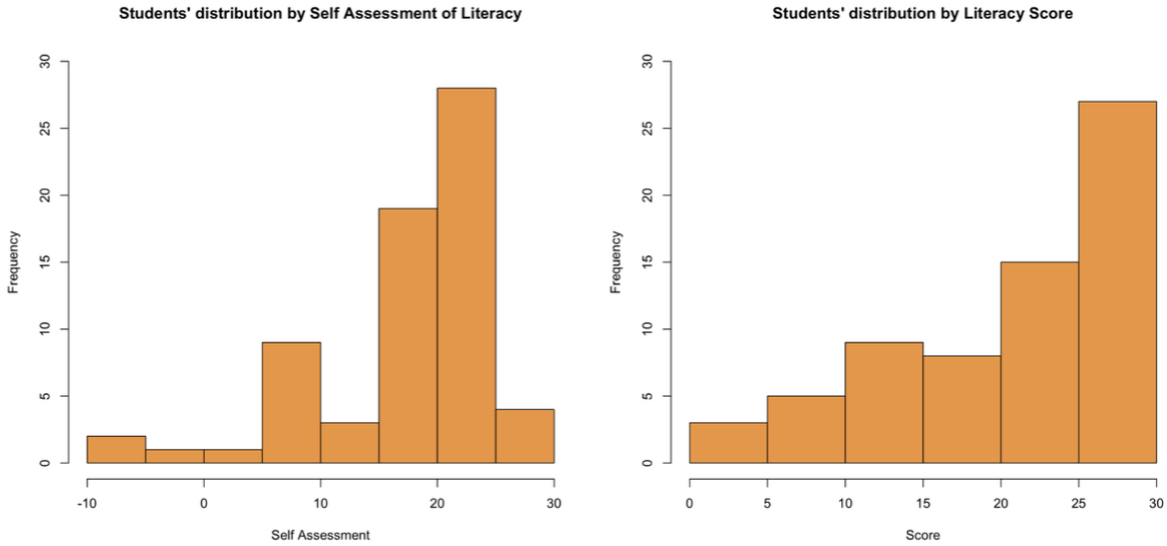


Figure 2 - Students' distribution by self assessment score (SA, *left*) and test score (L, *right*) for Literacy test.

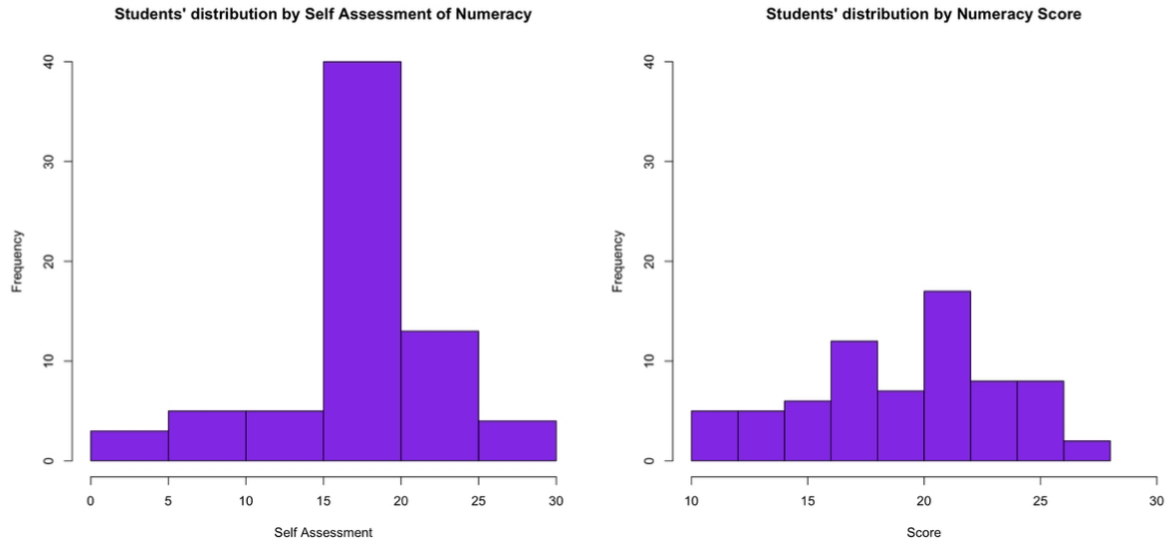


Figure 3 - Students' distribution by self assessment score (SA, *left*) and test score (N, *right*) for Numeracy test.

Figures 4 and 5 represent the graphs obtained plotting Self Awareness Index vs Score. They show the Dunning-Kruger effect.

The black dots (very few in the two graphs on the dotted line equal to one) represent the students who indicated the score they then actually got.

The red points indicate the students who overestimate their ability, and the green points are those who underestimate their scores.

The red points at the top left are the students with a low level of ability who consider their scores very high. The green points in the bottom right quadrant are those who have good abilities but have underestimated their readiness.

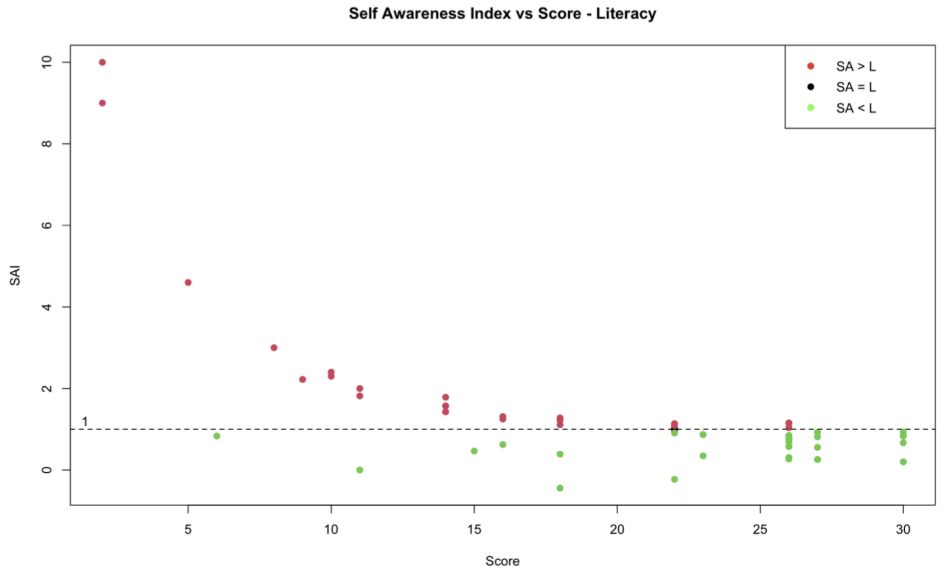


Figure 4 - Self Awareness Index vs Score - Literacy test.

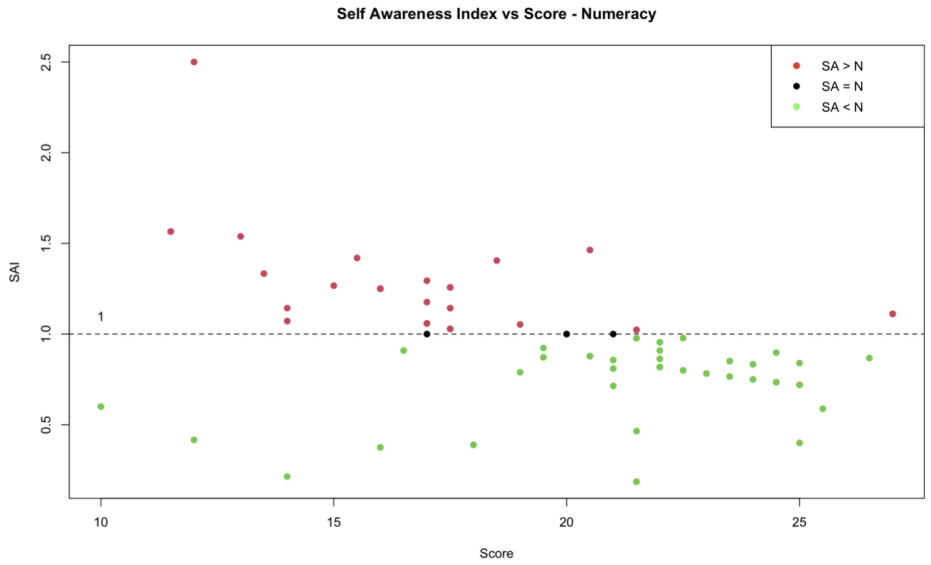


Figure 5 - Self Awareness Index vs Score - Numeracy test.

Moving to the DK effect on teaching and considering only the test score, we see the students who passed the literacy test are 47 (70%). For numeracy, they are 43 out of 70 total (61%).

Tables 1 and 2 show the confusion matrices indicating how many students correctly interpreted their readiness to pass or fail the tests. For the literacy test, their percentage got to 58% (39 students). 16 students (24%) thought they would pass the test and instead failed, and 12 students (18%) thought they would fail the test and instead passed it.

For numeracy, the percentage of students correctly indicating if they will pass or fail the test reaches 60%. 19 students (27%) thought they would pass the test and instead failed, and 9 students (13%) thought they would fail the test and instead passed it.

	Passed (L)	*Failed (L)*	*Sum*
Passed (SA)	35 (52%)	16 (24%)	51 (76%)
Failed (SA)	12 (18%)	4 (6%)	16 (24%)
Sum	47 (70%)	20 (30%)	67

Table 1 - Confusion Matrix for Literacy.

	Passed (N)	*Failed (N)*	*Sum*
Passed (SA)	34 (49%)	19 (27%)	53 (76%)
Failed (SA)	9 (13%)	8 (11%)	17 (24%)
Sum	43 (61%)	27 (39%)	70

Table 2 - Confusion Matrix for Numeracy.

In more details, looking at the self perception of abilities, we can say for literacy that:

- *In the Self Assessment for only 2 students SA = L.*
  They passed the test.
- *In the Self Assessment for 28 students (42%) SA > L.*
  All of them declared to pass the test. 16 of them failed the test.
- *In the Self Assessment for 37 students (55%) SA < L.*
  16 of them declared to fail.
  Only 4 really failed the test.

For numeracy:

- *In the Self Assessment for only 4 students SA = N.*
  3 passed the test, 1 failed.
- *In the Self Assessment for 27 students (39%) SA > N.*
  Only 2 of them declared to fail.
  21 of them failed the test.
- *In the Self Assessment for 39 students (56%) SA < N.*
  14 of them declared to fail.
  Only 5 really failed the test.

As teachers or educational researchers, our attention usually focuses on students who didn't pass the test and for whom the training was unsuccessful. In addition, given these results, we have to question ourselves on students who failed the test thinking instead they were at an advanced level and those who passed the test thinking they would fail.

4. Discussion

The results presented here, involving first-year students with a Digital Education degree, underscore the profound significance of the Dunning-Kruger Effect (DKE) in the literacy and

numeracy skills self-assessment. We found a compelling alignment with the general characteristics of the DKE, demonstrating that students with lower actual performance tend to overestimate their abilities, while those with higher performance more accurately assess or slightly underestimate their skills, both in literacy and numeracy domains.

In terms of literacy, the data reveal that the students' perceived scores (SA) tended to cluster in the 15–25 range, while their actual scores (L) were slightly higher, with a median of 22. Data indicate that although students believed they were performing adequately, there was still a tendency for overestimation, particularly among lower-performing students. The numeracy results follow a similar trend. The median perceived numeracy score (SA) was 18, while the actual test scores (N) showed a higher median of 20.25. The numeracy test produced a wider distribution of self-assessed scores compared to literacy, but like literacy, the students with lower scores were more likely to overestimate their abilities.

We add some observations about the findings:

- Further analysis is necessary to deepen our understanding, mainly focusing on the potential connections between self-assessment accuracy and other academic or personal factors such as study habits or prior educational experiences.
- Further research is necessary on self-assessment accuracy. Students with low metacognitive awareness are consistently inaccurate in evaluating their overall academic abilities, not just in specific subjects.

The low number of participants limits this investigation. Despite this, this study provides valuable insights into the Dunning-Kruger Effect and its influence on first-year university students' self-assessment of literacy and numeracy skills. We would in future expand the research to involve a more extensive and diverse sample (es. other degree students or PhD students) would allow for broader generalizations and offer a more comprehensive view of how the Dunning-Kruger Effect manifests across different demographics and educational contexts.

In addition to literacy and numeracy, our intention for future research is also to explore how digital competences are affected by students' self-assessment biases. Given the increasing importance of digital skills in education and the workforce, investigating students' perceptions of their digital abilities could provide useful insights for developing more targeted educational interventions. Improving metacognitive awareness in the digital domains, alongside literacy and numeracy, will be crucial to fostering well-rounded, competent learners prepared for the demands of modern education and beyond.

Authors' contribution

According to CRedit system Claudia Bellini (corresponding author): Conceptualization, Resources, Writing - Review & Editing; Annamaria De Santis: Investigation, Formal analysis, Visualization, Data Curation; Katia Sannicandro: Resources; Tommaso Minerva: Conceptualization, Methodology, Supervision.

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· Section 3 ·
Digital UpSkill and ReSkill for Adult Learners, Career Development and Training

Social robotics in hospitals and the professional learning needs of professionals. An empirical research design

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Abstract

The ethics of social robotics is currently part of a broader debate related to emerging and pervasive intelligent technologies. The aim of this contribution is to explore the specific context of social robotics in hospital settings. Specifically, our study focuses on the professional learning needs of professionals involved in these delicate, technology-mediated socio-relational interventions. The authors' prior research laid the groundwork for the present multiple case study design, which employs a qualitative ethnographic methodology, instantiated through fieldwork, to explore the professional dynamics involved in experiences of social robotics in hospitals. The primary aim, within the action-research perspective inherent to the case study, is to gain an in-depth understanding of the following dimensions: (a) identification of professionals involved in social robotics interventions; (b) the potentialities and ethical concerns (especially in terms of quality care) that professionals hold towards the use of social robotics in hospitals; (c) the existence of specific training paths and the training needs of professionals; (d) the significance of the educator as a professional involved in social robotics interventions in hospitals.

Keywords: Social Robotics, Education, Professional Learning, Hospital, Research Design.

1. Introduction

The research project aims to explore the emerging and expanding technology of social robotics within the sensitive context of hospital care, from primarily ethical, pedagogical, and educational perspectives. Specifically, the teleological focus is centered on the in-depth analysis of the professional roles involved in these delicate technological-relational interventions, identifying the training needs associated with the ethics of good care (Mortari, 2015; Coeckelbergh, 2022) and professional agency (Bandura, 2006; Biesta & Tedder, 2016; Kerr, Barry & Kelleher, 2020; Raffaghelli, 2022) capable of responding ethically, equitably, and consciously to the relational challenges introduced by human-technology interaction (Raffaghelli, 2022; Khun & Raffaghelli, 2023).

The narrative and systematic literature reviews conducted by the authors have highlighted a growing interest in the uses (and misuses) of social robotics, also from an ethical standpoint (Coeckelbergh, 2022; Tamburrini, 2020; Doumochel & Damiano, 2019). For example, Sharkey & Sharkey (2012) focus on ethical discussions related to vulnerable individuals (such as young children and the elderly), highlighting several thematic issues that intersect with risks and respect for fundamental human rights: (1) the potential reduction in the amount of human contact; (2) an increase in feelings of objectification and loss of control; (3) a loss of privacy; (4) a loss of personal liberty; (5) deception and infantilization; (6) the circumstances under which elderly individuals should be allowed to control robots. Other research emphasizes ethical considerations for the responsible use of AI (currently inextricably linked to social robotics). A guiding example for the authors' research lines is the contribution by Floridi et al. (2018), which outlines the principles of beneficence, non-maleficence, justice, autonomy, and explicability (Floridi et al., 2018).

To avoid the risk of ethical discussions remaining confined to an abstract level (Kerr et al., 2020), this contribution acknowledges the urgency of focusing on professionals who concretely operate

with social robotics in hospital settings. Literature reviews have indeed identified a unified research gap concerning the professionals engaged in such interventions and, more importantly, the existence of specific training paths.

In the systematic review process, only one article centered on the training needs of professionals emerged: the international work by Papadopoulos et al. (2023), which lists a series of needs identified by professionals, primarily focusing on technical requirements for the functional use of social robots. There is no broad reflection in ethical, educational, or agentive terms, raising two risks: downplaying the inherent complexity of the predominantly relational nature of social robotics; relegating the concept of training to a purely technical "training," without opening up to broader horizons of professional learning.

The constitutive characteristic of relationality, moreover, highlights another gap in the examined literature: although the interdisciplinary nature of social robotics is emphasized (Rossi, 2019; Becchimanzi, 2022), specific references to the contribution of predominantly pedagogical-educational figures are almost absent. This gap is particularly important to highlight, especially in the hospital context where social robotics is an expanding technology, mainly used with vulnerable pediatric and elderly patients. It is also an area where the concept of care transcends therapeutic boundaries, entering the space of good care, where the educational relationship plays a central role.

In line with the ethical principle that technology is not inherently neutral but fundamentally depends on the quality of the socio-cultural context in which it is embedded (Cingolani & Magnani 2018; Cingolani 2019; Coeckelbergh, 2022), there is a recognized need to build environments of trust, with clear agentive responsibilities aligned with reliable human values (Floridi et al., 2018; Dumouchel & Damiano, 2019; Rossi, 2019).

It is believed that a fundamental step in this direction is to emphasize attention and care towards the dimension of professionalism, which plays a primary role in the governance and operationalization of social robotics interventions and consequently has an undeniable impact on their outcomes.

This perspective implies recognizing that ethics must necessarily be linked to the educational dimension, within the space of relationship and good care: an inextricable, circular, and systemic triangulation that, once again, calls for the need to "care for those who care," advancing research lines that involve professional agency, education, and training in terms of professional learning.

Based on this scenario, four main areas of investigation for the project are identified, guiding and establishing the framework for the empirical phase: (a) identification of the professionals involved in social robotics interventions in hospitals; (b) ethical potentials and concerns that professionals have regarding the use of social robotics in hospitals; (c) the existence of specific training paths and the training needs of professionals; (d) the significance of the educational role as a professional category involved in social robotics interventions in hospitals.

The general aim of the research design, therefore, is to promote a formative and reflective culture regarding the use of social robotics in the hospital context, with particular attention to the ethical implications of good care and the challenges of educational agency for the professionals involved.

The specific objectives converge on:

- Identifying existing training lines and the configuration of professional teams involved in social robotics interventions in hospitals;
- Identifying the training needs, highlighting the critical-reflective and practical implications for professionals in the use of social robotics in hospitals;
- Understanding the relevance of educational professionalism in the hospital context that uses social robotics;
- Raising awareness within the scientific community about the importance of ethical care and professional agency in relation to technology, contributing to the development of innovative training tools.

2. Materials and Methods

In line with the exploratory and comprehensive objectives that guide the research project, the methodological approach is qualitative in nature. The accuracy of the information that qualitative research allows one to acquire within a specific context, and the flexibility of data construction procedures that "enable participants to express themselves in their own words and act in their natural life contexts" (Cardano & Gariglio, 2024, p. 35), represent the foundational strengths underlying the authors' choice. The ability to explore personal narratives and interpret the meanings attributed by social actors to their lived experiences makes the qualitative approach particularly effective for investigating emerging or underexplored phenomena (Merriam & Tisdell, 2015), "combining rigor with creativity" (Cardano & Gariglio, 2024, p. 37).

Specifically, the methodology employed is the multiple-case study (Yin, 2017; Creswell & Poth, 2017; Günes & Bahçivan, 2016). This approach enables an in-depth understanding of a complex phenomenon through the analysis of multiple cases that may present significant variations, convergences, or differing conditions: "a multiple-case study includes two or more cases or replications across the cases to investigate the same phenomena" (Lewis-Beck, Bryman & Liao, 2003; Yin, 2017).

The involvement phase of the case studies did not follow a completely linear path, primarily due to the limited dissemination of social robotics as an emerging technology, which is often confined to experimental and non-continuous projects. Additionally, access to hospital environments, characterized by high complexity, regulation, and sensitivity, represents a significant challenge for conducting research.

In particular, one of the initially involved cases underwent a change during the process due to unforeseen timing issues, which indefinitely postponed the start of the social robotics project. However, addressing unforeseen events and continuously adapting the research design is an integral part of the qualitative research process (Becker, 1998; Coffey, 1999), in line with the flexibility of the approach. From this perspective, the authors' reconsideration has led to recognizing the value of expanding the study's perspective by initiating collaboration with an international hospital setting.

Given these premises, the research design includes the involvement of three case studies:

- *University of Padua (Department of Women's and Children's Health)*, under the direction of Prof. Franca Benini, which envisages the use of social robotics in pediatric care (Pediatric Hospice Unit). Specifically, the Hospice utilizes the social robot OHMNI Robot (Figure 1).
- *University of Modena and Reggio Emilia*. At the Modena Polyclinic (PASCIA Center), the team coordinated by Prof. Maria Grazia Modena uses the social robot NAO (Figure 2) with pediatric patients within the autism spectrum.
- *Hôpital de jour du Centre André Boulloche, Paris*. Director Marie-Noëlle Clément, with the team coordinated by Dr. Olivier Duris, uses the NAO robot (Figure 2) with pediatric patients within the autism spectrum.

Figures 1 and 2 below illustrate the aesthetics of the social robots considered in the study. OHMNI Robot (Figure 1) is a telepresence robot developed by OhmniLabs, designed to facilitate remote communication in various settings, including healthcare. OHMNI Robot stands out for its ease of use and high-definition video and audio capabilities, allowing for smooth and natural interactions from any location. It is equipped with advanced technologies such as a high-definition camera, noise-canceling microphone, and an autonomous navigation system that avoids obstacles, enabling users to move safely even in complex environments like hospitals. Aesthetically, it consists of a kind of stem topped with a screen and camera, on which the professional appears in telepresence (https://ohmnilabs.com/). The NAO robot (Figure 2), developed by SoftBank Robotics and originally created by Aldebaran Robotics, has humanoid features. It is equipped with joints that allow various movements, including the ability to walk, dance, and gesture. It has numerous sensors that enable it to interact with the surrounding environment and people. NAO is programmable through various platforms and can thus be adapted to projects ranging from artificial intelligence to human-robot interaction (https://us.softbankrobotics.com/nao).





Figure 1 (left) – OHMNI Robot (source: telepresencerobots.com).
Figure 2 (right) – NAO Robot (source: NAO | Robot Wiki | Fandom).

Regarding the empirical phases of the multiple-case study, the authors have outlined four key stages for each case involved, as summarized in Table 1. For each research phase, the objectives, data collection tools, timeline, and data analysis approach are highlighted.

Based on Table 1, which provides a summary of the empirical phases of the research design, the authors highlight a methodological note regarding the use of a speculative scenario as a prompt for initiating the focus group. The purpose of utilizing a speculative scenario establishes a bridge of continuity and alignment with the methodological reflexivity lines that have characterized the research project since its inception (Valentini & Raffaghelli, 2023). Referring to Jen Ross's speculative method (2016) and Futures Studies, we acknowledge that 'working with the future' (Poli, 2019) can open up an innovative and creative theoretical-operational approach to address complex topics collaboratively.

Citing Ruha Benjamin (2016), Costello et al. (2024) emphasize certain statements recognizing the methodological and educational value of the futures approach: "the facts, alone, will not save us […]. Social change requires novel fictions that reimagine and rework all that is taken for granted about the current structure of society. Such narratives are not meant to convince others of what is, but to expand our own visions of what is possible' (Benjamin, 2016)" (Costello et al., 2024, p. 1).

Moreover, as Poli (2019) points out, working with the future represents a highly collaborative activity, wherein a powerful mutual enrichment occurs in the co-construction not only of a novel narrative to aspire to but also of concrete actions to be translated and implemented in the present (Poli, 2019). This approach deeply reconnects with the essence of educational planning, restoring ethics to the here and now as a space for choices, in light of the transformative value of the 'not-yet' (Ross, 2017).

3. Results

Currently, the research is focused on developing the four empirical phases at the Modena and Padua sites, with the collection of raw data. At the Modena University Hospital, two semi-structured interviews were conducted: the first with Prof. Modena, as the key professional figure in organizing social robotics interventions, and the second with the engineer responsible for programming NAO. The complexity of the hospital organization allowed for a focus group with three professionals: a doctor, a resident, and an administrative technician from Unimore with a significant role in organizing and training related to NAO.

Table 1 - Empirical Phases of the Research Design.

Research phases	*Objectives*	*Data Collection Tools*	*Expected Duration*	*Data Analysis Approach*
Non-Participant Direct Observation	Observe professional dynamics during a social robotics intervention	a) Paper-pencil recording b) Autoethnography diary c) Photos/videos	Duration of observation depends on hospital service organization	Thematic qualitative analysis of collected data
Semi-Structured Interview	a) Identify and interview the key figure overseeing social robotics interventions in the hospital services b) Highlight the overview of social robotics use in motivational and organizational terms c) Identify the presence of training paths for professionals involved in interventions d) Assess the perceived training needs of the key figure e) Understand the presence and role of educational professionals in the team	a) Audio recording b) Autoethnography diary	Max 45’	Thematic qualitative analysis of collected data
Focus Group	a) Hear the voices of professionals involved in social robotics interventions in the hospital service b) Identify the training needs of professionals c) Initiate a critical reflective discussion on ethical (good care) potentials and concerns regarding social robotics use d) Understand the presence and role of educational professionals in the team e) Share interdisciplinary professional agency experiences f) Use a speculative scenario as a starting stimulus for discussion	a) Audio recording b) Autoethnography diary	Max 1h/1h.15’	Thematic qualitative analysis of collected data
Member checking	a) Public engagement Transparency c) Data validation through participant confirmation and research quality improvement	a) Audio recording b) Autoethnography diary c) Photos	1h	Thematic qualitative analysis of collected data

Regarding non-participant observation, it was possible to attend two social robotics interventions with pediatric patients, in the presence of the caregiver and three professionals. Similarly, at the Pediatric Hospice in Padua, two non-participant observations of social robotics interventions with pediatric patients were conducted, with the caregiver and the professional (psychologist) in telepresence via the OHMNI robot. The semi-structured interviews collected contributions from Prof. Franca Benini, the service director, the psychologist coordinating social robotics interventions, and the psychologist using the robot remotely to conduct psychological sessions with patients and parents. The focus group phase involved eight professionals: two doctors, an engineer, a psychologist, and four nurses.

Since the research is ongoing and the raw data are awaiting thematic analysis, the authors provide a preview of some preliminary observations without interpretation or conclusions. A primary consideration concerns the aspect of training: a general lack of training in terms of professional learning and good care emerged, and some professionals emphasized this as a

genuine professional need. A second observation concerns a general (but not absolute) lack of understanding of educational professionalism: participants often suggested that educational professional skills could be seen as transversal attitudes that might be fulfilled by other professions. Only in a few cases was the value of the pedagogical-educational contribution recognized within teams dealing with social robotics. A third preliminary insight from the focus group highlights a general appreciation for the speculative scenario proposed as an initial reflective stimulus. In terms of preliminary results, it is also noted that the autoethnographic diary (present throughout all research phases) has proven to be an effective tool for capturing nuances and dynamics from a personal and pedagogically oriented perspective.

"Autoethnography is a unique combination of a heterogeneous set of research approaches and writing forms that aim to systematically describe and analyze ('graphy') personal experiences ('auto') in order to understand the cultural experiences ('ethno') in which they are embedded" (Gariglio, 2017)" (Cardano & Gariglio, 2024). This "authoritative" tool (ibid.) has allowed for exploring the intersections between individual experience and cultural context with a distinctive level of depth and reflexivity. Through autoethnography, the researcher has taken on an active role in the interpretive process, giving voice to personal experiences and perceptions, which, ex+pressed through their own lexical choices, become an integral part of the scientific narrative (Ellis, Adams & Bochner, 2011). In this way, the autoethnographic diary not only serves as a record of observations but also as a tool for critical analysis and introspection, enriching the overall research framework.

The research group's expectations regarding the final results aim at understanding the professional dimension involved in the delivery of social robotics interventions in each hospital case involved. This anticipated understanding particularly seeks to:

- Highlight existing training pathways
- Identify the training needs of professionals
- Emphasize the critical-reflective implications of using social robotics for professionals from a perspective of good care
- Emphasize the practical implications of using social robotics for professionals from a perspective of good care
- Identify convergences and divergences among the case studies involved
- Understand the relevance of educational professionalism in the hospital context using social robotics
- Contribute to documenting the use of social robotics in hospitals from the perspective of professional dynamics
- Contribute to raising awareness within the scientific community about the importance of "caring for those who care" to promote authentically ethical and educational contexts in relation to technology
- Generate new reflections and perspectives on educational action (e.g., the development of innovative teaching and training tools).

4. Conclusions

This contribution has described the empirical phase of the research design, which represents the core of a doctoral project. Based on the narrative review and the systematic literature review, four main areas of investigation emerged, guiding the project's development, including the related phases and data collection tools. The general and specific objectives, the methodological approach, the current progress, and the research group's open perspectives regarding the final results were highlighted. In conclusion, three cross-cutting considerations reflect the purpose and value of this work.

First, the complexity of today's digitalized *onlife* society and the relationship between humans and technology requires a new mindset: "complex situations are characterized by the lack of 'right' answers.

References to the past are no longer sufficient. New innovative patterns emerge" (Poli, 2019, p. 64). This calls for an urgent appeal to planning, reflexivity, creativity, knowledge, and skills inherent to pedagogical-educational professionalism, which is called upon to take a stand and embrace the challenge posed by this ever-evolving relational complexity.

Lastly, this commitment must be embedded in the space of good care, that is, care that is both ethical and educational (Mortari, 2015). This space is necessary to promote the creation of authentic educational contexts, starting from the agentive training of those on the front line working with new technologies.

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We would like to express our gratitude to the hospital services that embraced our research proposal. The implementation of the research design is indeed anchored in the possibility of collaboration with hospitals that use social robotics, considering the delicacy and complexity that characterize these settings.

We see in these open collaborations a valuable opportunity to build a shared and synergistic sense of purpose, one that respects the inherent complexity and is aimed at fostering good care and the overall well-being of the individual.

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Women and Career Development: the role of digital soft skills in training

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Abstract

The Digital Skills Scoreboard presented by the European Commission in 2021 confirms that there is still a significant gender gap in specialized skills: only 19% of ICT specialists and about one-third of STEM graduates are women. According to the Digital Economy and Society Index, which measures the progress made by member states in building a digital economy and society, Italy ranked 18th among the 27 EU countries in 2021, below the EU average, particularly in the Human Capital component. This is critical when related to the literature that emphasizes how digital skills, especially digital soft skills, play a decisive role in career paths across all productive sectors in today's labor market dynamics. Based on these premises, the aim of this research project is to study the relationship between digital skills and career paths in a sample of 700 Italian women, predominantly unemployed, involved in various training programs. To this end, a mixed research methodology will be used, administering a questionnaire on digital skills and five open-ended questions specifically designed to investigate participants' perceptions of the relationship between digital soft skills and career paths. The expected outcome of the research project is to explore the perception of the role of digital skills and, specifically, digital soft skills in the career paths of the group of participants involved in the study.

Keywords: Digital Soft Skills, Soft Skills, Technology, Work, Women Empowerment.

1. Introduction

The continuous technological evolution has revolutionized our lives and influenced the skills required by employers. The shift from an industrial economy to an information society has led to an increasing emphasis on aspects such as Digital Team Working, Smart Collaboration, and Problem Solving in the workplace (Brynjolfsson & McAfee, 2014; Frey & Cerruti, 2021; Frey & Osborne, 2013). Soft skills are now essential not only for job access but also for excellent performance in the professional environment. A survey conducted by the Digital Skills Observatory revealed that soft skills are more relevant than process- and technology-related skills. In particular, there is an urgent need to develop communication and team management skills (Digital Skills Observatory, 2023; World Economic Forum, 2018). The term “digital skills” refers to a set of knowledge, abilities, and capacities necessary to effectively use digital technologies and leverage them for professional purposes. These skills include both specific technical skills related to the use of digital tools and software, as well as cross-cutting skills also known as “digital soft skills”. Digital soft skills are abilities that enable effective interaction, communication, and collaboration in the digital environment. These skills focus on the human and relational aspects of using digital technologies and involve the ability to adapt to technological changes. In a context characterized by widespread digitalization, employees must develop specific digital skills to ensure effective job performance. This includes competencies such as the ability to use digital tools, digital literacy, adaptability to technological change, and the ability to solve complex problems using available digital resources. These digital skills contribute to personal, professional, and business competitiveness during the Digital Transformation. The skills required of employees are evolving in response to the impact of technology in the information society. Cross-cutting skills, or soft skills, have become indispensable for professional success,

for working effectively in contexts characterized by widespread digitalization, and for maintaining personal, professional, and business competitiveness during the Digital Transformation (Global Digital Skill Index 2022; Venier, 2016).

The main objective of the research project is to thoroughly explore and analyze the perception of the role of digital skills, with a particular focus on digital soft skills, in the career paths of the participants involved in the study. Through this research, the aim is to understand how these skills influence professional opportunities, growth, and personal development of women in the contemporary work environment. Additionally, the project seeks to identify potential barriers and facilitators in acquiring and applying digital skills, in order to propose effective strategies for enhancing digital soft skills among professionals.

2. Materials and Methods

Based on these premises, the objective of this research project is to study the relationship between digital skills and career paths in a sample of 420 Italian women, predominantly unemployed, involved in various training programs. To this end, a mixed research methodology was used, administering a questionnaire on digital skills and five open-ended questions specifically designed to investigate participants' perceptions of the relationship between *digital soft skills* and career paths.

The aim of this research project is to examine the relationship between digital skills and career paths in a sample of 420 Italian women, predominantly unemployed, engaged in various training programs. For this purpose, a mixed research methodology was adopted, which included administering a standardized questionnaire to assess digital skills, supplemented by five open-ended questions specifically formulated to explore participants' perceptions regarding the influence of digital soft skills on their professional development.

The digital skills questionnaire investigated five domains, including: *digital literacy, information management, online communication, digital problem-solving, and self-directed learning.* An initial analysis indicates that the candidates' levels of digital skills are medium-low, with greater difficulty observed in digital problem-solving and the inability to access suitable dedicated training courses.

Regarding qualitative analysis, a questionnaire consisting of five questions was administered via an email containing a link to Google Forms. The objective of the questionnaire is to explore candidates' perceptions of the role of digital soft skills in the career paths of the participants involved in the study. The responses to the questionnaire were analyzed using content analysis methodology, identifying *four* main recurring themes among the participants:

1. The importance of flexibility and adaptability: Digital skills have profoundly influenced how professionals interact with colleagues and clients. Email and mobile phones have facilitated and accelerated communication, reducing physical distances and improving work interaction efficiency. For example, emails are used for formal interactions, while smartphones facilitate informal communications. Additionally, sharing software like Dropbox has optimized collaboration by allowing quick and secure exchange of documents and information.
2. The need for continuous training.
3. The perception of increased empowerment through digital skills.
4. Awareness of career opportunities linked to mastery of digital soft skills.

The possibility of enhancing digital skills through training courses is considered essential, but workplace opportunities are often limited. When available, these opportunities are generally aimed at high-tech professions. This scenario has motivated many professionals to adopt a self-taught approach to fill their digital gaps, relying on practical experience rather than structured training. This spontaneous learning process is often simple and intuitive, especially for those born in the digital age. However, the lack of formal training can make it difficult to efficiently and effectively use software necessary for daily work. Targeted rather than general training would be more useful,

focusing on specific software or digital tools used in one's field of work. Despite the digital revolution, the lack of adequate training programs represents a significant challenge that needs to be addressed to improve effectiveness and innovation in work contexts.

3. Results

The analysis of the collected data revealed central elements regarding the perception of digital competences and *digital soft skills* in the participants' career paths. The quantitative results show medium to low levels of digital skills within the sample, with pronounced difficulties in digital *problem solving* and access to structured training. The responses to the five open-ended questions allowed a deeper exploration of the participants' subjective perception of the role of digital skills, highlighting recurring themes and significant differences between responses.

With respect to the first question, "*Which digital skills have played a relevant role in the development of your career?"*, three main thematic areas emerged:

1. *Knowledge and use of software*: Participants often cited knowledge of specific software as an essential element for career advancement. The term "software knowledge" was mentioned 95 times, confirming the importance of tools such as data management programs, productivity applications, and collaboration platforms.
2. *Cross-cutting digital skills*: The phrase "digital skills" was the most repeated (160 times) in the responses, highlighting how these skills are perceived as fundamental not only for performing daily tasks but also for managing one's career in increasingly digitalized contexts.
3. *Data management and analysis*: The ability to handle and interpret digital data emerged as another key competency, mentioned 109 times. This skill is considered crucial, especially in sectors where managing large amounts of data is a decisive aspect of professional success.

In response to the second question, "*What digital tools/devices do you consider essential for your career development?"*, the participants revealed a strong dependence on a number of essential digital tools, with the following recurring mentions:

1. *Smartphone*: Cited 206 times, the smartphone is seen as an indispensable tool for managing communications and daily activities, confirming its central role in modern professional management.
2. *PCs* and computers: The terms 'PC' (153 times) and 'computer' (139 times) were frequently mentioned as key devices for career development, particularly for performing complex tasks and accessing professional software.
3. *Tablet:* Although its use is less widespread than PCs and smartphones, the *tablet* was mentioned 168 times, mainly with reference to its usefulness for mobile tasks and the quick handling of documents and presentations.

The information that emerges in response to the third question, "*What are the main challenges you have faced in acquiring and developing the digital skills necessary for your career?"* can be placed within three thematic cores:

1. *Lack Lack of Challenges:* Some participants in the data collection reveal that they have approached digital technology with ease, viewing challenges as stimulating opportunities. For them, engaging with new technologies is a natural process, driven by an interest in continuous learning, particularly evident among "digital natives." Overall, there is a strong interest in improving skills such as communication, collaboration, and problem-solving, which are enhanced by the use of digital tools. In general, the acquisition of technological skills is perceived as almost innate, and the transition to a digital environment is seen as an opportunity for both professional and personal growth.
2. *Learning Ability:* In the educational and professional journey of 186 people, the acquisition of digital skills has taken place through courses and continuous updates not always supported by their respective employers. This has allowed them to develop a solid

foundation to face technological challenges. One of the most significant barriers is self-directed learning to keep up with continuous updates. In 93 cases, autonomous skill acquisition helped overcome initial difficulties, driven by curiosity. This has fostered the development of soft skills such as flexibility and customization of skills.

3. *Difficulty of Use:* In 120 cases, the main challenge lies in adapting to new software and tools, complicated by digital obsolescence and the need to develop increasingly advanced skills. Technical malfunctions, compatibility issues, and device management are often perceived as obstacles that cause frustration. Additionally, data protection and privacy are growing concerns that require specific skills to ensure information security, posing a difficulty for those unfamiliar with technology.

The theme of relationships with colleagues and customers, highlighted by the question: "*How (and which) digital skills have influenced the way you relate with colleagues/customers?"*, revealed that many participants emphasized that digital skills in the field of online communication, such as the use of email, video-conferencing platforms and collaboration tools, had significantly improved the quality and efficiency of their working relationships. These tools were seen as an essential bridge for managing remote work and improving interactions, especially in international contexts.

In particular, these skills are seen as:

1. *work status recognition*: the answers show a clear link between digital skills and work status recognition, both by colleagues and customers. Being able to work independently, mastering specific tools and software, solving technological problems and keeping up-to-date are all key elements that contribute to being seen as a reference for both colleagues and customers.This advanced skill set not only emphasises the ability to support others and respond to user needs, but also to stand out as a reliable and competent professional in one's own field. The centrality of digital competences in the modern working environment is evident, and their impact on interpersonal relationships and self-perception within the professional environment is significant.
2. *communication and teamwork facilitators (space/time).*

Regarding the implementation of digital skills through training, the last question, "*How do you see the possibility of implementing your digital skills through a training course? Have you ever been offered this opportunity in the workplace in the past?", it emerges that:*

1. The most common responses highlight the *importance of training*. About 60 per cent of those who expressed this opinion indicated that they dedicated themselves to self-learning to fill existing gaps, while the remainder preferred to attend vocational courses.
2. The topic of *training* aroused *interest in* more than 49 respondents, yet none of the participants reported having attended specific courses. On the contrary, they opted for autonomous learning.
3. Of the most frequent responses (>200) emphasising the importance of training, most highlight and complain about the *lack of training* and further *training opportunities* in their companies.
4. Some participants mentioned that they had access to training or refresher training opportunities. However, among them, some felt obliged and found the training programme too general. Only a small number of them reported a sense of actual satisfaction from the training experience.

Hence, the answers to this question showed a strong interest in specific, targeted training courses to acquire digital skills. However, most participants emphasised the rarity or absence of such opportunities in their current work contexts, prompting them to seek individual learning solutions.

This desire to participate in specific courses to improve digital skills is accompanied by a general lack of training opportunities within work contexts. Therefore, many participants were prompted to seek and pursue learning independently as self-learners, highlighting their determination and self-motivation.

In summary, the data collected suggests that although digital skills and tools are perceived as crucial factors for professional success, significant barriers to accessing adequate training

resources persist. The responses to the open-ended questions offer a rich insight into the participants' lived experiences, highlighting the need for greater investment in digital training and specific professional support.

4. Conclusions

The results of this research highlight the strategic importance of digital skills, in particular *digital soft skills*, in the career paths of Italian women, especially in a context characterised by an increasing digitalisation of the labour market. The participants recognise the value of these skills for professional advancement, but their acquisition is often problematic, with medium-low levels detected especially in skills related to digital *problem solving* and information management. This training gap translates into a significant limitation of professional development opportunities.

The qualitative analysis revealed that digital tools, including smartphones, computers and collaboration software, are perceived as essential for improving communication and productivity, facilitating interaction with colleagues and customers. However, the lack of structured and accessible training paths continues to be a major barrier, driving many participants to self-taught digital skills. This lack of formal training limits the acquisition of more advanced skills and compromises efficiency in the use of complex digital tools.

The data that also emerged from the quantitative analysis underline, moreover, how the development of *digital soft skills* can foster greater *empowerment* of women in the world of work, improving their competitiveness and career opportunities. However, in order for these skills to be fully exploited, more investment is needed in targeted training programmes that address the specific needs of women who, as the sample revealed, are often unemployed or underemployed. The creation of tailor-made training pathways, combining technical and transversal skills, is crucial to overcome current barriers to entry and improve female participation in the digital sector.

5. Suggestions for future studies

The evidence gathered suggests several directions for future research. One relevant area of investigation could be to investigate the impact of *reskilling* and *upskilling* policiesin the digital domain, with a specific focus on women and disadvantaged social groups. In addition, longitudinal studies examining the evolution of e-skills in relation to career opportunities and occupational mobility, as well as comparative investigations between different regional or sectoral contexts, would be appropriate to better understand territorial dynamics and sectoral differences in the acquisition and application of e-skills. Another strand of research could explore the role of firms in facilitating the acquisition of advanced e-skills by analysing lifelong learning initiatives and their effectiveness in promoting digital inclusion and gender equality in the labour market.

In particular, based on the research findings, future studies could broaden the understanding of e-skills and their impact on working careers: i.e. one that aims to examine in more detail the transversal digital skills required in the labour market, based also on their impact on professional growth and adaptation to digital challenges.

Based on the data collected in response to the fourth and fifth question of the questionnaire, some areas for future research could explore in more detail the challenges encountered in the acquisition and development of digital competences required for professional careers, in particular one could examine:

a) how interest in lifelong learning and a proactive approach to the acquisition of digital competences influence professional and personal growth
b) the challenges associated with the adoption and use of new digital software and tools, focusing on the obstacles caused by compatibility issues and the need to acquire more and more advanced skills.

c) how organisations can effectively support the acquisition and development of digital skills of their employees through continuous courses and updates. In particular, examine in detail corporate training policies and practices to assess the effectiveness and adequacy of training opportunities offered to employees.

d) deepen the role and effectiveness of autonomous learning and self-motivation in digital skills acquisition. In particular, exploring the strategies used by employees to self-train and identifying best practices that could be incorporated into formal competence development programmes.

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A new teacher portfolio towards lifelong learning

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Abstract

The integration of a novel teacher portfolio for newly recruited teachers in Italy epitomizes a new approach to meeting the demands of lifelong learning within the teaching profession. This paper explores the deployment and implications of this innovative model, which has been embraced by over 40,000 teachers during their probationary year starting from the 2023/24 school year. Anchored in a set of minimum professional standards, the teacher portfolio promotes self-evaluation across a broad spectrum of teaching competencies, from didactics and engagement in school life to organizational involvement and professional advancement. It encourages teachers to undertake reflective practice by documenting their professional development experiences, thereby fostering growth and facilitating adaptation to the complex realities of contemporary classrooms. This transformative instrument is pivotal for the systematic documentation of teachers' professional trajectories and serves as an essential mechanism for continuous professional development and self-assessment. Its adaptability, extensive applicability across all educational levels and disciplines and flexibility across professional development phases (from Initial teacher Education, to Induction, to Continuous Professional Development) renders it a valuable tool in sustaining the principles of quality teaching and learning processes. Leveraging preliminary empirical data from the 2023/24 school year, based on the widespread adoption of the teacher portfolio by a significant number of teachers in their probation year this study articulates the teacher portfolio's potential to markedly influence teachers' professional growth from a lifelong learning standpoint.

Keywords: Teacher Portfolio, Induction, Teacher Standards, Reflective Practice, Lifelong Learning.

1. Introduction

The introduction of a new digital portfolio for newly hired teachers in Italy during the 2023/24 school year marks a significant step toward addressing the ongoing training needs of the teaching profession. Teachers and educators are required to engage in lifelong professional development, and countries worldwide are committed to supporting their teachers in maintaining motivation and continuously improving their expertise throughout their careers. Self-reflection (Schön1983; Vinatier & Altet, 2008) plays a key role in this process, serving as a critical lever for fostering growth and development.

The use of digital portfolios (also known as e-portfolios) has been widely studied in the context of pre-service teacher education. Recent research highlights that while portfolios show promise in supporting reflective practice (Imhof & Picard, 2008; Hopper et al., 2018), demonstrating student-teachers' skills and knowledge, and tracking their growth over time (Montgomery,

2003), their impact depends on various factors. These include the quality of implementation (e.g., clear instructions and feedback) (Zeichner, & Wray, 2001), individual characteristics such as self-efficacy and proactive learning approaches (Imhof & Picard, 2008), and the degree of ownership and personalization (Montgomery, 2003). Granberg (2010) adds that successful portfolio integration requires a nuanced understanding of pedagogical implications, continuous reflection on practices, and collaborative efforts among teacher educators and institutions.

In pre-service teacher education, a recent systematic review by Feder and Cramer (2023) synthesizes empirical evidence based primarily on quantitative data regarding the effects of

portfolios. Their findings reveal a prevalence of qualitative studies, reflecting the complexity of portfolio use and its multifaceted impact on aspects such as reflection and professional identity.

Despite the context-dependency of these results, key effects of portfolios include enhanced reflection, self-assessment, professional development support, facilitated dialogue and feedback, and improved motivation and engagement among student-teachers.

Feder and Cramer (2023) further emphasize the need for more methodologically rigorous research, particularly quantitative studies with larger sample sizes and longitudinal designs. This would provide stronger evidence of the effectiveness of portfolios and yield more generalizable findings—precisely the aim of the current study.

To our knowledge, large-scale research on portfolio use in both induction and in-service teacher education is scarce. However, small-scale qualitative studies offer valuable insights. For instance, Fox et al. (2008) examined portfolios of teachers at different stages of a professional development program and concluded that reflections within the portfolios offer important insights into teacher development, though individual differences in growth patterns must be considered. Similar conclusions were drawn by Aras (2021) in a study of early childhood teachers in Turkey, and by Espinoza & Medina (2021), who explored the impact of e-portfolios on the learning experiences of in-service English teachers in Chile.

Even rarer in the literature is the exploration of portfolio use beyond pre-service teacher education. Boulton (2013), in an action-research study, investigated the feasibility of extending e-portfolio use into the Newly Qualified Teacher (NQT) year and beyond. The study highlighted two key aspects: interoperability to support the transition and sustained professional development. Boulton found that digital portfolios could effectively support new teachers throughout their careers by encouraging ongoing professional learning. However, the study also stressed the importance of NQTs feeling a sense of ownership over their portfolios to use them as tools for self-directed learning and reflection.

One aspect that is notably underexplored in the literature is the connection between portfolios and teacher professional standards. Montgomery (2003) is one of the few to discuss this, emphasizing that aligning digital portfolios with professional standards is essential to demonstrate the attainment of required competencies. This aligns with a broader recognition of the importance of Teacher Professional Standards as key components in educational systems globally (Darling-Hammond, 2021).

The extensive research demonstrating the effectiveness of portfolios in teacher education, despite differences related to various stages of professional development, has driven the large scale adoption of the digital portfolios in induction programs in Italy since 2015, used by over 300,000 teachers (Pettenati, 2022). The recent introduction of a renewed portfolio version, flexible and adaptable to different stages of professional growth, offers an opportunity to explore its usability on a national scale within the context of teachers' continuous professional development.

This paper analyzes the introduction and preliminary results of the new portfolio, used in 2023/24 by more than 40,000 newly hired teachers during their probationary year. The study explores its potential for supporting lifelong learning. Drawing on empirical data from monitoring questionnaires administered to the entire cohort of newly hired teachers, the research questions guiding this paper are:

- Does the use of the online portfolio contribute to enhancing the quality of teacher training during the induction period?
- What is the potential for the portfolio to support Continuing Professional Development (CPD)?

2. Materials and Methods

The teacher portfolio is an online tool, designed to support teachers' professional growth, facilitating reflection and documentation of various development milestones. The theoretical framework for the lifelong teacher portfolio was developed in 2021 through collaborative research

by Indire, the University of Macerata, and the Catholic University of the Sacred Heart (Di Stasio et al., 2021). Building on previous large-scale teacher portfolio models (Rossi et al., 2017), this model centers around Teacher Standards, which support self-assessment and the evaluation of competencies defining professional practice. The model is structured around four key functions: Documentation, involving the curated collection of materials that substantiate professional development; Reflection and Narrative, where teachers link selected materials to articulate their competencies and growth; Projection, allowing teachers to assess their skills against a professional competence profile; and Publication, which enables teachers to share aspects of their professional journey with others.

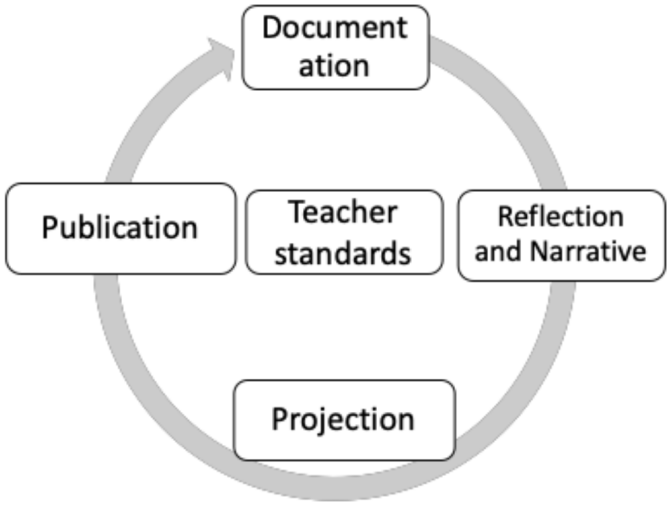


Figure 1 - Teacher's portfolio model (Di Stasio et al., 2021).

By construction, such a portfolio model should provide its suitability for accompanying teachers in a lifelong learning perspective through all phases and stages of maturity, from initial teacher education to in-service training.

As of school year 23/24, the general and theoretical portfolio model (Di Stasio et al., 2021) was reworked and implemented in the new version for newly qualified teachers for the purpose of supporting the documentation of professional development in the training and probationary year, as articulated according to DM 226/2022 by which it is regulated.

In accordance with the theoretical model, the new portfolio is based on two core constructs – Teacher Standards and Documentation of Experience – and culminates in a series of online activities that both mirror and integrate the face-to-face and school-based practices, fostering a comprehensive approach to teacher professional development (Figure 2, upper section).

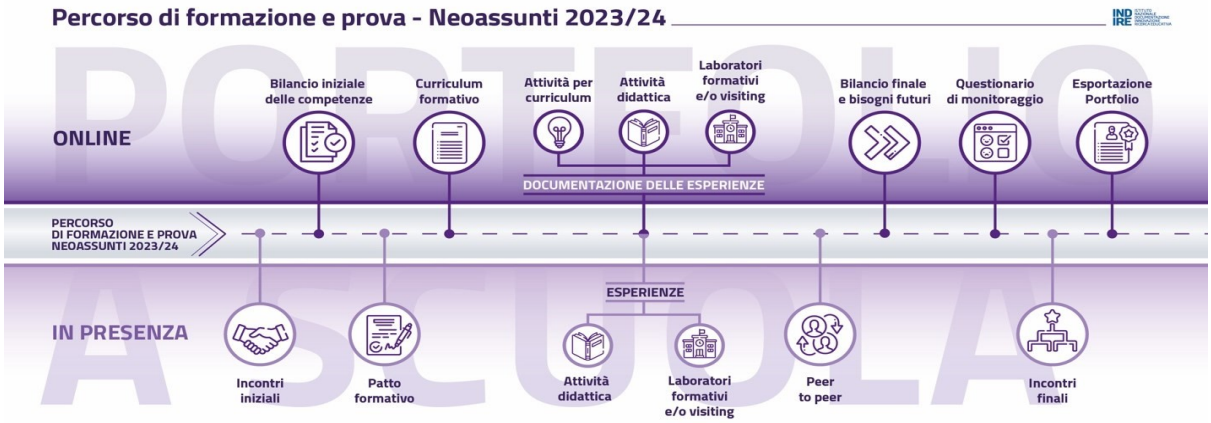


Figure 2 - Description of the online activities of the new teacher's portfolio released for newly qualified teachers in the induction school year 23/24 (upper section).

The Standards in the Competency Framework of the new portfolio for newly hired teachers have been designed to provide flexibility, accommodating various stages and purposes of professional growth. This adaptability allows the portfolio to be used primarily for self-assessment ("Where am I?"), as preparation for training decisions ("What do I want to improve?"), and to identify areas where one's role can extend beyond the classroom ("In what areas can I support my professionalism?").

Building on the work done at the ministerial level (MIUR, 2018) and on large-scale experimentation experiences with Competence Framework documented for the initial and entry training phases (Magnoler, 2017, Pettenati, 2022), the competences profile developed in the new portfolio (Pettenati, 2024) revolves around 3 main areas (Table 1): the Didactics area, the Institution and Community area, and the Profession area, 8 Professional Standards and 36 Competence Indicators.

Area	Teacher Standards
A. Didactics – Area of pedagogical, methodological, and relational competencies	Standard 1: Design and manage learning situations that promote the eight European key competences for lifelong learning, transforming teaching into meaningful and critical experiences, including the use of digital and face-to-face teaching tools, and using tools to document, assess, and certify students' personal competencies, also with an orientation perspective.
	Standard 2: Adopt and adapt teaching strategies and methods, including those personalized for the inclusion of students with disabilities and special educational needs, integrating disciplinary and interdisciplinary epistemologies and methodologies.
	Standard 3: Use assessment strategies and methods to promote learning.
	Standard 4: Manage relationships and behavior in the classroom to foster learning in a calm and collaborative environment.
B. Institution-Community – Area of competencies related to participation in school life and the social context	Standard 5: Actively participate in the organized professional experience at school, understanding and applying the functions and methods of internal and external assessment of formal, non-formal, and informal learning.
	Standard 6: Work collaboratively with the school's professional community.
	Standard 7: Establish positive relationships with families, institutional partners, and social partners.
C. Profession – Area of continuous training, professional care, and development of new responsibilities	Standard 8: Engage in continuous training and professional development, integrating foundational knowledge and teaching methods specific to one's subjects, with the ability to design and flexibly manage class/interclass groups for the personalization and promotion of talents, as well as the development of cross-cutting and communication skills.

Table 1 - Professional Standards used in the Competency Assessment of Newly Qualified Teachers, School Year 2023–2024 (Pettenati et al., 2024).

The Teachers Standards were also designed with the aim of linking to the most recent normative documents defining the "Concluding Profile of the Qualified Teacher, Professional Competencies and Minimum Professional Standards on initial teacher training for secondary school teachers", (DPCM 4/8/2023), but also with Annex A to DM 226/22, which regulates the training and probationary year and provides a tool (structured observation grid) for reciprocal observation between tutor and newly hired teacher, declining the evidence that can support the explication of professional competencies especially with regard to the area of Didactics.

The self-assessment is supported by the provision of five levels of mastery ranging from "the competence has never been tested" (level 0) to "the competence is mature and accredited and can be made available to/for colleagues and the school" (level 4) (Figure 4).

Eventually, the section of the new teachers portfolio called Documentation of Experiences in the general model (Figure 1), has been implemented to allow the documentation of formative professionalizing Experiences specific of the probationary. This section aims to support reflection in action and after action (Schon, 1993) and to stimulate constant adjustment of one's professional actions (Vinatier & Altet, 2008). It provides for the description of training activities (workshops, visits to innovative schools, didactic activities) according to the specific induction

model (DM 226/22) on which reflection guided by specific questions-stimulus is also part of the mandatory activity (Figure 5). Documented Experiences are also to be linked by the teacher to one or more Professional Standards that are influenced by the experience itself.
The complete structure of the portfolio (sections and related descriptors, guiding questions) for newly qualified teachers is summarized in the Table 2 below.



Figure 4 - Interface of the Competency Framework for the self-assessment activity implemented in the newly hired teachers portfolio s.y 23/24.

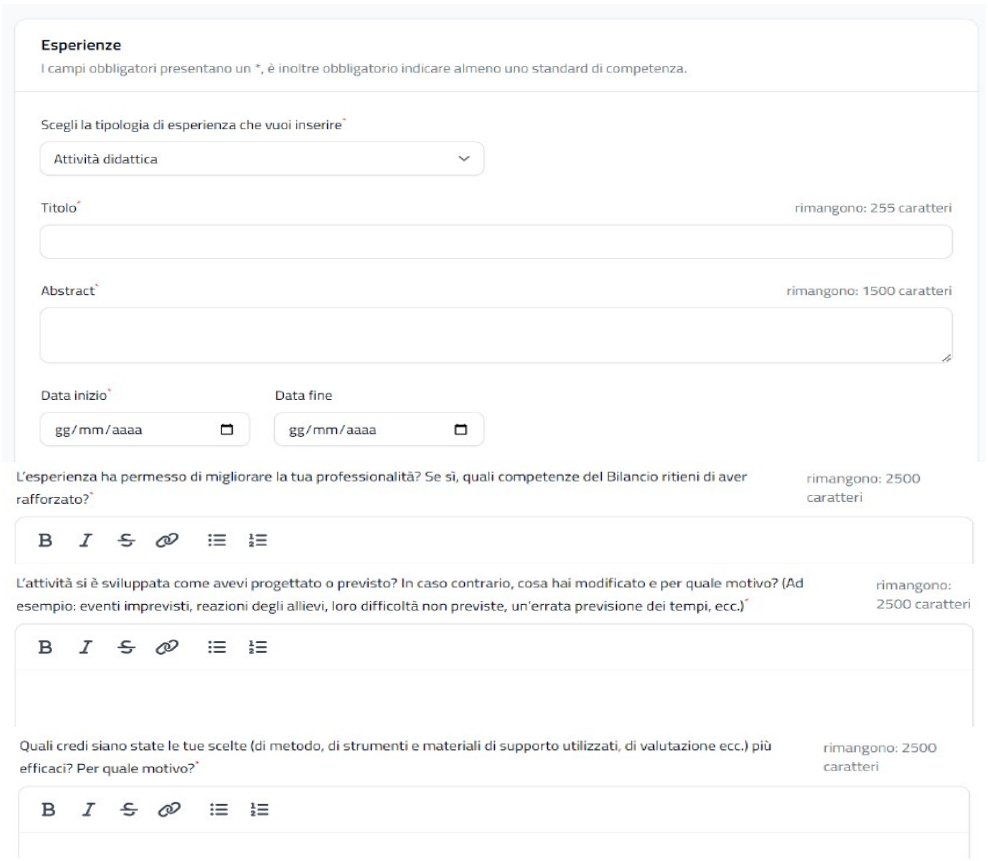


Figure 5 - Interface of the Documentation of the Experiences section in the newly hired teacher's portfolio s.y 23/24.
(to be continued...)

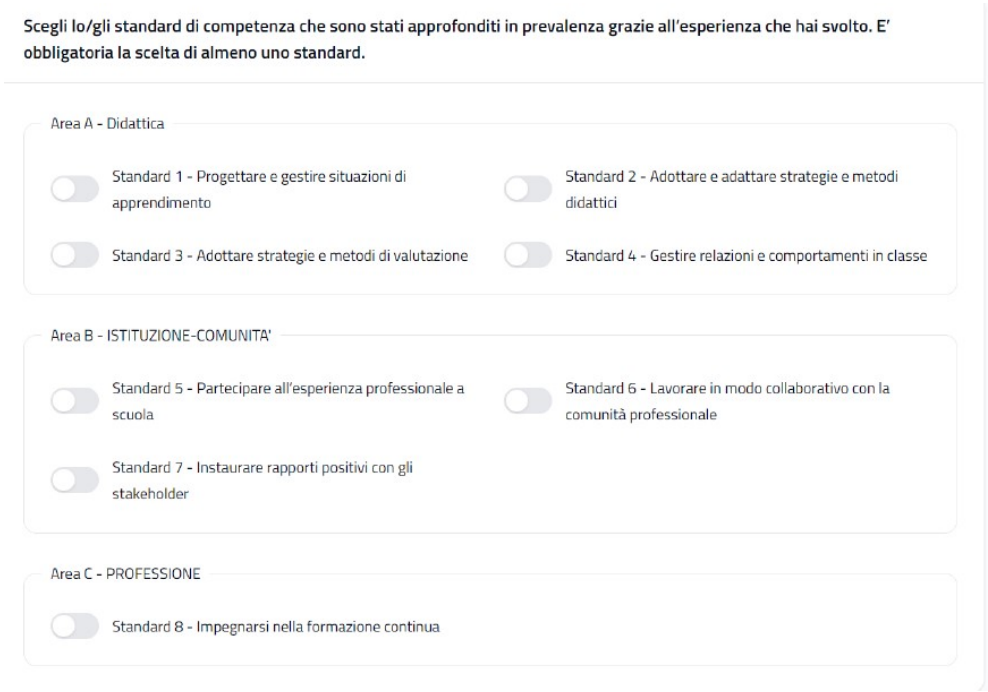


Figure 5 - Interface of the Documentation of the Experiences section in the newly hired teacher's portfolio s.y 23/24.

Table 2 - Structure and sections of the Teacher Portfolio for Newly Qualified Teachers.

PROFESSIONAL TRAINING RECORD

Describe a maximum of 3 experiences (formal or informal) that have been significant for your professional growth.

- Title
- Duration of Experience
- Brief Description

Open-ended Questions

- What knowledge/skills did you acquire during this experience, and how do they contribute to your professional practice?
- Which competencies from your initial self-assessment do you feel you have strengthened, and why?

Multiple choice question:

Which teacher standards were impacted by this experience? (Select from Standards 1 to 8)

LABORATORIES / STUDY VISITS

Describe 1 to 4 laboratories and/or 1 or 2 study visits.

- Title
- Duration of Experience
- Brief Description

Open-ended Questions for Laboratories

- Which of the following topics was addressed in the laboratory session you attended?
- Did the laboratory provide you with elements (methods, strategies, tools, or content) that you plan to or have already implemented with your students? If so, which ones?

Open-ended Questions for Study Visits

- What innovative practices did you observe?
- Are the practices you observed generalizable or applicable in your class or school? Are they sustainable, or do they require specific resources for implementation?

Multiple choice question:

Which teacher standards were impacted by this experience? (Select from Standards 1 to 8)

DOCUMENTATION OF A DIDACTIC ACTIVITY

Describe a teaching activity carried out during the probationary year

- Title
- Duration of Experience
- Brief Description

Open-ended Questions

- Did this experience enhance your professionalism? If so, which competencies from your initial self-assessment do you feel you have strengthened?
- Did the activity unfold as you had planned or anticipated? If not, what adjustments did you make and why? (e.g., unforeseen events, student reactions, unexpected difficulties, inaccurate time estimates, etc.)
- What do you consider to be your most effective choices (in terms of methods, support materials, evaluation, etc.)? Why?

Multiple choice question:

Which teacher standards were impacted by this experience? (Select from Standards 1 to 8)

INITIAL SELF-ASSESSMENT (To be completed at the beginning of the probation year)

- Self-assessment based on 36 competence indicators using a 5-level mastery scale.

FINAL SELF-ASSESSMENT AND FUTURE DEVELOPMENT PERSPECTIVES (To be completed at the end of the probation year)

- Self-assessment based on 8 teacher standards using a 5-level mastery scale.

Open-ended Questions

- What skills (abilities, knowledge, attitudes) did you choose to develop or did you improve this year? Do you feel they have improved? If so, in what ways, and through which activities?
- Among the proposed thematic areas, which topics do you wish to further develop in the future, considering both your personal interests and the improvement needs of your school (as expressed in the Three-Year Curriculum Plan and relevant to your specific role)?

To answer to the research question, this study employs a national survey aimed at assessing the perception of newly qualified teachers regarding the perceived value of this portfolio during their probation year and the potential use of a new online portfolio from the perspective of continuing professional development (CPD).

The primary tool for data collection was a questionnaire consisting of 17 items. The questionnaire was designed (Marradi, 2019) to elicit responses that would provide insights into:

- explore the potential use of the portfolio for continuing professional development; assess how the portfolio can be integrated into continuing professional development practices, identifying opportunities and perceived benefits for teachers.
- evaluate the contribution of the portfolio to training quality; analyze how the use of the portfolio may positively influence the quality of teacher training, highlighting areas for improvement and expected outcomes.
- gather feedback on teachers' experiences in the new environment; collect direct insights from teachers regarding their experiences using the new portfolio, understanding challenges faced and usability features that are most appreciated.

The target population for this survey included all teachers undergoing induction during the school year 2023/2024, totaling over 46.000 individuals. A robust response rate was achieved, with 42,072 respondents participating by June 16, 2024. Data were collected through an online platform to facilitate ease of access and completion. Some questions in the questionnaire, particularly those related to the potential use of the portfolio, were contingent on previous responses, where participants had expressed a certain level of interest (from moderate to high) in continuing to use the portfolio. Therefore, the number of respondents may vary across different questions.

The responses were analyzed quantitatively using statistical methods to identify trends and patterns in perceptions regarding the online portfolio's utility in CPD. Descriptive statistics were employed to summarize the data.

3. Results

Based on the responses from the questionnaire, the use of the online portfolio appears to have contributed positively to enhancing the quality of teachers' training during the induction period.

The portfolio helped and guided in completing all the stages of the probation year in a clear and organized way: a significant number of teachers, 34.9%, reported that the portfolio helped them “a lot” in completing the stages of the probation year, with an additional 44.5% saying it helped them “quite a bit”. This indicates that nearly 80% of the teachers found the portfolio to be a very helpful organizational tool. Only a small percentage, 1%, felt that it did not help at all. Moreover, the portfolio contributed to building a coherent and comprehensive view of the activities carried out during the probation year: 29.7% of the teachers said the portfolio helped "a lot" in creating a coherent view of their probation year activities, with 51.7% saying it contributed "quite a bit." This reflects a strong consensus (over 80%) that the portfolio helped in providing an organized understanding of their activities. Moreover, most teachers saw the portfolio as a valuable tool for fostering reflective practice: the portfolio contributed to facilitating critical reflection on teaching: 29.8% of respondents stated that the portfolio contributed “a lot” to critical reflection on their teaching practice, while 47.0% felt it contributed “quite a bit”.

The results for the question “Would you like to continue using the portfolio?” reveal a moderately positive trend towards continued use of the portfolio, but with some reservations.

Only 8.4% of respondents expressed a strong desire ("A lot") to continue using it, while 33.4% answered "Quite a bit," indicating significant but not enthusiastic interest. Together, these groups make up 41.8% of respondents, showing a generally positive, though not overwhelming, inclination towards the portfolio. The largest group, 36.2%, expressed moderate interest ("Moderately"), suggesting that most teachers see some value in the portfolio but do not view it as essential or highly beneficial. A further 16.6% responded "Slightly," showing low interest in continuing to use the portfolio, and finally, 5.3% indicated no interest at all ("Not at all"). This relatively small percentage suggests that only a minority of teachers find the portfolio completely irrelevant or of little use for their professional needs.

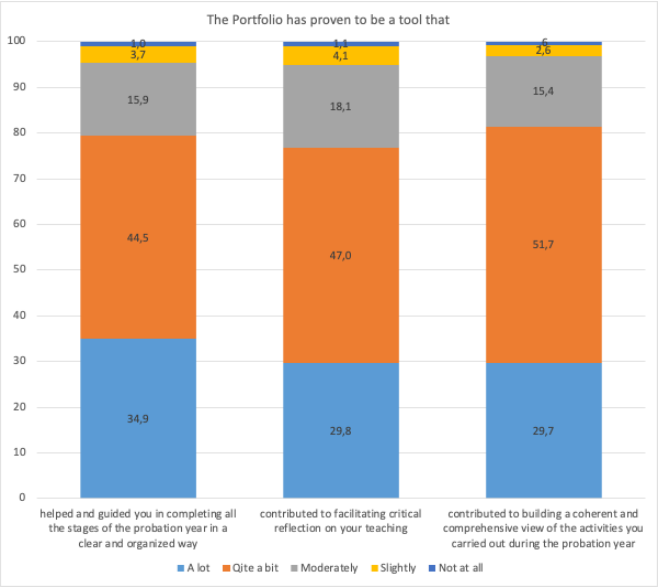


Figure 6 - Perception of the effectiveness of the portfolio as a tool for the probation year.

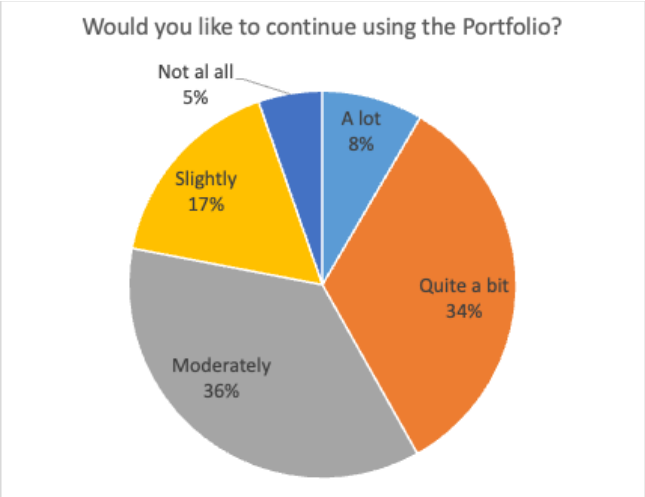


Figure 7 - Perception of lifelong use of the portfolio.

Based on the responses from the questionnaire to the previous questions, we surveyed the areas of potential use of the new portfolio for continuing professional development (CPD) only among those respondents that answered positively (from “moderately” to “quite a bit”) for a total of 32.771 individuals.

Among those, a significant proportion of teachers answered that the portfolio can be a tool of interest “as a self-assessment tool with a view to continuous professional development” since, 30.3%, believe the portfolio could be "a lot" of interest as a self-assessment tool for CPD, while 47.0% say it could be of "quite a bit" of interest. Hence, a strong majority (over 75%) see the portfolio as highly relevant for self-assessment in their ongoing professional growth. Only 6.0% do not see it as useful in this context. Also, the portfolio is seen useful also “for documenting and monitoring the development of professional skills”: 23.7% of respondents indicated that the portfolio could be “a lot” of interest in tracking professional skill development, with another 49.1% rating it as “quite a bit” useful. Again, this reflects a high level of support (over 70%) for the portfolio as a monitoring tool. The potential for using the portfolio in transitional periods is seen as more moderate: only 9.7% of teachers found it to be “a lot” of interest “in transition phases (e.g., returning from maternity/paternity leave, taking on new roles, etc.)” while 37.4% rated it as “quite a bit” useful, and 33.1% saw it as "moderately" useful. However, 8.2% felt it was not relevant at all.

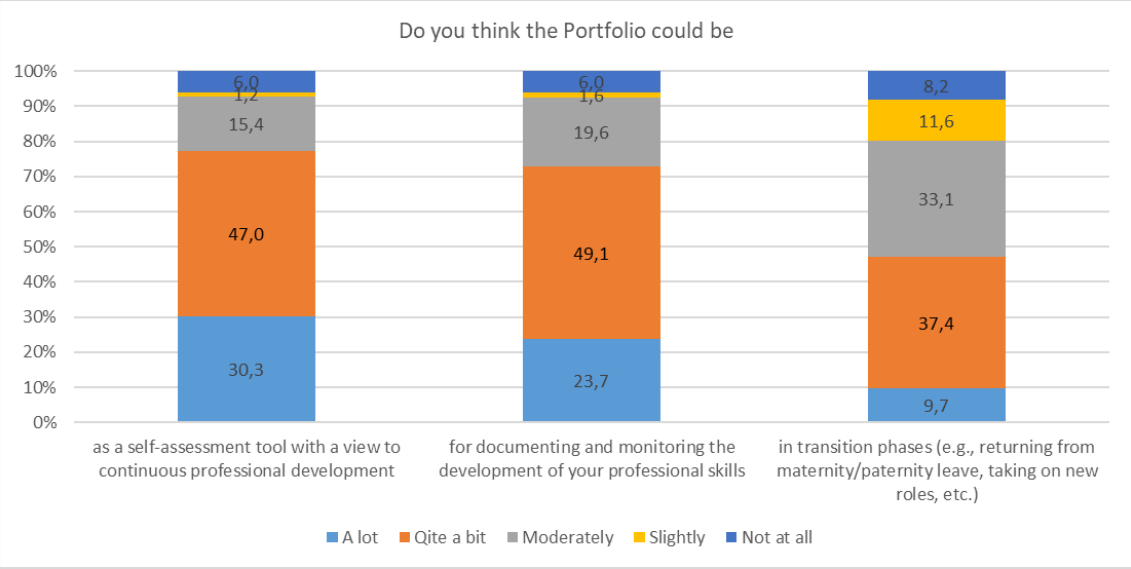


Figure 8 - Teachers' perspectives on the portfolio as a tool for self-assessment, skill monitoring, and use in transitional periods.

With regards to the interest of using the portfolio to sustain professional opportunities (within and outside the own school) and social accountability we witness a general positive outlook from the respondents: 20.8% of teachers felt the portfolio could be “a lot” useful in improving professionalism in schools other than where they currently teach, and 42.5% rated it as “quite a bit” useful. A smaller proportion, 7.2%, felt it was not relevant. This is confirmed also by the answer assessing the interest of using the portfolio a potentially helpful networking and collaboration tool: 20.3% of respondents indicated that the portfolio could “a lot” help in making them more accessible for inter-school projects or collaborations, with 41.9% agreeing it could be “quite a bit” useful.

Similarly to the previous question, 20.7% of teachers believe the portfolio could “a lot” contribute to enhancing professionalism within their own school, while 44.9% found it “quite a bit” useful. The majority of teachers see it as a valuable tool for professional development in their immediate teaching environment. The use of the portfolio as a tool for social accountability, instead, is viewed as moderately useful, with 15.8% of teachers seeing it as “a lot” relevant and 40.0% viewing it as “quite a bit” useful. However, 28% and 8,3% consider it respectively “moderately” or “not relevant at all”. This suggests that while the portfolio has potential in fostering accountability, it is not universally seen as essential in this regard.

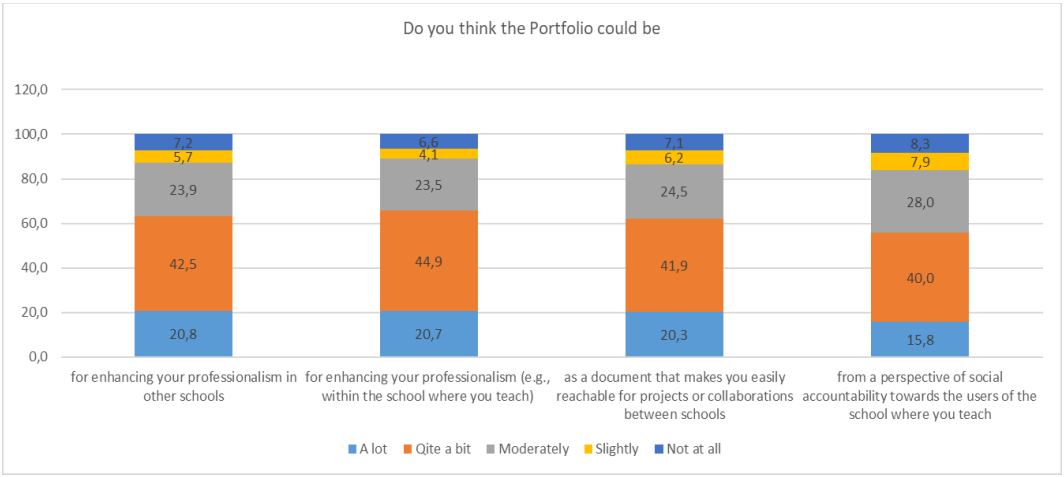


Figure 9 - Teachers’ perceptions of the portfolio's usefulness for sustaining professional opportunities and social accountability.

In contrast to the positive aspects above cited, 15.4% of the entire cohort of teachers surveyed, i.e. 42.072 individuals, said the portfolio required “a lot” of additional bureaucratic work, while 30.9% felt it required “quite a bit”. However, a notable 34.3% reported that it required only a moderate amount of additional work, and fewer teachers, 5.2%, felt it did not add much or any bureaucratic burden.

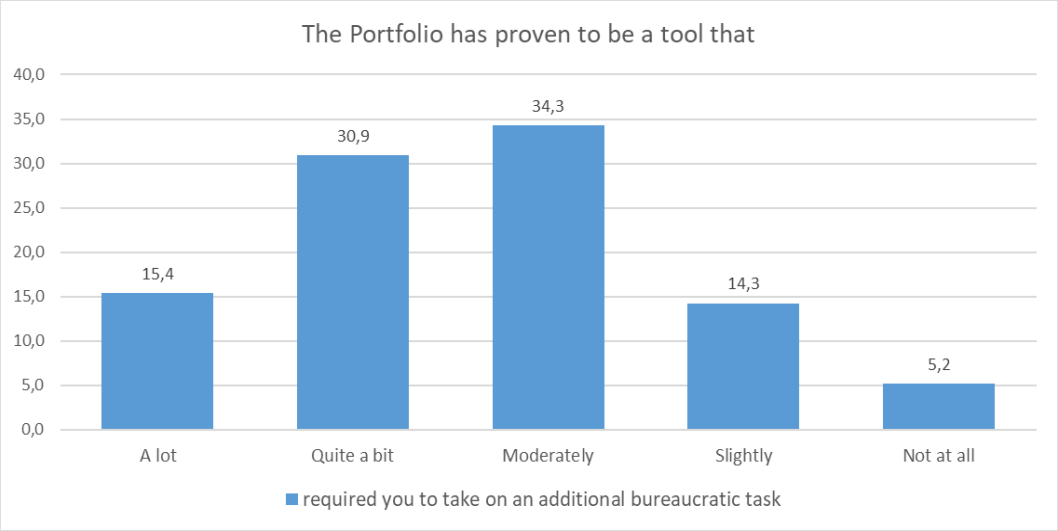


Figure 10 - Teachers' perceptions of the bureaucratic workload associated with the portfolio.

4. Discussion

The findings from this study suggest that the online portfolio used in the large-scale induction Italian program is largely perceived as a useful tool for enhancing organization, reflective practice, and providing a coherent and systemic view on the overall training and probation year. A significant majority of teachers, nearly 80%, expressed that the portfolio helped them complete probationary tasks in an organized and clear manner. Similarly, over 80% reported that it contributed to building a coherent view of their activities during the probation year.

However, a more nuanced picture emerges when considering the portfolio’s broader use. While many teachers see potential for the portfolio to be used as a self-assessment and skill development tool (75% expressing interest), the enthusiasm for its long-term use is more reserved. Only a minority (8.4%) expressed strong interest in continuing to use the portfolio, with the majority giving more moderate responses. This indicates that while the portfolio has value, it may not yet be viewed as indispensable by most teachers, maybe due to the need of a clearly defined focus and purpose for the continued use. Similar hesitancy has been observed in other studies where portfolios were implemented for professional development but emotional and personal challenges were faced by teachers during the portfolio creation process both because of the ambiguity around the portfolio's purpose and audience and the emotional labor involved in reflecting on and presenting one's teaching (Fitzpatrick & Spiller, 2010).

One critical limitation of the portfolio, as revealed by the data, is its perceived bureaucratic burden. Nearly half of the respondents (46.3%) reported that it required a moderate to significant amount of additional work, which may dampen enthusiasm for its continued use. Another notable point is the mixed feedback on the portfolio’s applicability in transition phases (e.g., returning from leave or taking on new roles) and for social accountability purposes. These areas were not as positively rated, suggesting that while the portfolio is useful for ongoing self-assessment and skill development, its role in these specific contexts may need refinement or further clarification to increase its perceived value. This finding aligns with Beck et al.'s (2005) conclusion that while e-portfolios can support professional growth, they must be carefully designed to emphasize reflection and teacher development, rather focused on summative outcome of the portfolio. The overlap between portfolio completion and the other formal obligations of newly hired teachers, as mandated by Italian regulations, may exacerbate this issue.

Several limitations should be acknowledged in this study. First, the study relied solely on a quantitative survey based on 3 out of the 17 questions from the teacher's questionnaire related to the preliminary data extraction from 40,072 teachers out of a total sample of approximately 46,500. The remaining questions in the survey will allow to explore additional aspects related to the initial findings discussed here and investigate other dimensions, such as the usability of the portfolio tool.

Moreover, while allowing for large-scale data collection, this study did not capture the more in depth, qualitative insights into teachers' experiences and challenges. Future studies should incorporate interviews or focus groups to explore the nuances of portfolio use, especially in terms of how it affects professional identity and reflective practice as well as its potential lifelong use. Moreover, the study's focus on teacher perceptions also highlights an important gap: while teachers acknowledge the portfolio's potential, this study does not measure the direct impact on teaching practices or student learning outcomes. This aligns with the broader literature (Feder & Cramer, 2023), where many studies focus on user perceptions rather than concrete outcomes. Future research should also aim to quantify the impact of portfolios on actual teaching performance and, possibly, on student achievement, providing a more comprehensive understanding of their effectiveness.

Second, the study was conducted within the specific context of the induction period for newly hired teachers in Italy, a time when teachers are already managing numerous professional commitments. This may have influenced their perception of the portfolio, particularly in terms of its workload as well as its summative purpose. The concentration of tasks during this period may have led to feelings of "fatigue", which could negatively affect their views on the tool's usefulness. Moreover, the portfolio's dual role as both a self-assessment tool and a key element in external evaluation (for the Evaluation Committee) may have affected its perception. The shift from a development tool to one used for evaluation could alter how teachers engage with the portfolio.

The results of this study align with research findings (Rossi, 2005; Fitzpatrick & Spiller, 2010; Giannandrea, 2017) findings, particularly given the context of large-scale portfolio implementations. In the case of Italy, the national-level adoption of the portfolio for newly hired teachers establishes a foundation for its systemic use across the teaching profession. However, as Fitzpatrick and Spiller emphasize, the institutional framework must play a crucial role in regulating and guiding this adoption to ensure that it achieves the necessary balance between institutional requirements and the personal, reflective growth of individual teachers.

Clear institutional guidelines and support are essential to harmonize the broader professional objectives with the reflective and developmental journey of each teacher. Further research could explore how perceptions of the portfolio change over a longer period, once the initial pressure of the probationary year has passed.

5. Conclusion

Thanks to the conceptual framework built around the two core constructs of Teacher Standards and Documentation of Experiences, the new teacher portfolio is proposed as a tool for strengthening teachers' professional identity, serving as a bridge between theory and practice and between initial training and continuing professional development. Its implementation and adoption by a significant number of teachers in their training and probationary year allows us to explore its potential for broader implications and from a continuing education perspective.

The online portfolio shows promise as a tool for supporting teacher organization, reflection, and skill development during the induction period. The study's findings suggest that while teachers recognize the portfolio's potential for self-assessment and professional growth, enthusiasm for its sustained use is tempered by concerns about bureaucratic workload and relevance. These findings extend previous research by confirming the portfolio's value in the induction phase but also highlight areas for improvement, particularly in terms of reducing administrative burdens and enhancing its applicability beyond the induction period.

Moreover, this study reinforces the call for future research to focus on measuring the portfolio's concrete impacts on teaching practices and learning outcomes, moving beyond teacher perceptions to offer a fuller understanding of its effectiveness.

Future studies should also explore the interoperable implementation of the portfolios for initial teacher education and in-service training to demonstrate its validity in supporting lifelong learning, examining whether it can be adapted to meet the evolving needs of teachers throughout their careers.

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Digital credential at the University of Turin

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Abstract

The University of Turin has been experimenting with methodologies and technological innovations in the field of digital credentials using Bestr, Italy's first digital credentialing platform, since 2016. This article aims to illustrate how the University is progressively creating an 'ecosystem' for digital credentials, consistent and complementary to that of traditional certifications, to enhance the skills acquired and relate them to the working reality. Over the years, the service has grown both in terms of the number of digital credentials issued and the number of structures involved, as well as the solutions adopted to meet new needs. Initially, it concerned the certification through Open Badges of skills and knowledge acquired by teaching and technical-administrative staff, with the perspective of enhancing internal training paths. The use of Open Badges then expanded to student users, particularly for certifying language skills and short extracurricular learning experiences. The UNITA project - Universitas Montium certifies international students' participation in select training initiatives as well.

Open Badges are also used to certify participation in lifelong learning paths, such as University Courses for Updating and Professional Training and some individual courses, attended by workers for professional upskilling and reskilling. Since 2023, the University has incorporated Blockcerts for certifying certain degrees alongside Open Badges, enhancing authenticity and verification ease. Among the planned developments are the integration between Bestr and the students' career management information system, for the automated issuance of digital credentials, and the integration between Bestr and the Europass platforms, for the issuance of European Digital Credentials for Learning.

Keywords: Digital Credentials, Micro-credentials, Open Badge, Lifelong Learning, Digital Technologies.

1. Introduction

Lifelong and life-wide learning are becoming increasingly important in today's job market (Giraudo et al., 2019, pp. 348-356). For this reason, there is a growing need to recognize and enhance skills, knowledge, and educational experiences, whether they are acquired within or outside formal careers. Digital credentials – particularly open badges (hereafter referred to as OB) – represent an innovation in the field of certification. OBs can consolidate multiple pieces of information into a single digital document, such as acquired skills and learning outcomes, the issuing institution, the badge holder, the criteria for obtaining the badge, its validity period, and more. Additionally, they are hosted on dedicated platforms which ensure their authenticity, are readable on any digital device, and can be verified in real-time by any user. The advantages of digital credentials compared to traditional paper certificates are many; as a result, various institutions, including various universities, are increasingly adopting these certification systems to enhance their learners' lifelong learning course of studies. This provides learners with the opportunity to build a portfolio of digital credentials which reflects the uniqueness of their proper educational journey.

2. Literature review and the theoretical framework

Although significant international studies have already been conducted on the use of digital credentials in the field of education (see, among others, Davis & Singh, 2015, pp. 72-83; Gibson

et al., 2015, pp. 403-410; Everhart et al., 2016, pp. 221-235; Grant, 2016, pp. 97-114), as of now there are still not many case studies describing the use of this technology within universities (see, for example, Mewburn et al., 2014, pp. 643-648; Hamson-Utley & Heyman, 2016, pp. 237-258; Niehaus et al., 2017; Whitehouse et al., 2022, pp. 272-295; for a systematic review of the literature on blockchain-based academic certifications, see Rustemi et al., 2023, pp. 64679-64696). Specifically, in the Italian context, there are still few contributions on the systems and solutions for issuing digital credentials by universities (Bertazzo and Furlati, 2015, pp. 171-172; Calò et al., 2018, pp. 107-115; Coggi, 2019; Cherubini and Mapelli, 2019; Baratto et al., 2024, pp. 135-145; Presutti and Natale, 2024, pp. 197-213). The last two contributions, in particular, describe from a technical and organizational perspective the experience of the project "Ecosystem for (micro) digital credential UniTo: open badge, blockcerts, and blockchain", funded by the University of Turin itself. This project introduced some significant innovations in 2023, including the activation of blockcerts, digital credentials based on blockchain technology. This paper aims to illustrate, from an internal perspective, how the University of Turin is progressively creating a coherent and complementary 'ecosystem' for digital credentials alongside traditional certifications, to enhance the skills acquired in the academic environment and attempt to connect them with the current job market and employer needs.

3. Case History: Digital credential at the University of Turin

3.1 Development milestones of the service

3.1.1 Experimental Phase

The service for creating and issuing digital credentials at the University of Turin was introduced experimentally at the end of 2016, as part of a training project aimed at the “Referenti per le Informazioni nel Portale Federale” (RIF), at the end of which OBs were awarded to recognize the skills acquired. From this experimental phase, the University has relied on the Bestr platform for the publication of OBs, which is the first Italian platform for issuing and managing digital credentials, along with technical support from CINECA, one of the largest computing centers in Italy and among the most advanced in the world for High Performance Computing (HPC), as well as one of the key providers of solutions and services for universities and research centers.



Figure 1 - Some OBs from the “Training Referring at UNITO” project.

Specifically, the initiative involved university staff responsible for managing various web services, including structural websites and e-learning platforms. The RIF, after participating in specific training on the use of tools to perform their work, had the opportunity to manage their assigned services with support available both in person (through dedicated meetings) and remotely (via the service desk or phone requests). After a period of direct use of the tools, some RIF voluntarily participated in an additional verification phase to assess the knowledge and skills necessary to excel in their roles. The positive evaluation of the training program then initiated the phase of awarding the specific OB.

3.1.2 Dissemination and consolidation of the service

The service was extended to the entire university community in 2018 and initially focused primarily on certifying the skills and knowledge acquired by faculty and administrative staff through OBs, aiming to enhance internal training pathways. A particularly significant initiative for the dissemination of digital credentials within the academic community was the “Teaching Research Incubator for Innovation” (IRIDI) project. Launched in 2018, the IRIDI project promoted the innovation of university teaching at the University of Turin through research activities focused on teaching and learning in academic contexts (including teaching strategies, assessment practices, and ICT for teaching, etc.). As part of the project, specific training pathways for faculty members continue to be offered. The initiative is also subject to an impact assessment (Coggi, 2019). The validation of the knowledge and skills acquired through participation in training activities is certified by the issuance of an OB. As of October 1, 2024, more than 780 OBs have been awarded to faculty and researchers who participated in various training programs. In 2019, the University Language Center (CLA) launched the “Open Badge@CLAUnito” project with the goal of issuing OBs for certifications of English language skills in academic contexts (EAP, ESP, EMI) and specialties (ESP) for the benefit of doctoral students, researchers, faculty, and university staff. In the following years, the use of OBs quickly expanded to the student population, particularly for certifying language skills and short extracurricular learning experiences (micro-credentials). Additionally, within a significant international project, UNITA - Universitas Montium, which the University of Turin leads, OBs have been awarded since 2021 to students, faculty, and administrative staff for participation in various training initiatives. As of October 1, 2024, 14 OBs related to the UNITA project have been published (for further information on the main projects at the University of Turin that involve the issuance of OBs, see Baratto et al., 2024, pp. 137-140). OBs are also increasingly used to certify participation in lifelong learning training careers, such as University Courses for Continuing Education and Professional Training (CUAP) and certain individual courses attended by workers for upskilling and reskilling.

3.1.3 Latest Innovations

With regard to lifelong learning and the growing demand for training careers that foster skill development with immediate benefits for professional growth, recent years have seen an increasing scenario that has led to the introduction of a specific type of OB, referred to as an "incremental OB with direct evidence". This solution allows for the differentiation and highlighting of individual learning outcomes within a common training framework, and enables the addition of new achievements over time to the same OB as further objectives are reached. For example, at the end of a training course for experts in school inclusion processes (see Figure 2), an OB with direct evidence is issued, allowing each award to specify the disciplinary area and school cycle in which the individual has specialized. Moreover, the OB is incremental, which means it can record all specializations obtained by the same teacher within the same electronic document. This allows a teacher to specialize, for instance, in inclusion processes for scientific subjects in primary education in a given year and later add specializations in other areas, with all specializations being recognized in the same award, which will be updated as new milestones are achieved. In this way, the OB transparently reflects the competencies acquired over time, providing a more efficient management of the OB for the issuer, who can create a single OB instead of multiple ones to highlight the various specializations.

Since 2023, the University has also started issuing OBs linked to the attainment of certain academic degrees, with specific career-related information about the student included as direct evidence in the award (e.g., final grade, exam average, thesis title, diploma supplement, etc.). Currently, the degree programs at the University of Turin that issue an OB upon graduation are as follows:

- Joint Master’s Degree in Environmental, Cultural, and Territorial Economics
- Joint International Master’s Degree in Viticulture and Oenology
- Master’s Degree in Business Administration and Control
- Master’s Degree in Administration and Digital Management of Companies

- Master's Degree in Business Administration
- Master's Degree in Economics and Management
- Master's Degree in Corporate Finance and Financial Markets
- Master's Degree in Statistical and Economic Methods for Decision Making
- Second-Level University Master's Degree in Insurance Innovation
- Single-Cycle Master's Degree in Veterinary Medicine
- PhD in Business and Management "Valter Cantino"
- PhD in Economics "Vilfredo Pareto"
- PhD in Technology Driven Sciences: Technologies for Cultural Heritage

Along with the OBs for degrees, an additional type of digital certification was introduced in 2023: the University of Turin now certifies the achievement of certain degrees through blockcerts in combination with the OB (Presutti and Natale, 2024, pp. 197-213), providing greater authenticity guarantees for the issued certificate and enhancing its verifiability. This new element marks a key milestone in the work carried out by a team of faculty and technical-administrative staff from various areas (teaching, student offices, job placement, IT systems, etc.), who defined a standard for the publication of degree OBs and their corresponding blockcerts. In particular, an in-depth study was conducted on the graphic elements of the OB page and how they can best be managed to consistently convey the University's image and/or one or more of its components. For example, the hexagonal image representing the OB, known as the 'visual,' contains elements common to all OBs issued by the University of Turin to ensure external recognizability and consistency with other communication channels (such as institutional websites, social media, etc.). Specifically, in the visuals of OBs awarded for degree attainment, the University of Turin's red seal is displayed, with the institution's name positioned to its right; additionally, the border color of the image echoes the red of the seal itself.



Subject area
Effective Inclusion of Students with Autism Spectrum Disorders

Subject area description
Skills acquired for the following order: Secondary school

Academic Year
2020/2021

Subject area
Internship Tutor

Subject area description
Skills acquired for the following grades: Secondary School

Academic Year
2021/2022

Figure 2 - Visual of the OB "Expert in School Inclusion Processes" and direct evidence of an award.



Figure 3 - Examples of Degree Obs.

At the same time, the need to ensure that each component (School, Department, Project, etc.) has its own graphic distinctiveness is addressed by focusing on these aspects from the need analysis and initial design phases. This is achieved by customizing certain elements of both the visual and the image that will appear on the OB page.



Figure 4 - Examples of OBs with graphic elements related to the structure/organization delivering the training program.

3.2 Development of the Service Management Process

The service is managed by the E-learning, Online Collaboration, and Information Systems Direction, Portal, E-learning (SIPE) staff according to an organizational model that has been refined over the years. This model involves a network of actors responsible for managing various operational phases, from the initial request to create an OB to its publication on the Bestr platform and subsequent assignment to learners. In particular, the current organizational model stipulates that anyone wishing to create an OB – whether it be a university structure, an external entity, or an individual lecturer – must submit a request by filling out a document that collects the necessary information and materials for the subsequent drafting phases. The submitted documentation is then examined and reviewed by the E-learning staff, with support from the Bestr editorial team, who provide guidance and suggestions to collaboratively define the text of the OB and all its informational components. Simultaneously, based on the received indications, the E-learning staff collaborates with the Graphics Section of the SIPE to propose designs for the graphic aspects of the OB to be submitted to the requesters. A key strength in the creation of OBs is the ability to network among different university structures and external organizations. From a quality perspective, the initial contact phase with the requester has become increasingly significant, as the types of training paths for which an OB is requested have diversified. This initial phase of detailed listening to the training experience that will lead to the issuance of an OB informs the decision on the type of OB to be produced: standard, incremental, learning path, etc. Additionally, based on specific needs, the possibility of adding extra options to the badge is evaluated with the requesters, such as the inclusion of direct evidence or a reference to an international competency framework (like ESCO), or pairing the OB with another type of digital credential, such as blockcerts and, in the future, European Digital Credentials for Learning (EDCL). As the number of OBs issued by the University of Turin has increased, the creation of Project Pages has gained greater importance in the editorial activity. These pages allow for easier classification and identification of an OB among all those published. The Project Page on Bestr also narrates the context in which the OBs are issued and provides detailed information about the structures that organize and promote the training paths leading to these digital certifications. Each Project Page can contain one or more OBs, and the same OB can be linked to one or more Project Pages. Regarding the assignment of OBs, methods have been implemented over time to make the process more efficient, developing automations that allow for better management of OB assignments. Specifically, compatibility between Bestr and the student career management system used at the university, as well as between Bestr and the Moodle platform, has already been tested. The growing importance of the service has also led to a reorganization of how

requests are managed, resulting in the creation of a dedicated channel in the service desk used by the SIPE for handling support requests from various stakeholders (faculty, students, structures, etc.).

4. Result and outcome

As described, over the years, the service has grown both in terms of the number of digital credentials issued and the number of structures involved, as well as in the variety of solutions adopted to meet new needs. Within the university context, the service has seen progressive growth, especially since 2022, both in strictly quantitative terms (i.e., OBs published and assigned) and in the quality of the editorial process. The graphs in Figures 5 and 6 show, respectively, the increasing evolution of the publication of Open Badges on the Bestr platform and the number of assignments made from 2016 to 01/10/2024.

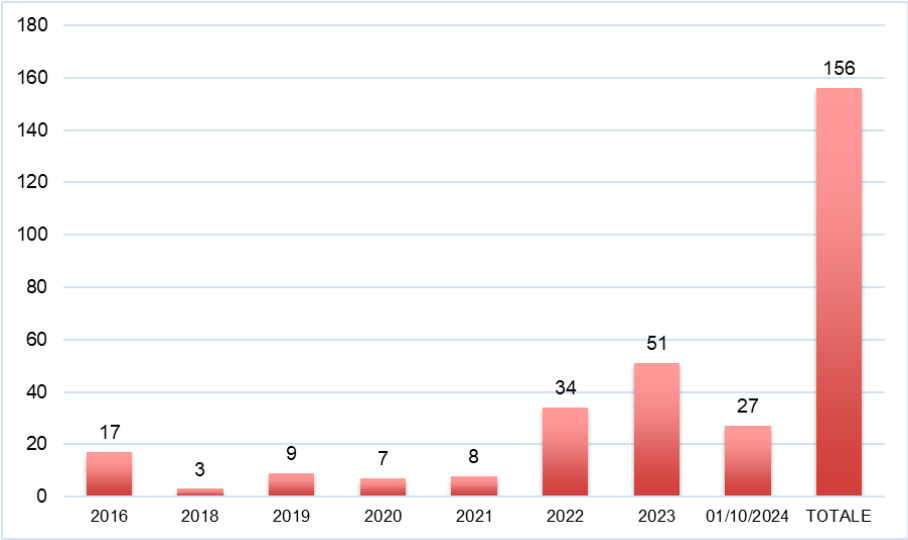


Figure 5 - Number of New OBs Published by the University of Turin Per Year.

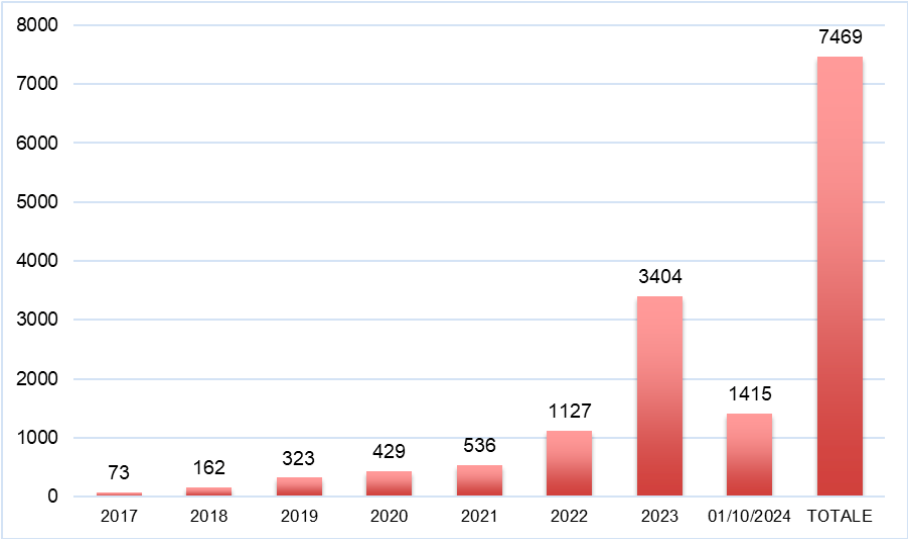


Figure 6 - Number of OB Assignments by the University of Turin Per Year.

The growing importance of the service within the university context is also evidenced by the publication in 2024 of a dedicated web page on the University Portal, where users can find useful information, such as what digital credentials are, the benefits of these certifications, the types of digital credentials issued by the University of Turin, how to obtain them, and more.

In March 2024, a survey was sent to the learners at the university who received an OB, specifically to gather feedback from the service recipients and to gain insights into how they have utilized the OBs and the perceived usefulness of the service. OBs can be shared by learners on their electronic CVs and social media (e.g., LinkedIn), enhancing the visibility of their educational pathways. The survey was emailed to approximately 4,400 learners and was fully completed by 155 participants. The data obtained, once analyzed, will be useful for evaluating further actions to take. Among the most interesting results, the responses to the following question are highlighted.

Most respondents (53.6%, N=138) believe that OBs can be useful for increasing their career opportunities or professional growth, while only 10.9% of participants think they are not. However, many claim they still do not have enough information to express an opinion (35.5%, more than one in three). It can be hypothesized that since digital credentials are a relatively recent form of certification, many learners may not yet be sufficiently familiar with them or may not fully understand their potential. It is also possible to assume that learners have not yet received adequate feedback from the job market to determine whether and to what extent these certifications are recognized and valued in hiring processes. Certainly, efforts will be made to further investigate these issues through future surveys, but a partial confirmation of these hypotheses has been found in the results of another survey conducted by the University of Turin. Indeed, shortly before, the Office for Guidance, Tutoring, and Placement (OTP) of the School of Management and Economics had also conducted a pilot survey to assess the impact of digital credentials on the careers of its learners and in the hiring processes of some partner companies. In this survey, a specific questionnaire was sent to more than 400 local companies that had collaborated in various capacities with the OTP Office to gather feedback on the effectiveness of the information conveyed through digital credentials, particularly regarding recruitment activities. It was observed that most corporate recruiters still have limited knowledge of this form of skills recognition. The interesting results of these two inquiries will be the subject of dedicated contributions discussing the outcomes in more detail.

From a theoretical standpoint, the introduction of the service has led the E-learning Staff to engage with a new area, rich in potential developments. The topic of digital credentials is currently of particular relevance at both national and European levels, and in this regard, methods for the integrated management of OBs between the Bestr platform and the Europass platform, which manages digital micro-credentials in the European context, are being investigated for the issuance of European Digital Credentials for Learning (EDCL) associated with the OBs published by the University. In fact, Bestr has seen several developments in recent years toward greater integration with European standard elements for micro-credentials and possesses flexible characteristics that can be leveraged in the future. At the same time, with the introduction of blockcerts, which are based on blockchain technology, a service has been introduced at the University that extensively utilizes this highly innovative technological solution to ensure the authenticity and integrity of the issued certificates with an even higher level of security.

5. Conclusions

The introduction and dissemination of digital credentials, particularly Open Badges (OBs), at the University of Turin represents an important step towards innovation in recognizing and valuing competencies acquired in both academic and professional contexts. The analysis of the implementation and development process of this service shows how, starting from an initial experimental phase, it has reached significant diffusion within the university in just a few years, along with a growing demand from departments and individual faculty members to certify the achievements of learners within their educational pathways, including in the context of lifelong learning – an area that could become strategic for the university sector in the future. The service for creating and awarding digital credentials is therefore experiencing strong growth. The initiatives being implemented by the E-learning Staff are aimed at preparing to manage a higher level of complexity and to streamline workflows. For example, a system is being studied to scale the creation of degree OBs, promoting the standardization of the process to identify common elements that can strengthen the University's identity on the Bestr platform and facilitate the

editorial work of a type of OB that is particularly complex to produce. At the same time, solutions are being implemented to automate, where possible, the activities related to the awarding of digital credentials. Another aspect being explored is the impact that OBs issued by the University can have on both job searching and the professional growth of learners, as well as how digital credentials are evaluated in recruitment processes. Data collected from surveys conducted with learners and employers suggest that, although there is a positive perception regarding the potential of OBs to enhance career opportunities, there is still a certain lack of awareness and familiarity with this type of certification. This indicates that the University of Turin will need to continue efforts to raise awareness among learners and the labor market about the potential of OBs, providing greater visibility to these certifications and supporting learners and companies in understanding their value.

In conclusion, the case of the University of Turin illustrates how the implementation of an 'ecosystem' for digital credentials – where traditional certifications are coherently and functionally complemented and integrated with digital ones – represents a significant step in valuing competencies acquired in academia and supporting the lifelong and life-wide learning of its learners. The increasing use of digital credentials not only at the academic level but also in international projects such as UNITA and in professional development pathways demonstrates that the university is well-positioned to continue innovating in this area. However, it will be necessary to continue improving the organizational and technical processes related to the creation, management, and awarding of digital credentials, including, for example, integration with other systems such as Europass, to ensure that these certifications are easily recognizable and accepted on an international scale.

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Gamification in workplaces: through learning aims and gamification purposes

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Abstract

Gamification, i.e., the use of game elements in non-playful contexts, is regarded by many as an effective way to increase the motivation and engagement of workers in staff development initiatives, to favour the development of transversal skills not only during the training but also beyond it, in trainees' professional life. The study aims to discuss in a deeper and pedagogical way, relevant findings of a previous study already published in 2024 (Alioto & Persico, 2024). The intent is highlighting a lack of a specific design process used to structure the gamified activities. This lack reflects on a mismatch between learning objectives and gamification purpose. As showed by the systematic mapping review considered, the implementation of the so-called "pointsification approach", consisting in prevalent use of Points, Badges, Leaderboards, is predominant even in case of deeper learning aims. This type of approach is generally functional in the short to medium term and lends itself better to knowledge acquisition rather than changing on the job behaviours or developing competences, let alone supporting practice sharing behaviours. The association of other game elements to the PBL structure, such as the use of narrative, is increasing, and while gamification goals mostly concern developing know-how, the game elements used do not seem to fit the learning objectives and target group. In this vein, gamification does not respond to what Nicholson calls "meaningful gamification" for each user, but replace a "one-size- fits-all" solution criticized from the state of the art.

Keywords: Gamification, Workplaces Training, Staff Development, Points Badges and Leaderboards (PBL), Systematic Review.

1. Introduction

Digitalization has been redefining working processes and required skills, by focusing on transversal and digital skills as key-elements to face continuous changes (LifeComp, 2020). In these rapidly evolving work ecosystems, updating workers' skills and developing their competences is widely recognized as pivotal to ensure long-term success and well-being of both individuals and organizations (Inapp, 2023; Pellerey, 2021). Predominantly, the need addressed by staff development initiatives is not just to update or increase workers' knowledge and knowhow, but rather, to change approaches and on the job behaviours, favouring the development of collective knowledge through the construction of a communities of practice and the development of lifelong learning skills and attitudes of individual workers, becoming agents of change inside their organisations (Emirbayer & Mishe, 1998). To do this, learners' engagement and motivation are of paramount importance, not only during training, but also when it comes to adopting the desired behaviours on the job.

In 2020, due to the Covid-19 pandemic, there was a forced, fast shift online not only of work processes (at least those that could be moved online) but also of staff training initiatives (OECD, 2021). The introduction of teleworking and online training clashed with pre-pandemic workers' often insufficient technological skills (Inapp, 2022; OECD, 2021). This situation enhanced the need to redefine training models with a view on building lifelong learning competences and self-regulated learning skills. This entails designing the training in such a way that it aims at developing transversal competences necessary to keep up and even anticipate the development of society (Pellerey, 2021; Alessandrini, 2018).

It has to be considered that online environments change the work practices, shifted from a material place into a more abstracted one. The new space assumes superficial characteristics, where significant and social dimensions lose their substance (Augé, 2011), influencing the identity of the worker (Pellerey, 2021).

It is in this context, that the concept of “gamification” has attracted attention, due to its promise in personal and learning terms, like boosting motivation, engagement, problem solving and learning (Alsawayer, 2018; Kapp, 2012). Although the term dates back to the beginning of this century (Pelling, 2002), one of its most popular definitions is Deterding’s (2011), according to whom gamification is “the use of game design elements in non-game contexts”. This definition, however, becomes problematic especially when it comes to clarify what “elements” it refers to (Thibault, 2019). The list of possible elements is very heterogeneous; it goes from points to avatars or from progression bars to the plot or narrative adopted to link together gamification’s key events. In Deterding’s definition (2011), the expression “non-game contexts” allowed its diffusion in different sectors: in marketing to encourage purchases (Zichermann & Linder, 2010), in health and wellness applications to encourage users to adopt healthier behaviors (Johnson et al., 2016), and in companies to increase productivity (Aziz et al., 2017). Finally, gamification has been widely used in education and training to improve engagement, motivation and ultimately learning outcomes, both in face-to-face teaching programmes and online learning environments (González-Fernández et al., 2022). Even if its adoption is especially advocated when the learners are children, due to the central role of play in their learning (Piaget, 1990; Montessori, 1970), gamification seems to work also when the trainees are adults (Alioto & Persico, 2024; Dicheva et al, 2015; Bateson, 1993). Indeed, there is a wealth of studies concerning the use of gamification in adults’ training, with aims spanning across a whole range of typologies, from knowledge to know-how and professional skills, up to transversal competences that may empower lifelong learning. Although these studies also include some reviews (Mahat et al., 2022; Larson, 2019), an updated picture of the research landscape in the field of gamification in worker training was needed because (1) many reviews are prepandemic or based on data sets that include pre-pandemic studies, and (2) others not only focus on gamification, but also on Game Based Learning (GBL), which is a related field of study but concerns the use of "games" fully entitled and not just “game elements”, so the image they provide is compounded with data about GBL. In addition, considering the training value of gamification practices, a more detailed study on the correspondence between learning objectives and game elements used was necessary.

Therefore, the purpose of this paper is to discuss the latter aspect, through the results of a systematic literature review conducted in May 2023 (Alioto & Persico, 2024). This is a study carried out on the use of gamification in corporate training.

The article will be divided into the following section: the first paragraph will focus on the terminology and practical problems of gamification. The second paragraph will present the results of the systematic literature review on the match between learning objectives and gamification purpose. The last paragraph aims to discuss and conclude evidence.

2. State of the art

Gamification can potentially be a suitable means to achieve specific learning objectives in corporate training, but there are some problems in the design process that sometimes hinder its proper use.

The first problem is the lack of a uniform definition. Although the definition of *gamification* as “the use of game design elements in non-gaming contexts” (Deterding, 2011) is perhaps the most well-known, it is not the only one. Considering some definitions, it appears that gamification is implemented as a solution to any kind of problem. Deterding’s is too generic, and it is not clear what the “game elements” really mean (Thibault, 2019; Alioto & Persico, 2024). The list of game elements is really heterogeneous, including points, badges and leaderboards, aimed at giving information and details on the amount of a predetermined element, to avatars and narratives, elements to empathize, reflect and interpret the world around (Koerner & Staller, 2024; Demetrio,

2000). Zichermann's (2011) definition specifies two specific objectives to be achieved through the gamified process, such as "engaging the public and solving problems". Similarly, Houtari & Homari (2012) define gamification as a process "to support the user in creating overall value", shifting the focus on the subject, the goals to be achieved and the importance of the process instead of the mechanics of the game. Finally, in line with this change, Kapp (2012) defines gamification as useful also for "motivating action and promoting learning". In the absence of a shared definition of gamification, the process of designing a path using game elements has been oriented towards "one-size-fits-all" aims.

The second problem of gamification's applications is the widespread use of Points-BadgesLeaderboards (PBL) structure. Gamification, as anticipated earlier, can be effective in developing both intrinsic and extrinsic motivation (Deci & Ryan, 1985), as well as in conditioning and modifying certain behaviors. However, simple structures of gamification, based on theories of behaviorism and systems of reinforcement (both positive and negative) may become counterproductive (Alioto & Persico, 2024) because they tend to foster extrinsic rather than intrinsic motivation, while competence development and lifelong learning skills are better achieved through intrinsic motivation (Helberg & Moll, 2023). Originally, this type of gamification was used mainly in the field of marketing "as a practice of marketers and consultants to build and then exploit an opportunity for profit" (Bogost, 2015). The same practices have since been extended to the education and training sector with the aim of increasing engagement and results in learning processes. The state of the art of gamification in corporate education (Mahat et al., 2022) as well as in any other order of education (Dichev & Dicheva, 2017), expressed concern that the simple use of PBL collides with the need to achieve higher level educational goals and long-term, so they have begun to consider the need to identify the conditions that make gamification "significant" (Helberg & Moll, 2023). "Meaningful gamification" is "the use of gameful and playful layers to help a user find personal connections that motivate engagement with a specific context for long-term change" (Nicholson, 2015). According to Bogost (2015), PBL not only tends to boost extrinsic motivation, but also raises ethical concerns by potentially fostering a type of productivity-centered education and/or manipulating workers (Bogost, 2015). Both Bogost and Nicholson acknowledge that, in certain cases, the extrinsic motivation encouraged by rewards can help individuals learn a skill that eventually becomes intrinsically motivating. However, they also note that the opposite can happen: once mastery is achieved, interest and motivation can diminish. Another potential risk is that critical thinking may be reduced during practice.

In the words of Thibault (2019), gamification "could also lead the person to accept uncritically that knowledge instead of questioning it". Due to it the solution is not to avoid gamification entirely, but rather to implement gamification approaches oriented on individual experiment, action, creation, as well as self-reflection and meta-reflection (Alioto & Persico, 2024; Thibault, 2019).

In this sense, the third problem of gamification concerns the design process. Empirical studies do not seem to define learning objectives or choose game elements that match them with the needs of learners (Larson, 2019). Against this backdrop, several researchers (Krath et al, 2021; Nicholson, 2015) are working to identify the conditions that make gamification effective. Krath and colleagues (2021) conducted an extensive literature review aimed at identifying the main theoretical principles that explain the effects of gamification. The authors summed up three theoretical principles, also used to label the results on the systematic literature review: principles that guide towards the intended behavioral outcomes; principles that foster individual relevance; and principles that enable social interaction and positive social effects (Krath et al., 2021).

Table 1 clarifies what these authors intend.

Furthermore, in these years, several design processes have been defined, i.e., the educational gamification five step model (Huang & Soman, 2013) and the Gamification Design Process (GaDeP) of Antonaci (2019). From one side, the first one is more oriented to define the educational path properly, using contextual game elements. It includes a first step aimed to understand the target audience, taking into account its learning needs. The second step is defining learning objectives. They include (1) knowledge, skills and competence to be reached by the learners through the gamification process; (2) the level of engagement, interest and unjoyful pursued during the learning path; (3) actions and/or habits to be acquired or modified during the pathway.

Table 1 - Theoretical principles that explain the effects of gamification (Krath et al., 2021).

Theoretical principles categories	*Principles*
Principles that guide towards the intended behavioral outcomes	Clear and relevant goals Immediate feedback Positive reinforcement Guided paths Simplified user experience
Principles that foster individual relevance	Individual goals Adaptive content Multiple choice
Principles that enable social interaction and positive social effects	Social comparison Social norming

The third step is defining the context, considering environmental and organizational principles, i.e. face-to-face or online experience, number of learners and technological resources. The fourth step regard building the educational experiences, working on the formative feedback, in order to allows a reflection part, defining what can be gamified and using educational principles useful to foster learning objectives. The last step is focused on the definition of the game elements to apply. This phase must reconcile learning needs with the game elements to be used in order to personalize the educational experience as much as possible. On the other hand, GaDeP (Antonaci et al., 2019) is a design process more based on finding the most suitable game elements. It also mimics design-based research (Euler, 2014). It consists of six consecutive phases which are designed to (1) analyze the context, (2) define the problem to be solved with the gamified path, (3) correctly select the elements of the game, (4) taking into account the theoretical framework, (5) design and implement the gamified path and then (6) to evaluate it (Antonaci et al., 2019).

3. Purpose of the study

The study aims to discuss in a deeper and pedagogical way, relevant findings of a previous systematic mapping review published in 2024 (Alioto & Persico, 2024). Whether the study already finished addressed broad research questions, in line with the mapping review method (Campbell et al, 2023), this study sets the goal to analyse specific research questions of Alioto & Persico's (2024) original study, in order to track different facets of the same dimension. In particular, the systematic mapping review (named from now as SMR or original study) has set the goal to map the state of the art on the use of gamification in corporate training. The paper search in May 2023 focused on Scopus and Web of Science databases using specific research strings. The application of inclusion and exclusion criteria allowed 253 articles to be deleted, leaving 25 for full reading, including two bibliographical reviews (Larson, 2019; Mahat et al., 2022). The remaining 25 articles were coded into two macro categories: study characteristics (e.g., training model, learning purpose) and gamification characteristics (purpose, game elements, technologies) (Alioto & Persico, 2024). In this paper the aim is to analyse how gamification activities are designed, taking into account the categories (C) of questions Q3 and Q4 of the original study (see Table 2).

The data on the articles analyzed in the systematic mapping review conducted (Alioto & Persico, 2024) will be framed into a pedagogical discussion and presented generically below.

4. Beyond the findings of the systematic mapping review and through the category's discussion: a pedagogical overview

C1.1 Types of learning aims

Taking in consideration the importance of a pedagogical approach in designing the training intervention (Trinchero, 2012; Rivoltella, 2015), the authors tried to understand the learning objectives of the studies selected.

Table 2 - Purpose of original study and deeper study in comparison.

Original study	*Deeper study*
Research questions	
Q3 What are the training contexts of use, in terms of work sector, training modes and types of learning aims?	Q1 How are the gamification activities designed?
Q4 What approaches to gamification were used, in terms of theoretical principles implemented, playful approach and game elements adopted?	
Purpose of analysis	
Mapping the state of the art according to specific categories: Q1 work sector, training modes and types of learning aims Q2 theoretical principles implemented, playful approach and game elements	Combining specific categories with the research question: C1 types of learning aims (1) and training model (2) C2 theoretical principles (1), game elements (2), playful approach (3)

Most studies did not describe them in detail but, in most cases, a rough distinction was possible between three macro-aims: know-what (factual knowledge), know-how (procedural knowledge) and know-why (competence). This label was made manually by the first author of this paper, based on Garud's distinction (Garud, 1997). This subdivision may be a simplification of the taxonomy of Bloom (1956). It associates know-how with the memorizing level of taxonomy, know-how with levels of understanding and application and know-why with levels of analysis, evaluation and creation (Alioto & Persico, 2024). The SRM reveals that "know-how" is the most frequently prioritized learning objective, followed by "know-what" and "know-why". This data suggests that organizations place high value on practical, operational knowledge, often overlooking the design of training environments centered on a capability approach (Costa, 2019) and neglecting to incorporate a human development perspective (Sen, 1990). It appears that companies may underestimate the importance of empowering their employees to attain a deeper level of competence (know-why).

C1.2 Training modes

According to the original study (Alioto & Persico, 2024), the prevailing training mode adopted in the studies is online training, followed only residually by face-to-face training. This is in line with the literature that highlights the shift of the work process in the online environment since the Covid-19 pandemic (Pellerey, 2021). The digital space, whether not used properly, can be associated to the definition of Augé (2011), about "no place", i.e., a means to use a service, but without an emotional and relational attachments. Hence, gamification, adapting to the trends of training model and, by definition, used to engage and motivate people, is mostly implemented online.

C2.1 Theoretical principles

To analyse the gamification approaches adopted, the theoretical principles of Krath et al. (2021) mentioned before were used. These categories frame the structure and the purpose of the gamification activities:

1. Principles that guide towards the intended behavioral outcomes: i.e. the clear definition of objectives through gamification, instant feedback, positive reinforcement, guided gamification path and a simplified gaming experience.
2. Principles that foster individual relevance: i.e. the design of a gamification activity which allows the worker to set his own learning objectives. As well as it allows to adapt tasks and their complexity based on workers' skills, with a view to scaffolding and the possibility of choosing between different options to achieve results.

3. Principles that promote social interaction and positive social effects, i.e. a gamification activity designed for collaboration between colleagues and peer's performance.

The latter (3) were the most targeted in the SMR (Alioto & Persico, 2024), followed by the behavioural principles. On the contrary, the category of individually relevant principles does not appear to be represented in any of the selected studies. This contrasts with the literature's need to use gamification to develop life-long skills, by stirring up intrinsic motivation (Deci & Ryan, 1985). Furthermore, it demonstrates that purpose of gamification (theoretical principals) and learning aims are not linked.

The results are also relevant to learning objectives: behavioural and social principles clearly emerge as prevalent, even when it comes to learning objectives that are more complex than the mere acquisition of knowledge, such as know-how and know-why. The last two require a form of reflection on behavioural patterns (learning level II) as well as a form of reflection on the world-interpretative patterns which guide action (level III) (Bateson, 1993; Mezirow, 2003). This finding suggests the adoption of gamification principles not strictly related to pedagogical objectives, contrary to what Antonaci (2019) claims, which suggests that gamification should be designed in harmony with the learning needs. In this regard it is important to emphasize that each of the theoretical principles is associated with a pedagogical theory, as suggested by Krath et al. (2021).

The gamification activity aiming at setting the learning objectives of the worker is linked to the theories of self-regulated learning (Zimmerman, 2002), self-directed learning (Knowles, 1975), goal theory (Locke, 1967) and the theory of hope (Snyder, 2002).

The introduction of adaptive content based on workers' skills is supported by constructivist learning theory (Vygotskij, 1978; Dewey, 1977; Bruner, 1966; Piaget, 1952).

The possibility of choosing different options to achieve the learner's goals is supported by the theory of experiential learning (Kolb, 1984; Dewey, 1977).

Each theories listed above requires the integration of two important pedagogical devices: reflection (Schön, 1983; Demetrio, 2003) and agency (Emirbayer & Mische, 1998). Being each gamification goal not detached from a pedagogical theory, designing a gamification activity considering the learning objectives is a mandatory.

C2.2 Game elements adopted

In line with a pointsification approach (Helberg & Moll, 2023), the original study presents a predominance of PBL structure. It alone rarely creates a game space that Nicholson (2015) would describe as "meaningful" - a gamified environment that encourages users to find personal connections and motivates genuine engagement. In fact, several studies indicate that additional game elements like challenges, scores, rewards, and progress bars are often layered onto the PBL framework without fundamentally altering the approach (Alioto & Persico, 2024). These elements largely align with behavioral psychology theories of reinforcement, punishment, and reward (Nesti, 2017; Nicholson, 2015), highlighting a gap in the integration of game elements that directly support learning objectives.

However, there are some notable exceptions: cases where materials became the core game element; instances where avatars were combined with PBL; uses of narratives in conjunction with PBL; and examples where narratives were paired with avatars. According to Demetrio (2012), the narrative component enhances the exploration of individual and collective experiences and identities. Furthermore, the metaphorical aspects of narrative in gamification have proven effective in encouraging personal disclosure and metacognitive reflection across similar contexts (Passarelli et al., 2022).

C2.3 Playful approach

Competition seems to be the most playful approach of the studies, followed by collaborative approaches and, equally, by mixed and individual playful approaches. Some authors (Antonaci et al., 2018; Riva & Mancini, 2023) claim that playful approaches, especially collaborative ones, maybe very helpful in online training, because they elicit a sense of social presence and creation

of a community of practice (Biocca & Harms, 2002). If workplaces, as well as learning environments, become virtual and interactions are increasingly mediated by computer conferencing systems, people will experience “presence in multiple places”, i.e., presence in a room and, at the same time, presence in the digital environment (Riva, 2023). Therefore, gamification can foster the social presence and the creation of communities of practice by allowing the worker to feel emotionally involved in online practices, both work and training (Riva & Mancini, 2023). Communities of practice are rooted in constructivist theories of learning (Knowles, 1998) and emphasize the importance of supporting both individual knowledge and common knowledge (Johnson, 2001). They are secure and trusted learning environments where people can share professional expertise and experiences, in order to create what Tuomela (2007) defined a “we mode”. It is difficult not to see a missed opportunity here for the companies and organizations involved in the studies analysed.

Table 3 - Game elements used in conjunction with the PBL structure.

Studies	*Additional game elements*
Iacono, S., Vallarino, M., & Vercelli, G. (2020).	Narrative Feedback Rewards
Loughrey, K., & O’Broin, D. (2019, October).	Challenges
Karra, S., Karampa, V., & Paraskeva, F. (2019).	Narrative Avatar Feedback Challenge
Kornevs, M., Hauge, J.B., Meijer, S. (2019).	Scores
Göschlberger, B., & Bruck, P. A. (2017)	Progress bar Avatar
Diakoumakos, J., Chaskos, E., Kolokotronis, N., & Lepouras, G. (2021).	Scores
Kim, S. (2021).	Progress bar Levels Rewards
Fauziyah, U., Kaburuan, E. R., & Wang, G. (2019).	Rewards
Santos, I., Sa-Couto, C., & Vieira-Marques, P. (2019).	Challenge Rewards Feedback Progress bar
Alfaquiri, A.S., Mat Noor, S.F., & Sahari, N. (2022).	Challenge Feedback

Combining categories

In order to have an overview of the design process of each studies reviewed; categories discussed in this paper have been gathered in Table 4. Looking at the column additional game elements, 3 out of 4 studies ([3],[11],[13]) with a learning objective oriented to know-why, use the narrative.

This result validates the role of the narrative as a pedagogical device to reflect on second and third level of learning (Bateson, 1996; Demetrio, 1999). At the same time, taking a glance at the playful approach column, even if residually, know-why seems to be foster through either a mixed playful approach, i.e. both collaborative, competitive and individual ones, or a collaborative approach. Its combination with PBL structure and additional game elements such as narrative, avatar, feedback, challenges, scores, levels aim to engage, intrinsically motivate, make reflection, as well as self-assess.

Table 4 - Categories for each reviewed study (full references in Appendix).

	Studies	Categories for each reviewed study							
				Theoretical principles underpinning gamification (Krath et al, 2021)			Playful approach	Game elements	
		Training model	Learning purpose	Principles that guide towards behavioral outcomes	Principles that enable social interaction and positive social effect	Principles that foster individual relevance	Competitive Collaborative Individual	Main game elements	Additional game elements
1	Alfaqiri, A.S., Noor, S.F.M., & Sahari, N. (2023).	Online	Not applicable	Yes	No	No	Not applicable	PBL	Challenges, Feedback, Progress bar, Rewards, Levels
2	Alvear, H., Arias-Flores, H., Ramos-Galarza, C., & Jadán-Guerrero, J. (2021)	Online	Not applicable	Yes	Yes	No	Not applicable	PBL	Not applicable
3	Cheng, C.C.L., & Chau, C.L. (2022)	Online	Why	Yes	Yes	No	Not applicable	Tangible (Lego serious play)	Narrative
4	Dacanay, A.P., Sibrian, J., Wyllie, C., Sorrentino, E., & Dunbar, G. (2021)	Face-to-face	How	Yes	Yes	No	Mixed	Tangible (Escape Room)	Leaderboards; Puzzles; Challenges
5	Despeisse, M., & Lunt, P. (2018)	Face-to-face	How	Yes	Yes	No	Mixed	Tangible (Cards)	Not applicable
6	Diakoumakos, J., Chaskos, E., Kolokotronis, N., & Lepouras, G. (2021)	Online	How	Yes	No	No	Collaborative	PBL	Scores
7	Fauziyah U., Kaburuan E.R., & Wang G. (2019)	Online	How	Yes	Yes	No	Individual	PBL	Prizes
8	Garcia-Garcia, C., Serrano, J.G., Escrig, R.I., Miralles, F.F., Torres, I.C.A, & Poch, M.P. (2018)	Online	How	Yes	Yes	No	Competitive	PBL	Not applicable
9	Garrison, E., Colin, S., Lemberger, O., & Lugod, M. (2021)	Online	What	Yes	Yes	No	Competitive	Not applicable	Not applicable
10	Goschlberger, B., & Bruck, P.A. (2017)	Online	What	Yes	Yes	No	Competitive	PBL	Progress bar, Avatars
11	Iacono, S., Vallarino, M., & Vercelli, G. (2020)	Online	Why	Yes	Yes	No	Mixed	PBL	Narrative, Feedback, Rewards
12	Kapp, K.M., Valtchanov, D., & Pastore, R. (2020)	Online	Not applicable	Yes	No	No	Individual	PBL	Casual games
13	Karra, S., Karampa, V., & Paraskeva, F. (2019)	Online	Why	Yes	Yes	No	Collaborative	PBL	Narrative, Avatars, Feedback, Challenges

	Studies	Categories for each reviewed study							
				Theoretical principles underpinning gamification (Krath et al, 2021)			Playful approach	Game elements	
		Training model	Learning purpose	Principles that guide towards behavioral outcomes	Principles that enable social interaction and positive social effect	Principles that foster individual relevance	Competitive Collaborative Individual	Main game elements	Additional game elements
14	Kim, S. (2021)	Online	Not applicable	Not applicable	Not applicable	Not applicable	Collaborative	PBL	Progression Status Levels Rewards
15	Kornevs, M., Hauge, J.B., & Meijer, S. (2019)	Face-to-face	Not applicable	Yes	Yes	No	Competitive	PBL	Scores
16	Larson, K. (2020)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
17	Loughrey, K., & O'Broin, D. (2019)	Online	Not applicable	Yes	No	No	Competitive	PBL	Challenges
18	Mahat, J., Alias, N. & Yusop, F. D. (2022)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
19	Metzger, E.C., Lubin, L., Patten, R.T., Whyte J. (2016)	Face-to-face	Not applicable	Not applicable	Not applicable	Not applicable	Individual	PBL	Badges
20	Palmquist A., Jedel I. (2022)	Online	What	Yes	Yes	No	Not applicable	PBL	Not applicable
21	Santos I., Sa-Couto C., Vieira-Marques P. (2019)	Online	How	Yes	Yes	No	Not applicable	PBL	Challenges, Rewards, Feedback, Progress bar
22	Singh, S. (2016)	Not applicable	How	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
23	Triantafyllou, S.A.; Georgiadis, C.K. (2022)	Online	What	Yes	Yes	No	Collaborative	Not applicable	Feedback, Challenges
24	Wang, Y.F.; Hsu, Y.F.; Fang, K. (2021)	Online	Not applicable	Yes	No	No	Competitive	Not applicable	Not applicable
25	Zainuddin, Z., Rasyidin, R., Zanzibar, Z., Aruni, F. Nurmasyahyati, N. (2023)	Online	Why	Yes	No	No	Competitive	PBL	Not applicable

5. Conclusions

Considering that the online training model prevails neatly with respect to face to face, it is important use the technological environment properly if the educators want to face lack of motivation and engagement through gamification, as well as pursuing deeper learning objectives. According to the latter, know-how prevails over know-what and know-why (C1.1). It is a somewhat contrasting result with the literature which states that it is important to improve workers' skills throughout their lives. These ones are not limited to practical skills but include metacognitive dimensions and changing of attitudes (LifeComp, 2020; Ranieri et al., 2024; Costa, 2019). Taking learning objectives into account, the main objective was to detect whether they are

usually linked to the theoretical principles underlying gamification (the purpose of gamification) (Q1). Despite the existence of several design processes, either focus on the value of pedagogical activities or on gamification choice, they seem to be not used from the studies reviewed. Krath (2021) categorization was used, and the results mainly demonstrate a combination of principles that lead to behavioral outcomes and positive social effects, without a study following principles that promote individual relevance (C2.1). This is aggravated mostly using PBL structure to reach even the deeper learning objective like the know-why (C2.2). However, there are exceptions: the use of narratives is increasing and generally related to a knowwhy aim. Narrative can be a relevant pedagogical device to touch the emotional chords of adults, engaging them from a behavioural, cognitive and emotional point of view (Ranieri, 2024; Immordino-Yang, 2017). The phenomenon of narrativization (Koerner & Staller, 2024) is slowly increasing in the literature. It is an approach where narrative is the main core of the activity and other elements, such as points, badges and leaderboards, orbit around. Something is changing if we consider the playful approach. In some cases, the know-why is achieved through collaborative or mixed approaches. The use of collaboration, as well as the combination of different approaches, should not be used sporadically. PBL encourages competition but is not something that comes directly from the game elements implemented. On the contrary, the trainer has to choose it exactly how he/she chooses it in a traditional setting.

This panorama is not far from the view of Bogost (2015). As Alioto & Persico (2024) pointed out, the widespread use of PBL reveals a vision of learning as a product, rather than an intrinsically process with a strong individual relevance, capable of fostering intrinsic motivation and change lifelong attitudes. The critique of the phenomenon of pointsification (Helberg & Moll, 2023), has led to the conclusion that this type of gamification does not allow for deep and/or and long-term learning, neither does it foster the development of lifelong learning skills, the necessary skills for achieving competence. At the same time, several authors (Krath at al., 2021; Mahat at al., 2022; Antonaci et al., 2019) have also contrasted Bogost's iconic phrase, i.e., "Gamification is bullshit", by showing that gamification, if accurately designed, can be of help in achieving meaningful learning.

Based on these insights, we propose that narratives represent just one example of gamification elements that could and should be utilized to achieve more ambitious learning goals—not only "know-how" but also "know-why." To this end, gamification principles that encourage intrinsic motivation, such as those promoting personal relevance (e.g., individualized goals, adaptive content, and multiple-choice options), are essential.

Moreover, a more systematic application of a pedagogical design process is needed to structure and deliver training interventions effectively, using game elements to support the attainment of these learning objectives (RQ1).

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· Section 4 ·
Experiences in Education

Misconceptions in Physics Education at the lower secondary school level: an initial experimentation

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Abstract

Achieving an adequate level of scientific knowledge is recognized as an important milestone not only for training future scientists, but above all to enable new generations to possess skills for responsible and critically informed citizenship. Regarding Italy, international comparisons highlight the increasing prevalence of specific critical issues in this area. As for research into educational actions aimed at improving the understanding of physical phenomena, it remains crucial to understand the preconceptions from which students move and the cognitive obstacles they entail. We have developed and validated a questionnaire to highlight the most common critical elements in the explanation of physical phenomena by students aged 11-14. The collected data confirm the presence of widespread misconceptions already reported in the literature, which it is important to bring to the attention of teachers. The questionnaire is complemented by formative feedback intended to provide initial indications for their revision.

Keywords: Science Teaching, Elementary Knowledge of Physics, Assessment, Foreknowledge, Cognitive Change.

1. Introduction

The issue of science education has a long history in Italy (Israel, 2008). Since the post-World War II period and more recently, local or regional initiatives have been active in its various branches (physical sciences, life sciences, earth sciences), often characterized by educational research activities conducted in collaboration between university professors and school teachers. However, in light of international comparisons (OECD-PISA), the situation worsened between 2012 and 2018 (Figure 1), without the problem currently being the subject of adequate debate or significant institutional interventions (Calvani et al., 2022).

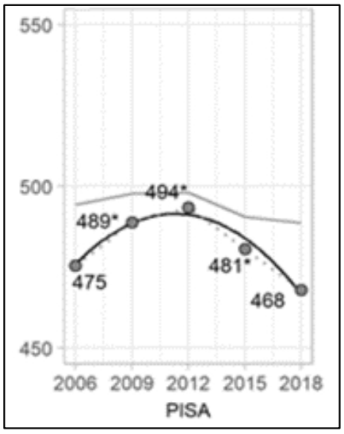


Figure 1 - Performance of Italian students in science in the OECD-PISA assessments.

In this work, we developed and validated a questionnaire that highlights the most common critical elements in the explanations of physical phenomena provided by students aged 11-14. The

hypothesis is that identifying major misconceptions could be particularly useful, as it enables teachers to immediately identify the most critical points in students' understanding of physical phenomena, which should be prioritized for intervention. It is assumed, in particular, that the history of science provides specific insights for diagnosing and anticipating the mental representations of primary or secondary school students (Leone, 2014; Rinaudo & Leone, 2024).

2. Materials and Methods

Based on the existing literature (Leone 2020; Allen 2014) and examples drawn from TIMMS and PISA, we developed a tool to provide a snapshot of the misconceptions presented by students aged 11 to 14 when faced with questions requiring the application of basic concepts and principles of elementary physics (CEF, Basic Physics Knowledge). The hypothesis is that identifying these problematic situations offers useful signals and reference points for targeted interventions on the most common misunderstandings regarding basic scientific concepts, which can and should be addressed with students.

The topics were selected based on the above-mentioned sections, distributed as shown in Table 1. The questionnaire presents students with common physical phenomena and asks for explanations through typical questions such as "*Why does this happen?*" and "*What happens if?*" with four response options, which usually include the most widespread naive conceptions. The first version of the questionnaire consists of 52 items to be administered in class in two sessions of 26 items each. After the full administration, a teaching feedback session follows, which the teacher can further enrich.

Table 1 - Distribution of items by topic.

TOPICS	N. ITEM
Conservation	3
Forces	10
Buoyancy	5
Air and Gas	6
Energy	3
Thermic equilibrium / Phase transitions	5
Elettricity	6
Magnetism	2
Light	6
Sound	2
Astronomy	4

The questionnaire can be considered "educational" in the sense that it does not merely administer questions to evaluate how students approach them (available at the web-address https://sapie.it/wp/wpcontent/uploads/2023/03/CEF_PRESENTAZIONE_20-11-1.pdf). After the questionnaire has been administered, feedback is provided with a brief explanation. Figure 2 shows an example of an item and the teaching feedback.

D.1.2 Ho un contenitore con dell'acqua e un blocco di pongo. Immergo il pongo nell'acqua e dunque il livello dell'acqua si innalza. Tolgo il pongo dall'acqua e lo modello a forma di «S». Lo reimmergo in questa forma nell'acqua. Il livello dell'acqua rispetto a quello di prima raggiunge:

A. Un livello più alto
B. Un livello più basso
C. Un livello più alto o più basso a seconda del peso del pongo
D. D. Lo stesso livello

R.1.2 Feed-back didattico. La risposta corretta è D.

Qui ci sono due cose da dire.
Prima cosa. Ti sarai accorto che quando entri nella vasca da bagno piena, vedi che il livello dell'acqua si alza. Questo succede perché il tuo corpo occupa spazio che prima era occupato dall'acqua. E qui è la stessa cosa! Quando immergi un oggetto vedi che il livello del liquido sale perché l'oggetto occupa spazio che prima era occupato dall'acqua.
Seconda cosa. E se deformi l'oggetto? Non cambia niente! Il pongo non riduce il suo volume; infatti la parte di pongo pigiata da una parte si sposta da un'altra. L'oggetto continua a occupare sempre lo stesso spazio e quindi a spostare sempre la stessa quantità di acqua.

Figure 2 - Example of an item and subsequent feedback.

3. Results

For the validation of the test was used a non-probabilistic sample, consisting of students from the 6th, 7th, and 8th grades of middle school, selected based on the availability provided by the school principal and the teachers. The administration of the tool involved 235 students from the provinces of Pesaro-Urbino and Naples (Table 2).

The data show that there are statistically significant differences between 6th-grade students, who have lower performance, compared to those in 7th and 8th grades. Additionally, the difference in performance between male and female participants is not statistically significant, although there are statistically significant differences between the group of 6th-grade boys and the boys in the other grades (see Table 3).

Since this was the first application of the CEF, it was necessary to evaluate some of its psychometric characteristics to improve its internal quality and develop a reduced version that optimizes its reliability. The internal consistency, which determines the reliability of the test, was assessed using Cronbach's alpha coefficient, which resulted in a very high value (0.96).

Regarding the specific item analysis, using Classical Test Theory (CTT), we evaluated the quality of the items in relation to difficulty and discrimination power (if the discrimination index is greater than 0.30, the item can be considered to have good discriminatory power between the "prepared" and the less prepared subjects). From the initial version of 56 items, by selecting only the items that exceeded the 0.30 threshold, we derived a reduced version of just 30 items, which can be administered in class in a shorter time, while still maintaining the original validity of the 52-item test.

Table 2 - Sample characteristics.

		MALE			**FEMALE**			**TOTAL**		
	CLASS	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**
PROVINCE										
PESARO-URBINO		11	23	14	13	16	11	24	39	25
NAPLES		33	19	26	21	26	22	54	45	48
TOTAL		**126**			**109**			**235**		

Table 3 - Results of the students from 6th to 8th grade compared using the t-Student test.

	Average	**Standard Dev.**	**t-Student on class**		
			1-2	**1-3**	**2-3**
Class 1	20.74	6.19	$p < 0.01$	$p < 0.01$	-
Class 2	25.33	7.48	$P < 0.01$	-	0.24
Class 3	23.97	6.97	-	$P < 0.01$	0.24
Total	**23.39**	**7.15**			

4. Discussion

A preliminary analysis of the data presents a picture of significant challenges. Even though we lack other reference parameters, the fact that the average score is below half of the possible total score is, in itself, indicative of an overall situation of clear difficulty, although the standard deviation suggests that there are significant internal differences within the sampled classes. Limiting ourselves to a quick review and leaving more in-depth analysis for future work, we can observe that:

- Students perform better on some specific items related to phase transitions, air and gases, sound, and electrical energy.
- Numerous misconceptions are found around concepts that have been analyzed and discussed in the literature. At first glance, the most critical issues arise from items related to volume and weight conservation, the concept of force (particularly the principle of inertia), lifting a weight, buoyancy, distinguishing between electrical and magnetic attraction phenomena, light (especially shadow length), the apparent movement of the Sun, and the Earth's rotation on its axis.

As an example, we focus here on item 1.17 related to buoyancy, from which we can draw interesting conclusions if interpreted alongside results published in the literature and the guidelines outlined by the National Curriculum for preschool and primary education (Miur, 2012). This document, in fact, lists among the learning objectives for the subject “Science” at the end of primary school, the identification of the properties of certain materials, including density, and by the end of middle school, the experience of conducting experiments on buoyancy. However, based on item 1.17, and by cross-referencing the answers with other items related to buoyancy, an insufficient differentiation between the concepts of weight and density emerges, consistent with results in the literature (Leone 2020). Item 1.17 is the classic question, already used by Piaget, about the buoyancy of ships: “*Ships are made of metal. So why don't they sink*?”

Less than half of the total sample (34.7%) and 45.2% of the 8th-grade students responded by referencing Archimedes' principle (“*because the force they receive from the water is greater than the weight of the ship*”). Another 26.5% answered that ships don't sink “*because the metal they are made of has a lower density than water*”, correctly applying the concept of density but in an erroneous way (the metal itself does not have a lower density than water).

Meanwhile, 24.5% of students answered that ships don't sink “*because the metal they are made of is chosen to be not very heavy*”, revealing the incorrect notion that weight determines whether an object sinks or floats. A small percentage of the sample, 13.6%, even chose the answer stating that ships don’t sink “*because they move on the water*”, demonstrating that they had not yet reached the 4th stage of Piaget’s developmental explanation of buoyancy (1972), typical of children aged 9 and above.

5. Conclusions

In this work, we focused on the knowledge of physical sciences possessed by students aged 11 to 14. We developed and validated a questionnaire (CEF, Elementary Physics Knowledge) that aims to provide a concise overview of the most common cognitive obstacles (misconceptions) that emerge when students of this age are asked to apply relevant basic physics concepts and principles to concrete situations. The questionnaire is also accompanied by a brief educational feedback, offering a quick explanation of the correct answer and why the alternatives are inadequate.

From an initial extended version of this tool, consisting of 52 items, a shorter version was derived, suitable for quick testing in middle school classes, and is available for use in any school. The hypothesis is that identifying the most common misconceptions on a broad scale can be particularly useful because it allows teachers to immediately identify the most critical points in students' understanding of physical phenomena, which are the areas that should be prioritized for intervention.

Even though in some cases a wrong idea may be just the tip of a more complex iceberg, providing corrective information, even through targeted examples or brief explanations, could potentially shed new light on the problem or create a form of cognitive conflict that encourages further revision of naive explanations. The next phase of this work involves strengthening the educational component by developing a set of brief interventions, mainly in the form of simulations or videos, aimed at raising students' awareness of the need to restructure their mental models regarding the identified critical points.

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Math and physics education in the ChatGPT era: the art of asking questions

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Abstract

Could conversational generative artificial intelligence truly have an impact on the teaching of mathematics and physics? The discussion is open. To address this question, during the academic year 23-24, I experimented with a didactic approach using ChatGPT that involved approximately 100 students from 3rd and 4th year of high school for a total of 8 hours of curriculum. The goal was to integrate ChatGPT into traditional teaching and consider it as a tool for skill development. Students posed verbal, algebraic, and arithmetic math problems to ChatGPT, as well as a questionnaire prepared to assess misconceptions in physics. These were valid examples to encourage metacognitive questioning (asking "why"), interpreting ChatGPT's responses, and guiding the bot to formulate the correct answer after its errors. These metacognitive dialogues shifted students' focus towards reflecting on the meanings of mathematical and physical terms proposed by ChatGPT and the necessity to explain "why" rather than settling for "how". Given the wide availability of chatbots, it will be interesting in the future to implement experimentation using other chatbots (such as Claude2, Gemini and Mistral) to compare responses provided on specific items.

Keywords: Math Education, Physics Education, ChatGPT, AI in High School, Metacognitive teaching.

1. Introduction

Cantor argued that in mathematics, the art of posing problems should be given more consideration than the art of solving them.

I believe this quote perfectly summarizes the situation that mathematics teachers face with the advent of ChatGPT, especially because I am convinced that in today's society, the role of scientific education must go far beyond and be something entirely different from merely learning formulas and their simple application. ChatGPT, and more generally, generative artificial intelligence (GAI), represents an opportunity to address the many challenges currently faced in the field of education. Specifically, I believe that ChatGPT can facilitate students' intrinsic motivation and active engagement during learning (Brett, 2008), a factor proven to be essential for an efficient and enjoyable learning experience (Mayuri, 2021; Blaženka & Damir, 2011; Ming-Hung et al., 2017), bringing the focus back to the role of metacognitive reasoning and the ability to formulate well-posed questions in mathematics and physics.

It is important to remember that ChatGPT is designed to execute users' instructions with minimal need for specific context (Brown et al., 2020; Zhou et al., 2023; Wei et al., 2021). This property, considered the strength of Large Language Models (LLM), must be understood and taken into account by those working in education. The goal of every teacher (particularly mathematics and physics teachers) is to train effective students, who, to be such, must be able to develop skills in formulating precise and timely questions (Oudeyer et al., 2016), and consequently, receive appropriate answers. For this reason, for ChatGPT to be an efficient "learning companion", it must be used in teaching in a way that transforms students into active learners who control their learning process, helping them develop the one ability ChatGPT does not possess: the ability to ask "why".

On the other hand, an unconditional, unmediated, and thus uncritical use of ChatGPT by students, without the guidance of a teacher, leads to a progressive increase in trust in the system (where students will systematically rely on its behavior) and consequently to excessive

dependence on GAI. More importantly, it results in the gradual loss of the critical-analytical instinct, which is essential for a proper and effective educational process.

2. Materials and Methods

The integration of ChatGPT into higher education represents an essential leap in the era of digitalization, inaugurating a transformative phase through a flexible structure of uses, where students and educators interact with educational materials and communicate with each other. With ChatGPT, students gain accelerated access to a wide range of information, linguistic assistance, cost-effectiveness, and personalized educational opportunities. ChatGPT provides support for students by adapting to their distinct learning styles and preferences. Kasneci et al. (2023) and Sallam (2023) argue that fostering a dynamic and stimulating educational environment can be achieved by engaging students in authentic dialogues mediated by ChatGPT. Within these dialogues, students are encouraged to ask questions, seek clarification, and actively participate in discussions on complex concepts. Recent research provides evidence that this approach promotes student autonomy, leading to improvements in metacognitive learning and the development of critical thinking skills.

Teachers can also benefit from using ChatGPT (Rudolph et al., 2023), as it provides valuable support in optimizing bureaucratic tasks, developing ideas for crafting innovative lessons, and even automating the assessment of student papers. However, the integration of ChatGPT in high school settings poses specific challenges, alongside which it is essential to address issues related to privacy, security, and the potential for technological exploitation using alternative terms. Likewise, the generation of false information and citations by ChatGPT has the potential to mislead students (Hsu & Thompson, 2023). Therefore, alongside educational experiments with students (such as the one described in this article), it is crucial to offer training and professional development opportunities for teachers to enhance the effective use of ChatGPT (Baidoo-Anu & Owusu Ansah, 2023).

The educational approach described aims to explore the potential use of ChatGPT in the high school context, with a specific focus on two main objectives: addressing the challenges of integrating ChatGPT into the teaching of mathematics and physics; and highlighting the possible benefits derived from the use of ChatGPT on the metacognition of scientific concepts. A proposal for a training program on GAI and various types of chatbots dedicated to teachers of all levels and disciplines will be the subject of another publication.

3. Results

In the 2023-24 school year, I designed a teaching pathway on the basics of Generative AI (specifically on ChatGPT) and its applications in the teaching of mathematics and physics. The teaching pathway was initially shared with three other teachers from my institution (with 4 hours of “field” experimentation on the correct use of ChatGPT and the sharing of best practices) and then tested in class, involving a total of 108 students from the last two years of high school, for a total of 8 curricular hours. Among the “experimenting” colleagues, one is a history and philosophy teacher: his teaching considerations and results are not reported in this article, for consistency with the chosen structure, but will be considered in another publication. The aim of the teaching pathway is to integrate ChatGPT into traditional mathematics and physics instruction and consider it as a tool for consolidating and developing higher-level skills such as metacognition, critical thinking, and intellectual vigilance, which are considered essential components of learning. Metacognition, in fact, is crucial for taking active knowledge acquisition behaviors: Loewenstein (1994) explains that information-seeking driven by curiosity is primarily motivated by an individual’s ability to recognize a gap in their own knowledge. This stage mobilizes the metacognitive ability to assess one’s knowledge and decide on the cognitive behaviors to adopt. Numerous studies (Hutchinson, 1993; Whitebread et al., 2009) have also shown that students with average or particularly low mathematical performance benefit substantially from metacognitive

teaching procedures. In fact, students with learning difficulties often suffer from metacognitive deficiencies that lead them to fail at one or more stages of problem-solving, from failing to understand the problem's text, identifying relevant information, operations, and errors, to difficulties in building a representation.

A central theme of the teaching pathway was to put students in the position of developing the ability to ask for further information if surprised by ChatGPT's responses, engaging in "scholarly" dialogue with the chatbot. At the same time, the pathway maintains the teacher's central role, who is tasked with guiding students to develop metacognitive skills, such as the ability to ask scientifically deep and sensible questions, as well as writing short texts with correct and appropriate scientific language. The ultimate goal of the teaching experiment was also to raise awareness among teachers (especially those of mathematics and physics) of the need for a more emphasized use of metacognitive teaching, with the understanding that students cannot develop mathematical skills if they are not able to examine problems from different perspectives, or compare their solutions with other solutions or structurally similar problems. Setting the explicit goal of a metacognitive scientific education means not being content with asking ChatGPT standard exercises or shared definitions, but rather posing problems that require a personal intervention by the ChatGPT user, the student. As Polya (2016) said, "solving problems is a specific task of intelligence, and intelligence is the specific gift of humankind".

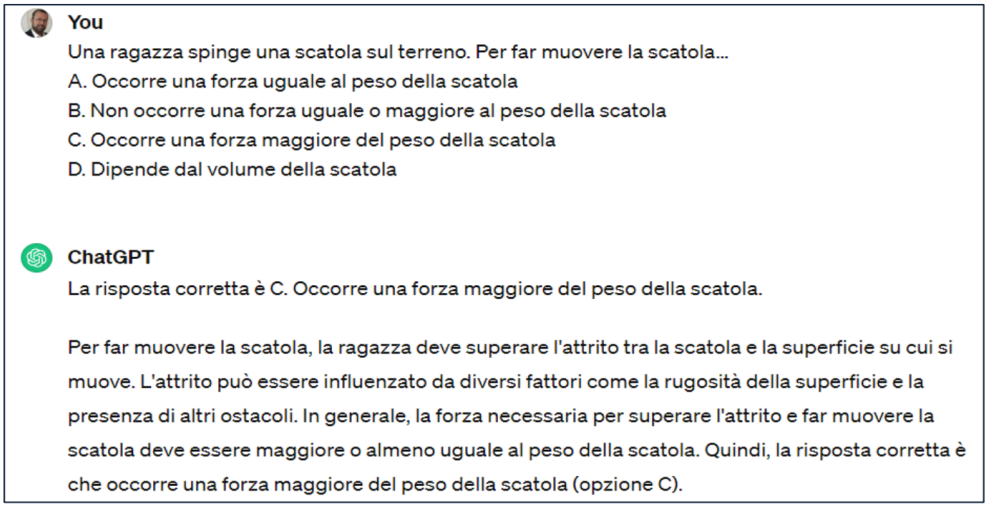


Figure 1 - Example of an item and subsequent feedback.

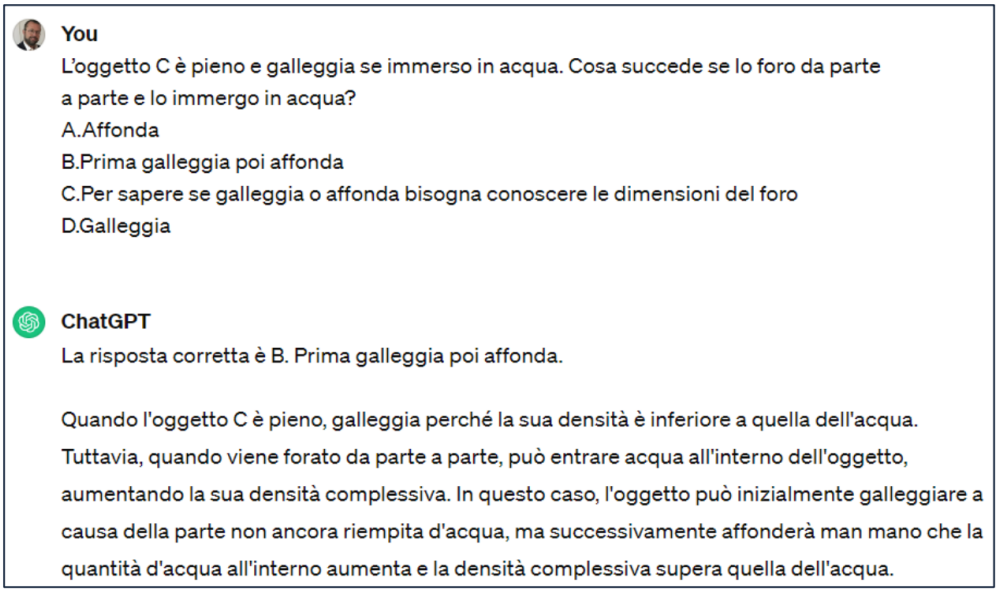


Figure 2 - Example of an item and subsequent feedback.

The teaching pathway required students to submit verbal, algebraic, and arithmetic problems to ChatGPT, as well as a physics questionnaire designed to assess misconceptions in students aged 11 to 14 (this is the CEF, Elementary Physics.

Knowledge questionnaire), presented in another article at this conference (Torre et al., 2024). The questionnaire is available at the web-address: https://sapie.it/wp/wp-content/uploads/2023/03/CEF_PRESENTAZIONE_20-11-1.pdf.

The questions from standardized tests (e.g., INVALSI and OECD-PISA) and the items in the CEF questionnaire are excellent examples to work with, as they require students to develop metacognitive questions (using "*why*") to interpret ChatGPT's responses and, more importantly, to guide the bot to formulate the correct answer. At the same time, students were also asked to invent some questions, taking inspiration from standardized test questions, thereby activating their creative skills in the mathematical field (Figure 3).

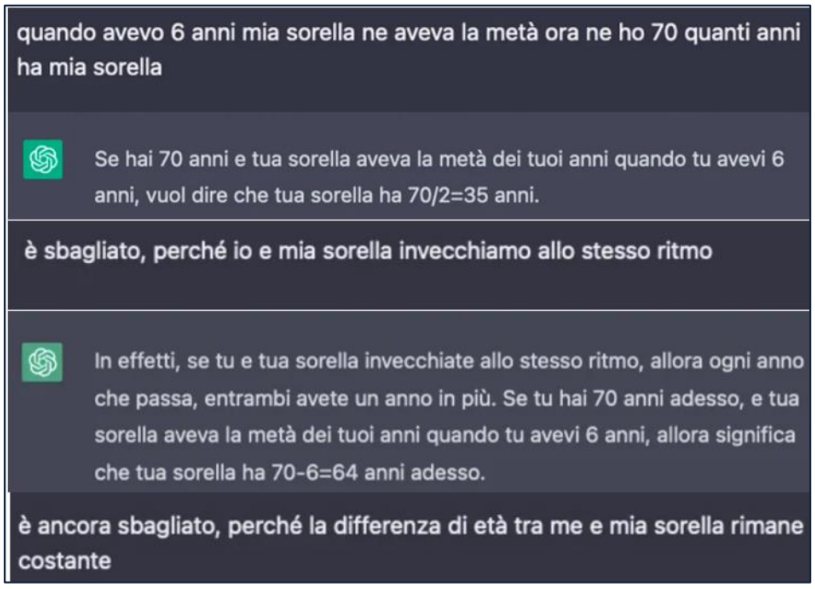


Figure 3 - Example of an item and subsequent feedback.

As described earlier, ChatGPT is not designed to explain the "whys," but to generate immediate responses. The teaching proposal asked students to use the described item types to engage in metacognitive dialogues with ChatGPT about mathematics and physics (see Figures 1 and 2) with the goal of correcting mistakes and becoming "teachers" to the chatbot. These metacognitive dialogues shifted students' focus towards reflecting on the meanings of the mathematical and physical terms progressively proposed by ChatGPT, fostering a critical approach to study and the need to explain the "*whys*" rather than just settling for the "*hows*".

4. Discussion

The acquisition of mathematical skills is a slow and laborious process, which must be grounded in prolonged engagement with concrete elements that are examined, discussed, and represented in ways appropriate to each individual's level of maturity and knowledge. You cannot "do" mathematics if you are unable to examine problems from above, from different perspectives, if you cannot cross-reference them with other situations, or compare their solutions with other solutions or problems that may initially seem distant, but in which a structural similarity can be found. This is precisely why a metacognitive education in mathematics is no longer an optional or a "pet project" of irreducible idealists, but an indispensable tool for effective and comprehensive teaching of the subject.

One of the biggest challenges in using generative AI tools is the misleading overhype surrounding their capabilities and comprehensibility. To provide a more realistic understanding of these tools,

we believe it is important for students to see their true potential, strengths, and weaknesses and to understand the motivations and reasoning behind their design. At the same time, explaining that these models rely heavily on statistical methods to predict their next behaviors can help students grasp the difference between AI and the functioning of biological brains. In turn, this can lead to a more accurate representation of the power of these models: it is highly likely, based on students' experiences, that ChatGPT will display various issues related to logical reasoning, bringing to light the same widespread difficulties present both nationally and internationally in the entrenched misconceptions in mathematics among students aged 14 to 18. Lastly, it was crucial to draw students' attention to the various errors that generative AI tools – and ChatGPT in particular – can generate. Problems such as outdated information, unverified content, incomplete information, lack of context, or outright falsification can easily occur when interacting with ChatGPT. Additionally, students need to be aware of the existence of cognitive and/or social biases in these models' behaviors, which can arise from the initial training datasets. Understanding these specific limitations can encourage students to be more cautious, analytical, and critical of AI behaviors, prompting them to reflect more deeply before adopting them. Most importantly, it helps them understand that the ability to conduct efficient information retrieval strategies depends on their skill in formulating specific, goal-oriented questions.

5. Conclusions

Given the wide availability of chatbots, it will be interesting in the future to replicate and expand on this educational experiment by following the described approach but using multiple chatbots currently in widespread use, beyond just ChatGPT (such as MathGPT, Claude2, Bard, and Mistral). This would allow us to compare the responses provided to specific items where only ChatGPT failed on the first attempt. The idea is to involve an even larger number of students in cooperative and collaborative group work, engaging them directly in debates about mathematics and physics.

Will conversational generative AI truly have an impact on science education? The discussion is open. Certainly, in just a few months, we've seen unexpected and yet-to-be-explored scenarios emerge, and even though the technology is impressive, we are only at the beginning. It is important to engage with these new technologies to start understanding their strengths and the risks, which should not be underestimated, in order to undertake a responsible and informed exploration that can seize the opportunities they may offer for teaching and learning processes. Today more than ever, math teachers, and the education system in general, need to cultivate a "culture of doubt" through metacognitive teaching, so that AI is not viewed as a sophisticated source of disruption but as a valuable companion in the search for new pedagogical possibilities.

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Fostering metacognition through musical activity: a pilot study of novel experiences in primary education

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Abstract

Preliminary literature findings suggest a positive correlation between engagement in musical activities and enhanced metacognition among primary school students. Moreover, qualitative insights reveal an increase in intrinsic motivation, enjoyment, and sense of accomplishment experienced by participants during their involvement in musical endeavors. This pilot study investigates the relationship between engagement in musical activity and the development of metacognition in primary school education. Recognizing the critical role of metacognition in educational development, particularly in the formative years, this research explores the potential of innovative musical activities to nurture creative thinking among young learners. Through the implementation of novel musical activities within the primary school curriculum, this research aims to uncover the potential benefits for fostering metacognition among students. Drawing upon theories of creative pedagogy and experiential learning, the study examines how music stimulates cognitive processes associated with metacognition, such as divergent thinking, problem-solving, and imaginative expression. A cohort of primary school students participates in this study, engaging in a series of carefully designed musical activities tailored to their developmental stage and learning needs. A mixed method of qualitative and quantitative assessments has been adopted before and after the intervention. This pilot study provides valuable insights into the potential of integrating music into primary education as a means of fostering metacognition and cognitive development among young learners. Further research is recommended to explore long-term effects and optimal strategies for incorporating musical experiences into the educational curriculum.

Keywords: Inclusion, Metacognition, Music, Education, Data Analysis.

1. Introduction

Promoting metacognition, or awareness and understanding of one's own thought processes, is an important aspect of overall educational development, especially during the formative years of elementary school. Recent research suggests that participation in musical activities may promote metacognitive skills in young learners. (Benton, 2013; Pelley, 2014; Taylor, 1983). The purpose of this pilot study is to examine the relationship between participation in new musical experiences and metacognitive development in an elementary school context.

Metacognition, the ability to reflect on and regulate one's learning, is widely recognized as a key component in successful academic achievement and cognitive development (Thorpe & Satterly, 1990). Existing literature indicates that metacognitive skills are not only essential for success in school but can also be effectively promoted through appropriate instructional means. Furthermore, research has shown that music-based activities can stimulate cognitive processes related to metacognition, such as divergent thinking, problem-solving, and imaginative expression (Benton, 2013; Barate et al., 2014).

Recognizing the importance of promoting metacognition in primary education, this pilot study explores the possibility of incorporating innovative music experiences into the curriculum as a means of improving metacognitive skills in young students.

A growing body of research indicates that music may act as a catalyst for the development of metacognitive skills. One study highlights the importance of incorporating metacognitive strategies into the design of e-books for instrumental education, highlighting the role of cognitive

and multimodal structures in improving learner performance. (Benton, 2013) Similarly, a comprehensive review of instructional approaches to promote metacognitive thinking in primary and secondary school students suggests that music-based activities can be effectively used to promote metacognitive awareness and self-regulation.

Literature also highlights the broader importance of metacognition in educational settings. metacognitive skills are essential for school success and can be promoted through a variety of learning experiences, they should be considered a fundamental aspect of cognitive development and a curriculum priority (Taylor, 1983).

Although research on the intersection of music, metacognition, and primary education is limited, available evidence suggests that incorporating music activities into the curriculum may promote metacognitive skills in young learners. This pilot study aims to build on these findings and further explore the potential of music experiences to promote metacognitive development in an elementary school context.

To examine the relationship between participation in music activities and metacognitive development in primary education, this pilot study used a mixed-methods approach that included both quantitative and qualitative assessments. Recognizing the importance of employing a comprehensive and rigorous methodology, the research team designed a study that combined standardized metacognitive assessments with in-depth observations and interviews with students. The research team carefully selected a group of elementary school children and had them participate in a series of novel music activities tailored to their developmental level and learning needs.

2. Metacognition

Metacognition is defined as the ability to “think about thinking”, or to monitor and control one’s own cognitive processes, and plays an important role in learning and education (Pintrich, 2002). In cognitive neuroscience, metacognition is divided into two main components that stem from Flavell's (1975) groundbreaking work on metamemory. First, metacognitive knowledge (hereafter metacognition) is defined as the knowledge that individuals have about their own cognitive processes and their ability to monitor and reflect on them. Second, metacognitive control (hereafter metacognition) consists of a person's self-regulatory mechanisms, such as planning and adjusting behavior based on outcomes. According to Nelson and Narens’ definition (1977), metacognition is characterized by the flow and processing of information from the object level to the goal level, and metacontrol is characterized by the flow from the goal level to the object level). The object level includes cognitive functions such as: object recognition and identification, decision making, semantic encoding, and spatial representation (Nelson, 1990). At the meta-level, information is processed at the object level and top-down regulation is imposed on object-level functionality (Shimamura, 2014).

Educational researchers have mainly studied metacognition through the lens of self-regulated learning theory (SRL)(Zimmerman,1990; 2001). Although SRL shares conceptual roots with the theoretical framework of cognitive neuroscience, it differs in several ways. First, SRL is usually limited to learning activities in an educational context. Second, metacognition is only one of three components that comprise “learning motivation” and “behavioral processes” that enable individuals to learn independently. In SRL, metacognition is defined as goal setting, planning, organizing, self-monitoring and self-assessment “at various points of acquisition.” Although the distinction between meta-knowledge and meta-monitoring has not been formally established, reference has been made to a “self-directed feedback loop” that describes the relationship between reflective and regulatory processes. To facilitate comparisons of operational definitions, in educational science, protocols are referred to as metaknowledge when they govern selfawareness and strategy knowledge, and as metaknowledge when they govern the selection and use of learning strategies and plans.

Offline metacognitive research is primarily conducted in the classroom, while assessments of executive functions (EF), such as the Stroop task and BRIEF, take place in the laboratory. All

offline metacognitive protocols involve some form of self-disclosure by students, either during learning activities (e.g., through audio protocols) or afterward (via surveys, interviews, or learning diaries). Questionnaires, while popular for their ease of use, have been criticized for potentially providing distorted evaluations of metacognitive skills. Learning diaries, on the other hand, may offer a more authentic indication of students' engagement in reflective thinking. The sensitivity of think-aloud protocols to online metacognitive processes, such as error correction and effort regulation, remains uncertain. Additionally, the strength of the association between metacognitive skills and academic performance depends on how metacognition is measured: questionnaires and self-report interviews show weak associations, while think-aloud protocols and EF assessments have stronger correlations. Based on the relationship between metacognition and academic performance, educational researchers have hypothesized that promoting metacognition can enhance learning. Consequently, metacognitive training interventions have been introduced, including direct metacognitive instruction, learning diaries, and metacognitive prompts, aimed at guiding and facilitating offline metacognitive processes such as reflection, planning, and strategy selection.

3. Materials and Methods

A cohort of 92 sixth-grade students, aged 10-12 years, from primary schools in the Foggia area of competence, participated in the study. The study employed a quasi-experimental design (prepost) to assess the impact of musical activities on students' metacognitive abilities. The intervention consisted of structured musical activities administered to the students over a specified period. The Metacognitive Functions Screening Scale (MFSS-30), a 30-item questionnaire developed by Alaimo and Schimmenti (2013), was used to measure metacognitive function as the dependent variable.

The hypothesis posited that musical activities would produce measurable effects on the students' metacognition. Data were collected and analyzed to evaluate the extent of this effect.

The Metacognitive Functions Screening Scale (MFSS-30) is a versatile self-report instrument designed to assess metacognitive functions across various domains. It consists of 30 items presented on a 4-point Likert scale, where responses range from 0 (low) to 3 (high). Of these 30 items, 18 are reverse-scored to control for response biases. The overall score ranges from 0 to 90, with higher scores indicating stronger metacognitive abilities, such as self-awareness, problem-solving, and reflective thinking. This instrument can be used in both clinical populations and general settings, making it applicable for a wide range of age groups, starting from children aged 10 years and extending to adults.

Its adaptability makes it suitable for both young individuals and adults with varying cognitive abilities, making it a valuable tool for assessing metacognition in populations where cognitive development is still ongoing or in individuals facing cognitive challenges. The administration of the MFSS-30 typically takes around 10 minutes. Participants respond based on their selfperception of their metacognitive functions. To calculate the total score, the sum of the individual items is taken, ensuring adjustments for reverse-scored items to maintain accuracy. For reverse scored items, a 0 becomes a 3, a 1 becomes a 2, and vice versa. In addition to the total score, the instrument breaks down metacognitive functions into specific components: 1. Recognizing Emotions (CRE): This subscale measures the ability to identify and understand emotions, with items like 4(R), 9(R), 10(R), 14(R), 19(R), and 26(R). 2. Understanding Causal Relationships (CRC): This assesses the ability to understand causal links between events, evaluated through items such as 11(R), 12(R), 13(R), 17(R), 18(R), 23(R), 24(R), and 25(R). 3. Decentering (CDD): This component measures the ability to adopt multiple perspectives and reduce egocentric thinking. It is assessed through items 2(R), 3, 5(R), 6, 7, 15, 20(R), 21, 22, 27(R), and 28(R). 4. Weighting Information (CDP): This subscale measures the ability to weigh and balance different information for decision-making, using items 1, 8, and 16.

The MFSS-30 is suitable for both clinical and educational settings, helping professionals assess metacognitive skills in children, adolescents, and adults. Its reverse-scoring method ensures valid

and reliable results, making it a critical tool in identifying and supporting metacognitive development across diverse populations.

The intervention was carried out over multiple sessions with the sixth-grade students participating in the study. Initially, the students received training on the concepts of nature and the environment to establish a foundational understanding.

This was followed by an activity where a musical instrument was introduced that captured electromagnetic waves from plants, transforming them into musical sounds. Students worked in groups and used Google Lens to identify various plant types, linking their observations to the musical sounds produced by each plant.

They recorded the musical tracks generated from the plants, further fostering collaboration and teamwork. After recording the music, each group listened to their track and, using Google Docs, collaboratively explained the sensations and emotions evoked by the music.

The intervention concluded with each group producing a poster that summarized their experiences, including insights on the connection between nature, music, and metacognition.

Additionally, trainees from educational science programs and psychologists contributed to the administration of the tests and facilitated the hands-on laboratory activities. This multi-step procedure was designed to assess how musical activities, specifically through interaction with nature, could influence students' metacognitive functions.

4. Results

The analysis of the Metacognitive Functions Screening Scale (MFSS-30) showed no statistically significant differences between the pre- and post-intervention scores. The total MFSS-30 score had a mean pre-test score of 48.79 (SD = 10.35) and a post-test score of 48.82 (SD = 10.96). The paired t-test resulted in T = 0.494 with a p-value = 0.311, indicating no significant change in overall metacognitive functions after the intervention (see Table 1).

Table 1 - Sum of Mean, Standard Deviation, T-Test and P-Value for overall results (MFSS_30) and subcomponent results (CRE, CRC, CDD, CDP).

	Mean (Pre)	*SD (Pre)*	*Mean (Post)*	*SD (Post)*	*Test T*	*p-value*
MFSS_30	48,7934783	10,3515546	48,81521739	10,9593949	0,49448977	0,311076
CRE	7,14130435	3,49121825	7,195652174	3,56490565	0,45845481	0,32385937
CRC	12,6413043	4,19989932	12,0326087	4,15747992	0,1622453	0,4357362
CDD	22,1304348	4,89497924	22,34782609	5,03053267	0,38337634	0,35116746
CDP	6,88043478	2,9082769	7,239130435	2,81428681	0,19818524	0,4216711

For the subcomponent CRE (Recognizing Emotions) had a mean pre-test score of 7.14 (SD = 3.49) and a post-test score of 7.20 (SD = 3.56), with a T = 0.458 and a p-value = 0.324, showing no significant change. For CRC (Understanding Causal Relationships) showed a slight decrease from a pre-test score of 12.64 (SD = 4.20) to 12.03 (SD = 4.16) post-test. The t-test showed T = 0.162 and a p-value = 0.436, indicating no significant change. CDD (Decentering) had a pre-test score of 22.13 (SD = 4.89) and a post-test score of 22.35 (SD = 5.03), with T = 0.383 and a pvalue = 0.352, again showing no significant change. Finally CDP (Weighting Information) had a slight increase from 6.88 (SD = 2.91) to 7.24 (SD = 2.81), with a T = 0.198 and a p-value = 0.422, also indicating no significant difference.

In addition to the t-tests, a correlation analysis between the subcomponents of the MFSS-30 was conducted (Table 2).

Table 2 - Sum of Correlation Matrix between overall results (MFSS_30) and between subcomponent results (CRE, CRC, CDD, CDP); p-value (<.05).

	1	*2*	*3*	*4*	*5*
CDP	-	-	-	-	-
CDD	.37	-	-	-	-
CRC	.11	.33	-	-	-
CRE	.05	.25	.48	-	-
MFSS_30	.50	.78	.73	.65	-

Significant positive correlations were found between several components. CDP showed a significant positive correlation with CDD (r = .37), and with the total MFSS score (r = .50). CDD correlated strongly with CRC (r = .33), CRE (r = .25), and the total MFSS score (r = .78). CRC had significant correlations with CRE (r = .48), CDD (r = .33), and the total MFSS score (r = .73). CRE correlated significantly with the total MFSS score (r = .65), CDD (r = .25), and CRC (r = .48).

These correlations indicate strong relationships between the metacognitive subcomponents, with the total MFSS score being most strongly correlated with CDD and CRC, suggesting these domains are interrelated and contribute significantly to overall metacognitive function. However, despite these intercorrelations, the intervention did not lead to significant changes in the metacognitive scores.

Furthermore, the normality of the data distribution was evaluated using the Kolmogorov-Smirnov test (Figure 1). The test returned a result of h = 0, which indicates that the null hypothesis of normality could not be rejected at the default 5% significance level. The empirical cumulative distribution function (CDF) was plotted against the standard normal CDF, and the close fit between the empirical CDF and the theoretical normal CDF confirmed that the distribution of the scores follows a normal distribution. This result further supports the conclusion that the intervention did not produce significant changes in the metacognitive scores.

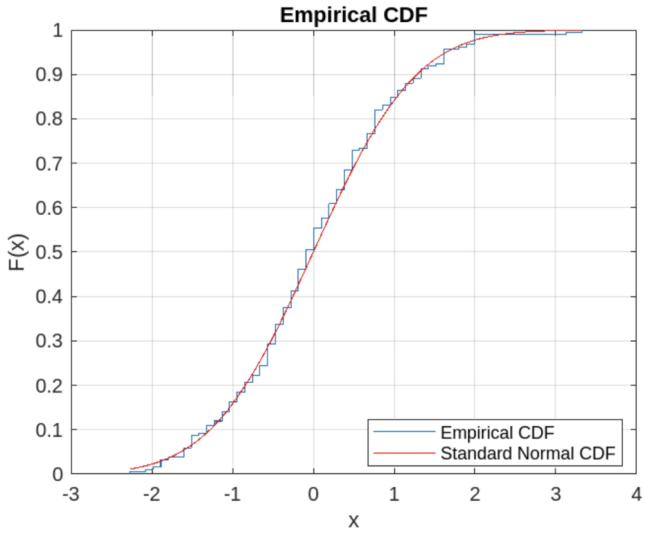


Figure 1 - Kolmogorov-Smirnov test. The empirical cumulative distribution function representing the people's score distribution (Blue Line) is compared with the standard normal CDF (Red Line).

Finally, the R-ANOVA conducted on the total MFSS score found no statistically significant differences between the pre- and post-intervention scores.

The F-test (Table 3) yielded a value of 1.17 with a p-value of 0.28, indicating that the observed F-value, and thus the difference between group means, was not significant at the 5% level. This confirms that there is no significant difference in metacognitive scores following the intervention.

Table 3 - Sum of Correlation Matrix between overall results (MFSS_30) and between subcomponent results (CRE, CRC, CDD, CDP); P-Value (<.05).

	SS	*df*	*MS*	*f*	*p-value*
Column	130.6	1	130.571	1.17	0.23
Error	20246	183	111.242		
Total	20376.6	184			

5. Discussion

The results of this study demonstrate that the musical activities intervention did not lead to significant changes in the metacognitive abilities of the participants as measured by the Metacognitive Functions Screening Scale (MFSS-30). Both the total score and the individual subcomponents (CRE, CRC, CDD, and CDP) showed no statistically significant differences between pre- and post-intervention scores. The paired t-tests, with p-values well above the 0.05 threshold, indicate that the hypothesis – that the intervention would positively affect metacognition – was not supported by the data.

The lack of significant change could be attributed to several factors. First, the intervention may not have been sufficiently intensive or long enough to affect metacognitive development. Musical activities, while engaging, may require a longer exposure or integration with other cognitive strategies to have a meaningful impact on metacognitive functions, particularly in a cohort of students with a short age span (10–12 years).

Second, the Kolmogorov-Smirnov test confirmed that the data followed a normal distribution, meaning that the lack of significant results is unlikely to be due to data distribution issues. The results from the R-ANOVA further support this conclusion, with the F-test yielding no significant differences between group means. The p-value of 0.28 indicates a 28% probability that the observed F-value (or a more extreme one) could occur if the null hypothesis were true. This is well above the common significance level of 0.05, reinforcing the conclusion that the intervention did not significantly influence metacognitive abilities.

Despite these findings, the correlation analysis revealed significant positive relationships between the various subcomponents of metacognitive functions (CRE, CRC, CDD, CDP). Specifically, strong correlations between CDD and CRC and between these subcomponents and the total MFSS score suggest that these areas of metacognition are interrelated. This interconnection indicates that while the intervention did not lead to measurable changes, the domains of metacognitive abilities do function cohesively.

It is important to consider that the intervention might have impacted other cognitive or emotional areas not directly assessed by the MFSS-30, such as creative thinking or emotional intelligence, which could have been better suited for a qualitative analysis. Moreover, the involvement of psychologists and educational science trainees may have created a supportive environment that could foster other types of cognitive or emotional benefits not captured by the current study's design.

Future research might explore the possibility of combining musical activities with more targeted cognitive strategies to foster metacognitive development. Alternatively, a longer intervention period or a more varied set of activities might produce more observable changes. Researchers could also consider incorporating qualitative methods or other instruments alongside the MFSS30 to capture a broader spectrum of cognitive and emotional growth.

While this study did not find significant evidence supporting the effectiveness of musical activities in enhancing metacognitive abilities, the relationships between the subcomponents of metacognition indicate potential areas for future exploration. It is possible that more comprehensive or extended interventions could yield different results.

6. Conclusions

This study investigated the potential of musical activities to enhance metacognitive abilities in sixth-grade students, yet the results did not show statistically significant changes in metacognitive scores as measured by the Metacognitive Functions Screening Scale (MFSS-30). The hypothesis that interaction with music – through an immersive and nature-inspired experience – would positively influence students' metacognition was not supported by the data, with both the total score and subcomponent analyses yielding no significant differences between pre- and post-intervention results. However, these findings prompt several broader reflections on the role of music in education and how metacognitive development might be supported. One important implication for educational practice is that, while musical activities did not significantly alter metacognitive functions in this study, they may still hold considerable value for other cognitive or emotional domains. The collaborative nature of the musical activities, such as recording plant-generated music and reflecting on the sensations evoked, could foster creativity, teamwork, and emotional regulation, areas not directly measured by the MFSS-30. This suggests that music, even if not immediately metacognitively impactful, could still contribute positively to a holistic educational experience, promoting skills that indirectly support cognitive growth.

Additionally, it is worth considering whether the limitations of standard measurement tools like the MFSS-30 might have constrained the detection of more nuanced shifts in metacognition. Metacognition is a complex construct, and its development may manifest in ways that are difficult to capture quantitatively. Future research could benefit from incorporating qualitative methods – such as interviews, classroom observations, or student self-reflections – to identify subtle changes in students' awareness and self-regulation abilities that may not be evident through self-report instruments alone. Moreover, this study highlights the potential benefit of adopting an interdisciplinary approach to foster metacognitive development. Musical interventions, when combined with more structured cognitive strategies such as guided reflection or problem-solving exercises, might yield stronger effects.

By integrating music with cognitive tasks that explicitly challenge students to reflect on their thinking processes, educators could create more robust interventions that enhance both cognitive and emotional domains simultaneously.

While the data did not show significant improvements in metacognitive abilities, the strong correlations between the subcomponents of metacognition (particularly between Decentering and Causal Reasoning) suggest that these cognitive domains are interrelated. This finding points to the possibility that different forms of cognitive training, if applied concurrently or over longer periods, could produce more pronounced effects. The fact that metacognitive skills are closely linked indicates that future interventions might benefit from targeting these components in a more comprehensive manner, potentially producing cumulative benefits over time. Another important reflection relates to the variability in individual student responses to musical interventions. Not all students may respond to the same cognitive stimuli in the same way, and factors such as personal affinity for music, prior exposure to similar activities, and learning styles could influence the effectiveness of such interventions. Tailoring future interventions to individual cognitive profiles may enhance their effectiveness, as a more personalized approach could better address the specific metacognitive needs of each student.

Finally, it is important to recognize the value of musical activities in promoting other cognitive functions that were not measured by this study. Music has been linked to improvements in attention, memory, and creative thinking, and these areas may represent alternative benefits that were not captured by the MFSS-30. Future research could explore these possibilities by incorporating a broader range of cognitive measures or investigating the impact of longer, more intensive interventions.

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Principles for designing digital communities of practice: the case of argumentation

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Abstract

During the Covid 19 pandemic the sector of education had to face the challenge of professional development. Teachers of all levels changed their teaching practices by incorporating new ways of teaching, the distance teaching, and new technological tools in their teaching methodology (Pennisi et al., 2015).
We speak about the practice community, because during Covid 19 teachers found an environment in this space, a possibility to share with other teachers their feelings and their teaching experiences and new teaching practices (Zhao, 2020).
In our research, that is ongoing, we would like to investigate if and how working in a digital community of practice impacts the mathematics teacher's identity.
Our specific research questions are: which are the characteristics of a digital environment? How does this environment impact the mathematics teacher's identity? How does this impact specifically their practices about argumentation?
From these research questions come from also our research objectives.
Our intention is to design a digital environment which allows teachers to share their teaching practices thanks to the common purpose: the practices about argumentation, and so to see how this impacts into mathematics teachers' identity.
The common purpose of our community is therefore fostering, understanding and developing argumentation in pupils in primary schools.

Keywords: Mathematics Teacher, Digital Community Of Practice, Identity, Argumentation.

1. Introduction

All people can appropriate something more visible, such as an object, a material, a property, or something less directly visible, such as quality, a gift, knowledge, etc. Getting to "act in a transformative way" is something more, it requires commitment and effort (Rosa, 2020).

For the mathematics teachers it is not enough to "appropriate" the profession: it is necessary to know how to act in a transformative way on one's practices. The challenge is therefore to relate to one's mathematical practices in a meaningful way.

Covid19 has forced many mathematics teachers to think about a new approach in their teaching using digital tools, even those that allow interaction and communication between peers (Jessup, Wolfe & Kalinec-Craig C., 2021) for professional development. Research has highlighted, in fact, how online professional development, adapted to the different needs of teachers, can lead to changes in their educational practices (Arzarello, Robutti & Taranto, 2021), and in their personal identity. The Italian Government, specifically the Ministry of Merit Education, implements in 2015 with law 107 the National Digital School Plan (PNSD) "with respect to the most important innovation challenges of the public system", where at the center are “the innovation of school system and the opportunities of digital education".

The PNSD mainly follows four strands: connectivity (network access for all schools, right to the internet for students, enabling digital teaching); environments and tools (adequate and innovative learning environments, capable of placing teaching practice at the center with the use of digital resources and technologies); skills and contents (ability to find, understand, describe, use, produce complex and structured information); accompaniment (it is necessary to develop an approach that speaks comprehensively to all school staff, leveraging the structural investments envisaged by the Buona Scuola).

The sector of education had to really deal with the digital community of practice during Covid19 with the distance learning.

It was a crisis situation (we refer to crisis as a state of strong disturbance in the life of an individual or a group of individuals, with more or less serious effects), which despite the Good School and law 107 implemented already in 2015 on the National Digital School Plan, it caught many teachers unprepared, from the point of view of knowledge and the exchange of good practices in distance learning.

Our research area is located within the National Recovery and Resilience Plan, Italy Tomorrow, within Next Generation EU, "the economic recovery program activated by the European Union and dedicated to member states after the Covid-19 pandemic. 19, with resources to be used in the period 2021-2026" (https://pnrr.editore.it/). Specifically in this research, we refer to School Plan 4.0, to the continuous training of teachers, where attention is paid to the internal and external communities of practices between teachers to encourage not only "exchange and self-reflection on methodologies" using European Commission platforms such as Selfie for teachers (https://pnrr.editore.it/), also with respect to the exchange and sharing of teaching practices within digital learning environments.

In fact, our research aims to activate digital communities of practices for primary school teachers, in the field of mathematics teaching, and fit within the Next Generation Classroom project by sharing its objectives, namely: active learning and collaborative, with personalized teaching, relationships, motivation, emotional well-being, peer learning, problem solving and co-planning, consolidation of cognitive and metacognitive skills (critical thinking, creative thinking, learning to learn), social and emotional skills (empathy, responsibility and collaboration), practical and physical skills (correct use of new information and digital communication devices) (https://pnrr.editore.it/).

2. Materials and Methods

“Research is not knowledge. Research, whether empirical, theoretical or philosophical, is an active process of investigation, one that relies on strategic use of knowledge, in context” (Boaler, Ball & Even, 2003), as research is something to do. In our research we started by reading to formulating research questions. We reviewed related literature to find answers to our research questions. Our three aims are:

1. knowing the characteristics of a digital community of practice.
2. how this, in order, could impact on the identity of the participants.
3. and if participants could change their professional way of teaching, working with a specific common purpose that is the argumentative skill of their pupils.

2.1 Digital Community of Practice: what it is, what we know

Practices are the result of "experiences, knowledge, objectives, context" (Zhang & Morselli, 2016), all factors that have to do with the construction of a person's identity, and in specific in this research in the identity of a person as a mathematics teacher. By practice we mean habitually acting in a certain way, that is a specific action that the mathematics teacher implements in the context of mathematics teaching, in a specific historical and social context. Practice is also understood as constant exercise with the aim of learning, becoming an expert in that specific practice, in teaching mathematics (Lampert, 2010).

With the term community we refer to an association of people who share experiences, practices, understood as a “living organism”, “whose action is expressed in movements by which two bodies change their mutual position” in “a common and mutual way of feeling” (Tönnies, 1979).

The digital community of practice focuses on actions and routines relevant to the teaching and learning of mathematics, around which members coexist, share information, help each other, interact, build relationships, collaborate and discuss ideas; how engagement occurs is influenced by the structure of the platform (Radakovic & Jao, 2020).

> *"It's a deep process of reflection and selfevaluation where past, present, and future mathematics teacher identities enter into a dialogue that leads to awareness of a tension or gap between the current and ideal state of mathematics identity" (Lutovac & Kaasila, 2014, pp.131).*

In our digital community of practices mathematics teachers share a common purpose: working with argumentation and the evaluation of argumentation.

2.2 Identity

Identity is a layering of events of participation and reification through which our experience and its social interpretation inform each other. Identity is something related to experience, understood as a fact or state of having been affected by or gained knowledge through direct observation or participation, and as a practical knowledge, skill, or practice derived from direct observation of or participation in events or in a particular activity. Experience reminds us to practice, skills and abilities that are recognized in a community of practice. "We become who we are through the ability to play a role in the relationships of engagement that constitute our community" (Wenger, 2006).

"Studies demonstrate the interaction between teacher identities and teachers´ practices, making it apparent that changing one will affect the other" (Metzuyanim, Lutovac & Kaasila, p.16, 2016). As Schoenfeld said, "what matters in teaching is not so much what people say but what they do" (Zhang & Morselli, 2016). Our intention in our research is to see "how the beliefs affect the task implementation, and the task implementation might be affecting beliefs" (Zhang & Morselli, 2016).

We would like to see how a digital community of practice allows mathematics teachers to share their teaching practices in a common purpose: the implementation and the evaluation of argumentative activities, and so to see how this impacts into mathematics teacher identity.

Thanks to the teachers' argumentative practice in classroom, pupils feel considered in their opinion and become meaning makers.

> *"In the relationship between teachers and students we usually tend to overlook an aspect: mutual respect as the basis for a good culture of error and feedback" (Rosa, 2020).*

In this case the competence of mathematics teachers in teaching lessons is not pure "appropriation of a technique" but refers to the process of entering a relationship with the student through resonance, or a process of "transformative appropriation", where in it I also transform my identity as a teacher (Rosa, 2020).

2.3 Argumentation

The common purpose for the participants, the mathematics teachers, is the argumentation because: first, it provides a strong common purpose to the participants, since it is something, whose importance is clear because mathematics is linked to logical thinking, but for which there is not a clear and established teaching tradition.

Second, beliefs related to argumentation (what it is, if it is an innate competence, how it may develop…) are important component of teachers' identity, albeit often implicit. Third, practice about argumentations, and in particular assessment practices, are not common in primary schools- there is an overlapping in common understanding between "argumentation" and "proof", in the sense of "demonstration of theorems" that restricts the classroom working on argumentation to secondary schools (Boero, Fenaroli & Guala, 2018).

We can read in the National Guidelines for the curriculum of nursery school and the first cycle of childhood, the importance of working in class with students on argumentation in mathematics, where according to the Ministry of University Education and Research "of extreme importance is

the development of an adequate vision of mathematics, not reduced to a set of rules to be memorized and applied, but recognized and appreciated as a context for tackling and posing significant and to explore and perceive relationships and structures that are found and recur in nature and in human creations" (Ministry of University Education and Research, 2012).

Also, because there are less reference materials on this topic, there is more interest on that, and it is relevant in mathematics education research (Guerrier et al., 2012).

3. Our Project

We present here the principles that should guide the planning and the implementation of a digital community of practices aimed at actively helping the transformation of the identity of mathematics teachers participating in it.

3.1 Design elements

These principles refer to purpose, space, relations, time, and working.

1. Purpose: why teachers should participate and getting involved
2. Space: where teachers interact
3. Relations: who does what in the digital community of practice
4. Time: when they interact
5. Work: which activities will take place in the digital community of practice

3.1.1 Purpose: why teachers should participate and getting involved

Teachers involved in a community of practices should share a common purpose. This common purpose may be a general educational one (they work in the same school with the same pupils, f.i.) or a more specific one (developing skills for teaching a particular topic, f.i.).

Since our purpose is to explore how a community of practice may impact the identity of a teacher, i.e. something that is not completely explicit and deeply rooted in the person, the common purpose must be chosen looking to the deeply embedded beliefs about the discipline taught. In the case of mathematics, argumentation (from the epistemological point of view) and argumentative skills (from the educational point of view) are a good ground for sharing goals.

3.1.2 Space: where teachers interact

To answer our first research question about the characteristics of a digital community of practice, we need to focus on the affordances of this environment. According to INDIRE which documents in a publication volume examples of innovative schools according to the PNRR plan and learning environments, our digital community of practice is an environment that respects the properties of flexibility (to promote both consolidated teaching strategies and innovative approaches), adaptability (which allow a reconfiguration of the setting), challenging (able to stimulate new solutions), creative (able to inspire teachers), supportive (to develop and enhance the potential and aptitudes of each teacher), multifunctionality (in order to satisfy different and constantly evolving needs). Among these characteristics we underline some evident affordances of the use of google classroom in our community of practice about the documentation and the familiarity. The documentation is *flexible*: a document can contain text, images, video, audio, all in a single document. *reproducible*: it is possible to quickly create a high number of copies that are perfectly identical to the original, which can still be modified; *transmissible*: thanks to software and applications that we use every day, such as emails and instant messages, we can send a document from one part of the planet to another via the world wide web in a few seconds. *interactive*: digital documents can easily be related to each other via hyperlinks. Google classroom is knowable: mathematics teachers use already in their activities this tool.

3.1.3 Relations: who does what in the digital community of practice

In our research we would like to explore also the roles of participants in the digital communities of practice: mathematics teachers, researcher, digital animator.

Mathematics teachers are the subject of the digital community of practices, but also the researcher's study object.

The researcher plays a role of observation, collection and analysis of information thanks to the affordances that the digital environment offers. They will not intervene Title directly in the activities, if not request explicitly, but they will give guidance and feedback to the digital animator.

The digital animator plays the role of bringing the focus of the discussion to the common purpose of the digital community of practice, the argumentation, highlighting reflections, directing towards new discussion points, offering support.

3.1.4 Time: when they interact

The digital community of practice works on two kinds of time: synchronous, asynchronous. Participants (see below our open issues) may share also physical presence, and of course these interactions will impact also on time spent in the digital environment.

In synchronous time all participants of the digital community of practice are in the same digital environment, where they can interact with the researcher, the digital animator and with the other participants. In the asynchronous time the researcher, the digital animator and the other participants are not involved in the interaction process at the same time. Participants on this kind of time can use, share digital material and reflect on their own time. Synchronous time (of the whole group or of subgroups) is devoted to discussion, focused analysis, sharing experiences. Asynchronous time is devoted to documentation, deepening of topics, elaboration of mutual feedbacks.

Blogs inside the community will allow asynchronous interactions.

3.1.5. Work: which activities will take place in the digital community of practice

The activities in which participants are involved are: documentation, analysis of situations, planning, discussion of the experimentation.

There are steps that should be cyclically repeated along the lifetime of the community:

1. analysis and examination: to identify and define problems. The animator will intervene also with interviews and focus groups. Synchronously, information on experiences in class regarding the common purpose (in our validation case argumentation and its evaluation) are collected and discussed.
2. design and construction: Adaptation of existing and validated activities or design of new activities to bring in the classes, with a lesson-study methodology (digitally adapted).
3. evaluation and reflection: synchronous and asynchronous evaluation of the collected materials.

4. Open Issues

The project is based on the reference literature, the validation phase is based on the implementation of the project with two groups of teachers of South Tyrol. In particular, a group is composed by primary school teachers of the same school, whilst a second group is composed by teachers of different schools, who don't know themselves. In such a way, the first group will interact in a blended way, hence the digital community will we complementary to their sharing physical spaces, whilst the second one will interact exclusively with the digital tools.

The methodology of validation part of the research is educational design research (McKenney & Reeves, 2013), aiming to understand the theory of a phenomenon but also to define educational design: starting from a real context, to define an educational design research, to resolve specific problems.

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Towards the construction of an observational tool for interactions between children and Ozobots

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Abstract

The integration of robotics in early childhood education holds promise for transforming teaching methods into more exploratory and engaging experiences (Sjoberg & Brooks, 2023). This transformative approach can be realized by considering toy robots as didactic mediators (Damiano, 1993) operating within interactive contexts that feature enjoyable and adaptable environments (Bers, 2012), guided by adults and tailored to children's perspectives, utilizing various types of robots (Bozzi & Zecca, 2021; Belland et al., 2019; Angeli & Georgiou, 2023; Terroba et al., 2022).This project focuses on developing an observational tool to study how children aged 3-6 interact with Ozobots, aiming to understand the cognitive and social dynamics involved in robot play. Drawing from sociocultural and ecological perspectives on children's learning, we conducted observations in natural settings using a quasi-experimental research design. Video recordings were analyzed to identify specific actions and problem-solving approaches employed by children during interactions with Ozobots (Gaudiello & Zibetti, 2013; Gabriele et al., 2017). The analysis resulted in defining the grid categories using a bottom-up approach. Unlike traditional performance-focused assessments (Bakala et al., 2021), our analysis prioritizes understanding the cognitive processes underlying children's engagement with robotics. The goal is to create an observational tool that can enhance the design of educational activities and support teacher training, empowering educators to develop learning experiences that leverage children's cognitive abilities and motivations. This project bridges research and practice, seeking to enhance early childhood education through robotics by providing insights into effective pedagogical strategies and fostering meaningful learning experiences for young learners.

Keywords: Children Robot Interaction, Observational Tool, Robot-Mediated Activities, ECEC, Teacher Training.

1. Introduction

A great deal of research over the past two decades has been developed around the cognitive skills that develop in the interaction between humans and machines, and in particular educational robotics in the developmental age, and the cognitive benefits associated with this. Particularly interesting are the research developments around the concept of Computational Thinking (TC), linked to the experiences of robotics in early childhood, which due to its indeterminacy has expanded the possibility of exploration and definition. Recent research (Fessakis et al., 2013; Di Lieto et al., 2017; Castro et al., 2019) has identified new possibilities for disciplinary learning, cognitive and metacognitive development, particularly with regard to second-level, high-order thinking skills (Vygotskij et al., 1990), such as abstraction, generalisation, and the handling of frustration and error. Wing (2011) defines abstraction as the capacity to comprehend the fundamental characteristics or properties of an entity, thereby reducing its overall complexity. In a study conducted in 2010, Levy and Mioduser found that children (aged between 3 and 6 years) carry out playful, in-depth investigations of robot behaviour and that their constructions are planned and anticipatory, demonstrating the ability to simulate behaviour before executing programmes. The development of skills, understanding, knowledge and interactions with robots is supported by formal language, the development of different spatial perspectives and an understanding of the relationships between behaviour and rules.

Similarly to CT, the definition of 'Educational' Robotics (ER) is far from unambiguous. Indeed, the choice of definition establishes the theoretical approach that is taken when discussing and researching robotics in early childhood. Bozzi and Merisio (2021) provide a critical analysis of the primary research strands in this area: educational robotics has been defined as a tool for teaching and learning (Atmatzidou & Demetriadis, 2016) and for the development of cognitive skills (Ioannou & Makridou, 2018). It has also been described as a vehicle for rethinking largescale teaching, learning and education (Angel-Fernandez & Vincze, 2018). It has been characterised as a teaching practice (Komis et al.,2017) or, on the other and, as a ‘mindtool based on constructivism and constructionism’ (Mikroupoulos & Bellou, 2013). At last educational robotics is understood in some approaches as an area of research towards new environments and tools for teaching and learning (Ruzzenente et al., 2012) and intersection of different fields of knowledge (Scaradozzi et al., 2015).

One of ER’s research trajectories considers the interrelatedness of robotics activities with other school activities. It argues that the thought processes involved in playing with robots promote the development of mental tools that are also useful in other domains (Angeli & Valanides, 2020). This is demonstrated in recent work by Bers (2018; 2020) and Botički and colleagues (2018) indicates that the promotion of CT at an early age improves children's analytical skills by introducing them to new tools for collaborative problem-solving and expression. Bers' (2010) work also demonstrates the importance of integrating technology into early childhood learning environments as a means of fostering positive interpersonal skills in the digital age.

These research trajectories acknowledge the necessity of interdisciplinary collaboration in the context of early childhood robotics education. This approach can facilitate meaningful learning experiences for children while offering teachers a playful and engaging method to integrate complex concepts through meaningful play (Bers et al., 2014).

The approach we adopt is predicated on the view that robotics can be conceived of as one of several potential expressive languages, or knowledge-building languages, that can be explored in educational contexts. From this perspective, the abilities displayed by children in their interactions with robots extend beyond the domain of computational thinking. These interactions demonstrate the manifestation of diverse and individualistic modes of reasoning, encompassing cognitive abilities, social competencies, communication and soft skills. The definition of ER that we endorse is that of a research area which ‘aims to enhance people's learning experience through the creation, implementation, revision and validation of pedagogical activities, tools, and technologies, with an active role assigned to robots under the timely guidance of pedagogical methods’ (Angel-Fernandez & Vincze, 2018).

Consequently, the development of programming skills is not the primary objective of educational activity; rather, it is a means of learning. In this regard, it can be seen to function as a conduit between subjects and objects in the production of knowledge (Damiano, 1993) a dispositif (Foucault, 2005; Massa, 1987). In its role as an educational and didactic mediator, the ER facilitates the enhancement of the cognitive, metacognitive and relational processes that children engage in, as these processes are integral to learning and cognitive development. Playing with robots is a way of playing to think, playing to create, and stimulates complex skills such as observing, describing, exploring, hypothesising, imagining experiments, (JoãoMonteiro et al, 2003), reasoning and the use of different expressive languages (Kazakoff & Bers, 2012), confronting oneself and others, thinking/discussing/deciding, feeling, thinking computationally, thinking metacognitively, and posing and solving problems algorithmically. Adopting the socio-constructionist approach to learning, robotic technologies are ‘objects with whom to think’ (Papert, 1980). According to this perspective, the integration of robotics into educational contexts changes the ethos of teaching from a competence-based approach to one that promotes exploration, discovery and play in learning (Sjoberg & Brooks, 2023), in which children's play strategies with robots reflect heuristic processes supported by peer and adult tutoring and scaffolding (Wood et al., 1976). At the educational level, this requires adopting the ‘didattica laboratoriale’ (workshop teaching) approach which is characterised by the implementation of activities that are designed with a didactic purpose and content, and which are conducted in a group setting. These activities are oriented towards operability, dialogue, research and planning.

Pupils engage in continuous reflection on their actions, evaluating the activities they undertake collectively and collaboratively. The workshop teaching, previously a domain reserved for specialized instruction, becomes a learning environment and a pedagogical approach that challenges the traditional transmissive 'classroom' teaching model. Laboratory teaching emphasizes active, multi-sensory, and reflective experiences, fostering creativity and the capacity to investigate.

Within the Italian institutional landscape, the interest in supporting and increasing the use of robotics in education is strongly determined by providing a stimulus to interrupt a transmissive didactic style by favouring, instead, critical and active thinking process (MIUR, Indicazioni Nazionali e Nuovi Scenari, 2018). Engagement with robotics provides an optimal learning environment, as it encourages problem-solving through experimentation, collaborative action and the utilisation of diverse forms of intelligence.

Within the field of ER, a variety of methodologies and robotic tools have been developed for use with different age groups undergoing developmental stages. In addition to code-line and block programming, there is a third programming principle that employs physical objects to represent and manipulate programming concepts, thereby facilitating a more accessible and intuitive process, particularly for the early childhood age group: tangible programming. A number of contributions can be found in the existing literature investigating the effects of using tangible programming. Belpaeme and colleagues (2018) emphasise the advantages of intuitiveness, collaborative learning and immediate feedback. Similarly, Horn and Bers (2019) identify tangible programming robots as effective mediators for fostering collaborative processes and valuable tools for supporting the development of abstract thinking and symbolic language skills. Moreover, the capacity to interact with robotic artefacts provides an opportunity to stimulate essential developmental competencies such as concentration and problem-solving, which also encompass fine motor and eye-hand coordination skills (Zecca and Bozzi, 2021). The tangible nature of robotic objects makes them particularly suited to facilitating learning among younger children, allowing them to actively construct knowledge within situated learning situations (Lave, Wenger, 2006), as well as learning-by-doing (Roussou, 2004). Tangibility, however, introduces a further level of complexity due to its impact on the relationship between algorithms and physicality. In addition to the difficulties involved in learning how to programme, tangible robots present children with the physical challenges of performing practical actions on which the outcome of the robot's movement depends. This introduces a further factor that must be taken into account when analysing interactions with robots.

The key factor emerging from Bers' work is the construction of fun and adaptive environments (Bers, 2012) in which children can play and explore skills and attitudes, guided by adults or peers, and tailored to children's perspectives (Zecca & Bozzi, 2021; Belland et al., 2019; Angeli & Georgiou, 2023; Terroba et al., 2022). The learning context incorporates bodily, imaginative and semiotic aspects on the basis of a multimodal approach to cognition (Ferrara et al., 2022). This necessitates that educators possess a diverse range of competencies. In order to establish these "interactive contexts", it is essential that teachers receive training, demonstrate observation skills, engage in reflective practice, and adopt a proactive approach. In the Italian educational context, this approach represents a means of repositioning workshop teaching as a central component of the curriculum. It offers an innovative and creative methodology through which knowledge and expertise are developed concurrently, thus providing a valuable contribution to the field of education. The implementation of didactic scenarios centred on robotics and educational electronics, logic and computational thinking, manual and digital artefacts, serious play and storytelling will facilitate the development of transferable skills within these spaces (Piano Nazionale Scuola Digitale, 2015).

Recent literature reviews (Tang et al., 2020; Bakala et al., 2021; Lockwood & Mooney, 2017) show how research interest in the field of ER tend to be oriented towards in-depth CT skills and competences or at least programming activities, hands-on exercises, even unplugged, thus oriented towards the development of programming skills and robotics competences. There is a paucity of research exploring the cognitive processes and learning outcomes associated with robotics in early childhood. Furthermore, there is a dearth of studies that have evaluated the

impact of social interactions and shared knowledge in ER, and social construction of knowledge during play with robots (Bakala et al., 2021).

The objective of our research is to develop an observation and design tool for the purpose of studying the interactions of children (aged between 3 and 6 years) with Cubet and Ozobot. The intent is to provide teachers with a tool to facilitate understanding of the cognitive and social dynamics involved in playing with robots, with the aim of constructing a design based on the development of play and experiences. This will be achieved through the utilisation of an observation grid, which will facilitate the codification of behaviours and solutions sought and experienced by children. The objective is to gain insight into the cognitive and social dynamics associated with playing with robots.

2. Materials and Methods

The research started in 2018. The team consisted of Professor Luisa Zecca, the scientific supervisor, together with two researchers and two students, who were involved in various stages of the research development.

The first phase of the research focused on outlining the scientific background and research trajectory. consistent with the theoretical approach of considering robot play as a laboratory education experience, and in line with the aim of investigating the processes at work during robot play, the research developed a multifunctional tool for teachers. This tool was designed to observe children in action during play, investigate their interactions and support the design and evaluation of activities involving toy robots.

The research process was informed by a mixed-coding methodological approach, comprising top-down and bottom-up phases, and concluding with an intersubjective test to evaluate the tool. The field phase was conducted at the Scuola dell'Infanzia Bambini Bicocca and the Scuola dell'Infanzia Maria Bambina di Lissone. A total of 29 children participated in the study, comprising 25 children aged between 4 and 5 years old and four children aged 3 years old. The robots selected for the research were Cubetto and Ozobot due to their tangible programming process and the potential for creating a vast array of experiences with these toys.

Cubetto is a wooden robot measuring approximately 10x10x10 cm. It was designed in 2013 by Primo Toys for use with young children, allowing them to learn to program through hands-on play with a tangible interface. The robot is programmed through the use of coloured coding blocks, which are placed on a physical board according to the commands that the children wish to issue. Each block represents a discrete command, such as “move forward”, “turn left”, or “turn right”. The arrangement of these blocks in sequences enables children to program Cubetto to navigate the space.

Ozobot is a small programmable robot that was first introduced to the market in 2014 by Evollve Inc. It was designed and created for use in an educational setting and is intended for children between the ages of 4 and 13. The device offers a variety of programming options, including Color Programming (suited for younger children and used in this study) with a tangible interface, where users draw colored lines on a clear surface to create a program; as well as Application Programming and Block Visual Programming, which employs platforms like OzoBlockly (block-based programming).

The overarching research question was to identify the types of problems children encounter during play and the strategies they employ in addressing these challenges (heuristics). In order to gain an understanding of the concepts of “problem” and “heuristic” a review of the relevant literature was conducted following the question:

Q1 *What is meant by problems and heuristic processes in children's play with robots?*

This top-down phase enabled us to ascertain the scope of application of the two concepts. The concept of 'problem' that informs this study is defined as a situation in which there is a discrepancy between the current state and the desired future state (Robertson, 2017). In particular, this occurs when the objective is to achieve a goal through a specific action, but the

method of achieving it is unclear. In instances where the desired outcome cannot be achieved through direct action, the mind is employed to devise a solution. This solution is typically presented as a series of strategic and planned actions, which are deliberately organised to reach a goal or solve a problem. This involves identifying potential courses of action that can bridge the gap between the current situation and the desired result, according to a specified criterion and method. In this study, the criterion in question is referred to as 'heuristics' (Aiello, 2001).

A number of categories of heuristics were derived from the literature review, with the work of Gaudiello and Zibetti (2013) and Gabriele and colleagues (2017) appearing to be particularly meaningful in classifying the strategies implemented by children when playing with robots:

1. A procedure-oriented heuristic is a solution-focused strategy that is task-oriented. It relies on changing parameters through trial and error to arrive at a solution to the problem through implicit reasoning.
2. Statement-oriented heuristics (or declarative-oriented) are problem-focused and knowledge-driven. They seek information about the rules of the task and only solve the problem once the task is fully understood. It involves applying individual actions to seek information about the rules of the task. The solution to the problem is only reached once the task has been fully understood.
3. Heuristics oriented towards metacognition are also focused on the problem, guided by awareness. They involve a combination of trial and error and logical reasoning, which is used to identify task limitations and to assess the individual's understanding. Metacognitive-oriented heuristics (problem-focused) are driven by awareness and involve the application of actions. The process entails a combination of trial and error and logical reasoning, which is utilised to ascertain the limits of the task and to evaluate the individual's comprehension. The debugging process encourages a reflective approach to programming, facilitating the gradual development of coding skills and the formulation of heuristics based on syntactic and semantic/logical knowledge.

The aforementioned definitions were instrumental in the construction of a grid for the interpretation of the observed play experiences in the bottom-up phase of the study.

The bottom-up phase entailed the identification and elaboration of specific categories for the labeling of articulations of thoughts and interactions during play with Cubetto first and then Ozobot. A quasi-experimental protocol was employed to refine the categories of problems and heuristics related to playing with robots. The aim was to construct a classification of problemsolving strategies employed by children during programming activities with the robot in question. The objective of this contribution is to present the refinement of the categories that emerged from playing with Cubetto and were adapted for the observation of interactions with Ozobots. A total of seven non-consecutive hours of video recordings were conducted of children aged between three and six engaged in playing with the robots in their natural environment, either independently or in social groups, the recordings were transcribed in their entirety, providing a comprehensive account of the problems encountered and the resolution strategies employed by the children. From the theoretical constructs of heuristics and problems, we found descriptors of behaviour that we looked for in the analyses of the videos, the ELAN 5.3 software was employed as a tool for the analysis, enabling annotations to be made by selecting the specific fractions of a second during which a particular behaviour occurred. The collected data were then subjected to qualitative analysis using a thematic approach, which resulted in the generation of behavioural descriptors (items). Subsequently, a grounded methodology was employed to group the descriptors according to similarity, with the objective of accurately describing a specific type of event while maintaining the possibility of referring to more than one situation. The items were identified through an intercoding process between two researchers who conducted a bottom-up analysis of the same game situations independently. The results demonstrated a compatibility level of 80% in the coding of the same behaviours. The items that exhibited compatibility with an inter-subjective interpretation process were selected. Ultimately, an observation grid was constructed based on the selected items, which was employed to code and inter-code the behaviours and to highlight the relationships between these and between strategies and problems/objectives. The grid is currently undergoing a testing phase to ensure its validity.

3. Results

In line with the objective of our study, which was to investigate complex problem-solving processes, the results of the investigation concentrated on the emergence of game heuristics (criteria guiding the subject in the choice of strategy) and problem-solving strategies. The bottom-up process resulted in the identification of specific types of problems and corresponding heuristics, which can be employed to describe the behavior observed in the game with both types of robot.

The analysis of the data obtained from the grid led us not only to classify different categories of problems and strategies (as discussed below), but also to distinguish between different levels of problems that emerged from the videos. All problems and related sub-problems were categorized according to the nature of the problem the subject was attempting to resolve. In order to facilitate the analysis of the data, a set of categories and descriptions have been defined. These categories are both general and specific, accurately describing a specific type of event while allowing for the possibility of referring to more than one situation, as can be observed in the table below (Table 1). The categories afforded the differentiation of a broad spectrum of issues encountered during the course of robotic programming. The differentiation was based on the initial identification of a general problem, defined as the goal (problem n°), and the subsequent emergence of several sub-problems of varying natures during the activity. The initial stage will entail comprehension of the movements the robot must undertake to achieve the desired outcome, which may be conceptualised as a 'movement problem'. Subsequently, the child will be required to select the appropriate codes that enable the robot to execute these movements, which may be conceptualised as a 'programming problem'. Finally, the child will need to understand how to act upon the code, which may be conceptualised as a 'tangibility problem'. Subsequently, the child must verify whether the constructed program is indeed the one that will bring the robot to the goal (verification problem).

Table 1 – Problem Type and Definition.

Problem Type	*Description*
Goal-setting problem	Possibility for children to propose the structuring of the problem (problem posing) in complete autonomy.
Movement mode problem	Problems related to understanding how the robot moves to perform the task/achieve the goal.
Programming problem	Problems strictly related to code construction, how to choose which codes to use, how to modify the program, how to complete the program.
Verification problem	Problems concerning the verification of the constructed program.
Direction problem	Problems concerning the direction in which the robot moves (left or right, forward or backward, choice when faced with a fork in the road).
Error detection problem	Problems in which the child has to detect an error that has been made.
Tangibility problems	Problems encountered in carrying out the physical actions necessary for the robot's operation (e.g. for Cubetto to fit the control blocks into the appropriate holes on the dashboard, for Ozobot to correctly manipulate the appropriate felt-tip pens to draw the lines of the appropriate thickness)

A variety of strategies are employed in response to the diverse challenges that children may encounter. These strategies, which are referred to as heuristics in accordance with the theoretical definition utilized, are behavioral descriptions that are precisely delineated with respect to a specific action, while allowing for the possibility of being applied to multiple situations, as evidenced in the following table (Table 2).

The observations revealed a variety of heuristics employed by the children during their interactions with the robots, thereby demonstrating the diversity of problem-solving strategies utilized. The data analysis defined the strategies related to solving the target problem by analysing each strategy used in solving sub-problems derived from the main problem. The wide range of heuristics that emerged highlights the children's ability to use varied and creative methods to solve the problems encountered. In certain instances, it was not possible to encapsulate the children's problem-solving strategies within a single definition. The analysis of the data revealed that problem-solving can occur through the utilisation of a complex strategy, which can be observed by breaking down the deployment of a multitude of strategies into micro-behaviours, adapted to the specific circumstances presented by the problem. It is essential that the observer breaks down the sequence of actions into micro-behaviours in order to gain an understanding of the general heuristics.

The purpose of utilising the observation grid is to facilitate the observation of interactions occurring throughout the entirety of the play sessions in question, employing a quasi-experimental protocol. The tool is currently being refined in a number of contexts, both in terms of its capacity to identify the processes that occur and its potential to support the adult observer in designing playful contexts for experimentation and learning.

Table 2 – Heuristic Type and Definition.

Heuristic Type	*Description*
Observational-intuitive strategy	Choices made through observation, guessing what to do to achieve the goal.
Decomposition strategy	Decomposition of a general problem into several parts or sub-problems.
Mental simulation	Adoption of a mental representation of the robot's movements.
Physical-body simulation	Problem solving through body movement.
Direct verification strategy	Verification of programming through robot movement.
Verbal simulation	Verbal explication of the movements required to achieve the goal.
Strategy of indifference to the problem	Various heuristics guiding reasoning in the presence of indifference to the problem.
Listening strategies	Solving the problem by listening to the instructions given by the guide.
Pattern imitation strategies	Achieving the goal by imitating the actions produced by another.
Asking for help	Strategy in which the child asks the guide or a companion for help in solving the problem.

3. Conclusion

It is widely acknowledged that an important yet challenging professional attitude is the ability to demonstrate one's own thoughts and expectations in a way that is transparent and conscious. This enables an objective observation of the children's thought processes and progress, rather than allowing preconceptions to influence this process. Such awareness allows educators to identify the multiple potential avenues and to avoid the assumption that their own line of thinking is the sole viable solution. The observational grid is an effective instrument for this purpose, as it directs the teacher's attention towards discerning the types of processes the children are currently engaged in. By directing the teacher's attention to discern the types of processes in which the children are currently engaged, the observation grid acts as a tool to support educational planning, because it is able to highlight the children's points of interest.

The majority of CT assessments focuses on students' abilities in relation to programming and the utilisation of computers. It is common practice to evaluate CT skills using traditional tests and performance assessments (Tang et al., 2020). In contrast to traditional performance-focused

evaluations (Bakala, 2021), our analysis prioritises an understanding of the cognitive processes underlying children's behaviour when playing with robots. This is accomplished through a comparative analysis focused on the transversality of events and situations, as opposed to the level and capabilities achieved. This is done in order to make it a tool for observation, documentation and the design of teaching activities. In alignment with Papert's (1980) constructionist perspective, which views robotic technologies as "objects with whom to think", engaging with robots offers a chance to examine metacognitive reflection (awareness of one's own cognitive processes), "aloud" reflection, and collaborative intelligence (Martinez, 2006).

This study aims to make a contribution to the existing literature on preschool educational robotics. It offers an analysis of the cognitive processes and social dynamics involved, and provides a framework for future research that can further explore the interactions between children and robots in natural educational settings. The observation grid developed can be adopted and adapted in different educational contexts, thereby contributing to the standardisation of formative assessment tools. The study identified specific types of problems and related heuristics that children use during activities with robots. These categories serve as a framework for understanding the diverse problem-solving approaches that children use during play. The behavioural descriptions derived from this analysis are both general and specific. They provide a clear and accurate depiction of certain types of events while remaining flexible enough to apply to various situations that may arise. This dual nature of our descriptions ensures they are robust and versatile, facilitating their use in different educational contexts. The constructivist approach, when applied to the field of educational robotics, has the potential to foster the development of a number of key skills, including technical abilities, metacognitive capabilities and collaborative competencies. These skills are widely acknowledged as being essential for meaningful and lasting learning. The implementation of teacher training programmes based on the findings of this study has the potential to enhance the efficacy of educational robotics activities within educational settings.

The limitations of our study, which may provide avenues for future research, include the following:

- The sample size (29 children) and the type of robot (two tangible programming robots) may limit the generalisability of the results. Further studies could expand the participant base and include different types of robots to compare interaction dynamics.
- The complexity of the robotic interactions and the variety of observed behaviours may require further research to deepen the understanding of heuristics and problems.

The future direction of the observation grid is to refine and experiment with teachers with the objective of deliberately designing teaching activities in accordance with an understanding of the cognitive, motivational and engagement processes that underpin learning. Indeed the approach expressed in this study facilitates the integration of research and practice, providing meaningful and quality experiences for early childhood education and care through robotics. It enables the development of design strategies, observational postures, and documentation tools that support teachers' professional role and action in the educational contests.

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The influence of preschool teachers' emotions and digital technologies in the educational context

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Abstract

The integration of artificial intelligence (AI) and digital technologies in educational settings is profoundly transforming the school system, offering new opportunities as well as complex challenges. This study aims to explore the influence of preschool teachers' emotions on the adoption and use of these technologies. By analyzing a sample of 90 teachers, the relationship between emotional management, attitudes towards technology, and the impact on students' educational experience was investigated. The findings suggest that emotionally competent teachers more easily integrate digital tools into their teaching process, enhancing students' socio-emotional wellbeing. However, significant gaps in teachers' continuous training on emotional and technological skills emerge. The article highlights the need for specific training programs to promote effective emotional management and the sustainable integration of digital technologies in educational practices.

Keywords: Emotions, Technology, Teachers, Learning, Training.

1. Introduction

The integration of Artificial Intelligence (AI) in educational contexts represents an unprecedented challenge and opportunity for the contemporary school system. The ability of AI-based technologies to personalize learning, to offer educational resources tailored to the students and optimize teaching management is revolutionizing the way we conceive of education. However, in addition to the advantages related to personalization and flexibility, the introduction of advanced technological tools raises a series of issues regarding emotional interaction and educational relationship between teachers and students, an aspect that deserves particular attention for its ability to profoundly influence learning dynamics.

The growing use of Artificial Intelligence in education not only redefines the traditional roles of teachers but can also change the way interpersonal relationships are built in classrooms. Technology, in this context, is not a simple tool, but an active agent that intervenes directly in the educational relationship, shaping teachers' and students' perceptions of learning and teaching.

Our study fits into this context of growing interest, with the aim of contributing to an in-depth analysis of the role of emotions in technological mediation within educational practices. This is a research based on a data matrix, started in 2023, which involved a significant sample of about 90 preschool teachers. These teachers, active in a particularly sensitive context such as early childhood, represent a fundamental sample for understanding how emotions and technologies intersect in shaping the educational experiences of the youngest.

The survey, conducted through structured questionnaires, has as its main objective the analysis of teachers' emotional behaviors, the emotions that they activate within educational contexts and their attitude towards technologies during the training process. The data collected allow us to deepen the interaction between teachers and AI, not only in terms of usability of technologies, but also from the point of view of the affective and relational dynamics that emerge from the use of digital tools. In particular, our focus on teachers' emotions is based on a growing awareness in scientific literature that underlines how emotions are central to the learning and educational mediation process (Holmes et al., 2023).

The approach adopted is ecological in nature, in the sense that it does not limit itself to analyzing the impact of technology in isolation, but considers the entire educational ecosystem. This

includes the physical environment, technological tools, social dynamics and, above all, the emotions of the subjects involved in the educational process. According to the ecological approach, emotions are not only passive reactions to external events, but represent an active and fundamental component that shapes the behavior and decisions of individuals, especially in learning contexts. Previous studies, such as those by Zawacki-Richter et al. (2019), have shown that the effective integration of digital technologies in education cannot ignore a deep understanding of the emotional interactions between teachers and students.

The concept of “technological mediation” is central here: AI is not seen as a simple passive tool, but as an element that, in its interaction with the teacher, can profoundly influence the educational experience. The emotions activated by such interactions can influence not only the way teachers use technology, but also the type of relationships they establish with their students. It is essential to understand to what extent teachers welcome or reject AI in their daily practices, and how their emotions, positive or negative, can influence this process. Studies by Adams et al. (2022) have highlighted how teachers' emotions can act both as barriers and facilitators in the adoption of new technologies in the classroom.

Another key aspect of our research concerns the relationship between emotions and continuous digital learning. Lifelong learning is a fundamental goal for contemporary education, and AI can certainly facilitate this process. However, for this to happen effectively, it is necessary to understand how emotions influence teachers' attitudes towards continuous digital learning. In other words, exploring the role of emotions allows us to assess how teachers can promote a responsible and conscious use of digital technologies, not only in their daily practices, but also in lifelong education.

The adoption of sustainable and digitally integrated educational practices requires not only technical skills, but also a deep understanding of the emotional dimensions that influence learning and teaching. Our study, therefore, aims to provide a broader and more articulated vision of the role of emotions in the integration of digital technologies, offering new perspectives for teacher training and for the development of educational practices that are truly inclusive and sustainable. The contribution of this research is part of an increasingly current debate on the future of education in the digital age, helping to outline a more complete and multifaceted picture of the relationship between emotions, technologies and continuous learning.

This research does not intend to limit itself to a simple quantitative analysis of the answers provided by teachers through questionnaires, but adopts a perspective that aims to understand in depth how emotions can act as a lever for the improvement of educational practices in the digital age. The aim is to investigate the interactions between emotional dimensions and the use of advanced technologies, with the intent of exploring how such interactions can positively influence the educational process, promoting a more inclusive and sustainable learning environment.

2. Methodology

This research focused on the analysis of the interaction between teachers' emotions and the use of digital technologies in the school context, with a focus on how these factors influence the learning process.

The main research question is: How do teacher’ emotions and use of digital technologies influence students' educational experience in preschool? To answer this question, a mixed approach was used, with the integration of a quantitative survey through a self-structured questionnaire distributed on paper and pencil, then proceeded to the data collection and statistical survey, followed by the interpretation of the data, which were collected among 90 preschool teachers in 2023. The questionnaire explored aspects related to the management of emotions, the use of digital technologies and the perceptions of the impact of these factors on teaching and on the socio-emotional well-being of students.

3. Search Results

The sample is strongly skewed towards female presence, with 87% of teachers identifying as female, compared to 3% of men (Figure 1). The gender distribution has an average of 30 participants per category, with a strong imbalance towards female presence. The standard deviation is 49.39, reflecting the strong disparity between males and females. The average age of participants is 18 years of work experience for the age group surveyed, with a standard deviation of 23.18. Most participants fall within the 36 to 55 age group, with a maximum peak of 58. Turning to the age distribution, the average shows a prevalence of teachers who are in the intermediate age groups, in particular between 36 and 55. This suggests that the sample is largely composed of professionals with solid experience, probably reflecting a certain stability in the education sector. The rather high standard deviation nevertheless suggests a certain heterogeneity, with teachers distributed across a diversified age range.

The majority of the sample has qualifications other than bachelor's and master's degrees. The average is 22.5 participants per qualification, with a strong standard deviation of 35.20, due to the predominance of those with an "Other" qualification. This data is in line with the trends in the educational sector, where women historically represent the majority in the role of teachers, especially in preschools. The absence of participants who identify as "Other" in gender could indicate a lack of gender diversity in this specific educational context, or the reticence to express a gender identification other than the binary one.

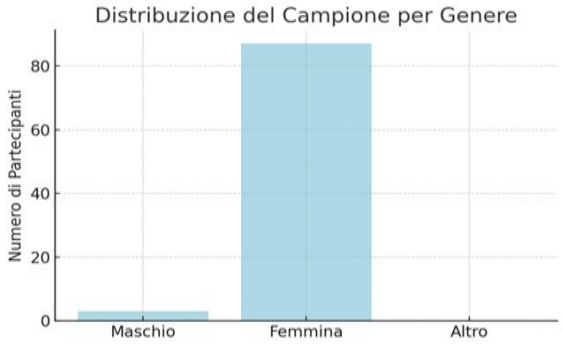


Figure 1 - Distribution by gender (Male, Female, Other).

The majority of the sample (75%) declared to have a qualification (Figure 2) that is not included in the Bachelor's, Master's or Doctorate degrees, indicating that many teachers may have specific diplomas or professional certifications, therefore a training more focused on educational practices or on the particular requirements for teaching in preschools is outlined. If the percentage of teachers with Bachelor's (9%) or Master's (6%) degrees is rather low, while none declared to have a Doctorate, suggesting that the level of higher academic specialization is not a common prerequisite for teaching in this context, but could represent an opportunity for the future development of advanced educational skills.



Figure 2 - Distribution by educational level (Bachelor's Degree, Master's Degree, Doctorate, Other).

In relation to educational qualification, the data reveal a predominance of non-academic educational paths, classified as "Other", compared to bachelor's, master's or doctoral degrees. This could indicate that many of the teachers interviewed have undertaken professional training paths or specific certifications rather than traditional academic paths. The strong standard deviation in this case highlights a significant diversity in educational levels among participants, suggesting that educational qualification varies considerably within the sample.

The geographical distribution (Figure 3) of participants shows a predominance of teachers from large cities such as Rome, which represents 20% of the sample. Marcianise and Naples follow with 10% and 8% respectively. This data suggests a greater participation of teachers from urban and semi-urban areas, probably due to a greater diffusion of schools and educational resources in these areas. Smaller cities, such as Viterbo and Terracina, represent a smaller percentage, reflecting the lower population density or the different distribution of school facilities.

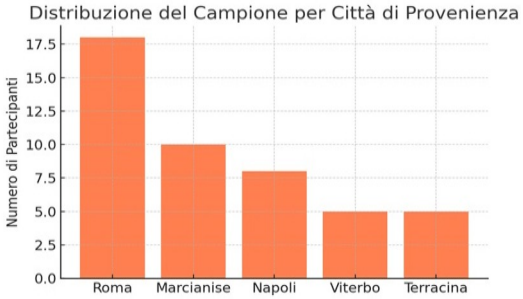


Figure 3 - Distribution by city of origin.

Participants come mainly from cities such as Rome, with an average of 9.2 participants per city and a standard deviation of 5.36. Rome represents the maximum with 18 participants, while smaller cities such as Viterbo and Terracina have the minimum number (5). Rome appears to be the city with the highest number of teachers involved, followed by other locations such as Marcianise and Naples. However, the lower standard deviation compared to the other variables suggests a more homogeneous distribution of participants across cities, which makes the sample quite representative of different geographical areas.

From the results of the questionnaire (Figure 4), 98% of the teachers interviewed stated that emotional self-awareness is "very important" for their professional role. 96% indicated that they possess high emotional management skills. Furthermore, 84% of teachers believe that the integration of digital technologies has a significant impact on improving the personalization of learning, while 59% of the interviewees consider technologies an important means for managing the different needs of students.

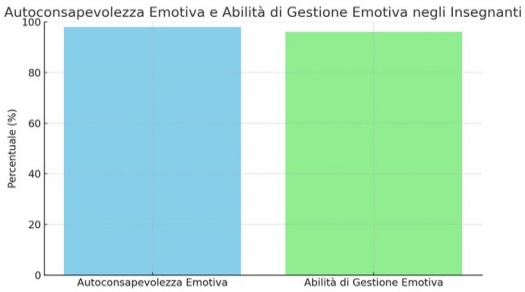


Figure 4 - Emotional self-awareness (left) and emotional management skills (right).

In terms of socio-emotional impact (Figure 5), 64% of teachers reported an increase in student well-being after introducing technology-supported emotional management strategies. However, 53% of respondents indicated that they faced challenges in integrating technology into their teaching practices, mainly due to a lack of resources or adequate training.

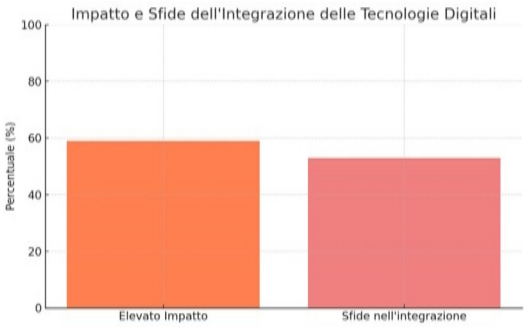


Figure 5 - High impact (left) and challenges in integrating technology (right).

The graph on continuous and specific training (Figure 6) shows that a significant part of the sample (53%) does not regularly participate in continuous training programs on emotional skills, while 47% has not received specific training on how to integrate these skills in the role of educator. These data highlight an important training gap, despite the growing importance of emotional skills in the educational context.

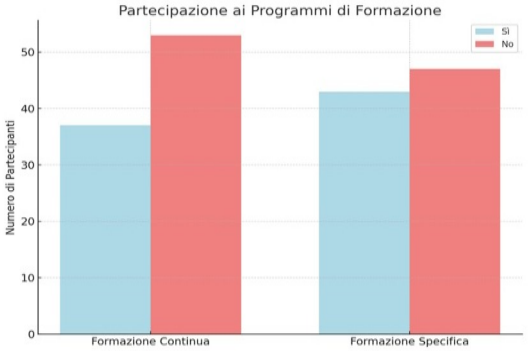


Figure 6 – Continuous training programs (left) and specific training (right) – yes/blu, no/pink.

The self-assessment of emotion management skills shows (Figure 7) that most teachers (79) believe they have a good ability to manage their emotions, with a few placing themselves at lower levels. This could indicate a fair amount of emotional awareness and mastery, although it is necessary to consider how the lack of specific training could limit further developments in this area, or in any case this finding generates perplexity. In fact, although the participants perceive themselves positively, they also express the need to increase the opportunities for continuous and specific training to consolidate these skills in educational practice.

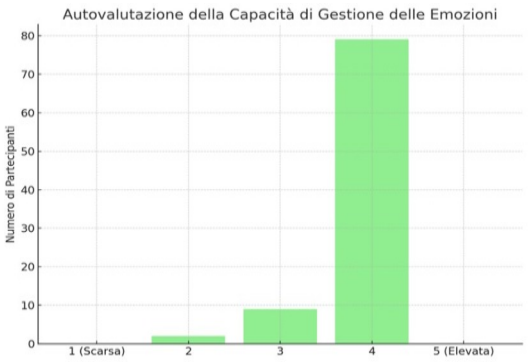


Figure 7 - Continuous training programs (left) and specific training (right) – yes/blu, no/pink.

Forty-seven percent of teachers reported collaborating with colleagues or parents to address student emotional issues, while 43% had no such experience (Figure 8). This data highlights that, although there is a good portion of teachers engaged in collectively managing student emotions, there is still a significant number of teachers who do not benefit from this type of collaborative support.

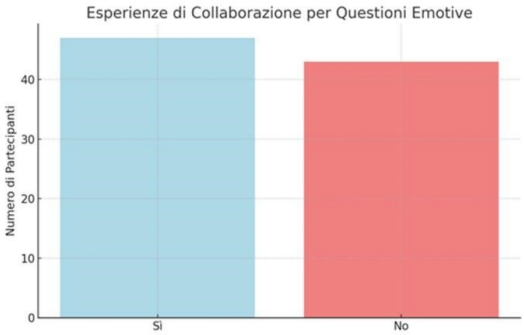


Figure 8 – Collaborative support – yes/blu, no/pink.

The majority of the sample (54%) considers the main role of emotional skills (Figure 9) to be that of promoting a positive learning environment, followed by improving the classroom climate (21%) and improving the relationship with students (15%). These results suggest that teachers see emotional skills as a key tool for creating more harmonious and inclusive educational contexts, rather than limiting themselves only to improving interpersonal relationships.

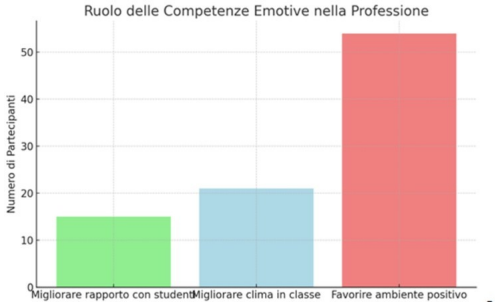


Figure 9 – Role of emotional skills (improving the relationship with students and the classroom climate, promoting a positive learning environment).

Significantly, 49% of teachers are not familiar with specific theories or approaches to managing emotions in the classroom (Figure 10). Lack of familiarity can hinder the effectiveness of strategies used in the classroom, making it difficult to adequately address students' emotional challenges.

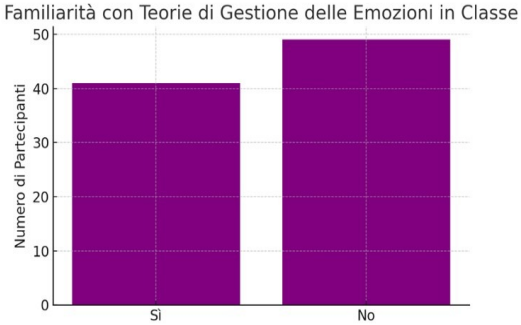


Figure 10 - Familiariaty with specific theories or approaches to managing emotions in the classroom (yes/no).

The data (Figure 11) show that a large majority of teachers (56 out of 90) believe that their initial training has adequately addressed the emotional skills needed for their role. This reflects a positive initial preparation for a large part of the sample. However, a non-negligible number of participants (9 and 19 for assessments 2 and 3) perceive a lack in this area, indicating that for some the preparation may not have been sufficient.

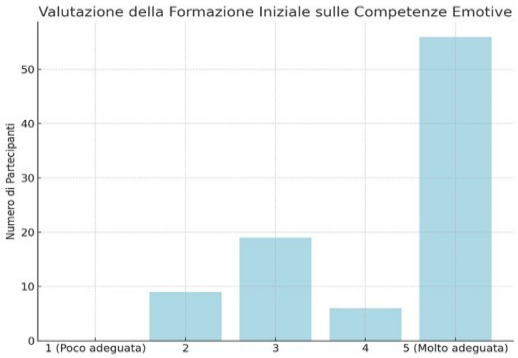


Figure 11 – Adequacy of previous training on emotional skills.

Sixty-four percent of teachers noted an improvement in students' social-emotional well-being (Figure 12) after implementing specific emotion management strategies, compared to 26% who did not see any significant changes. This finding suggests that introducing targeted emotional management practices can have a positive impact on student well-being, although not all teachers observed the same results.

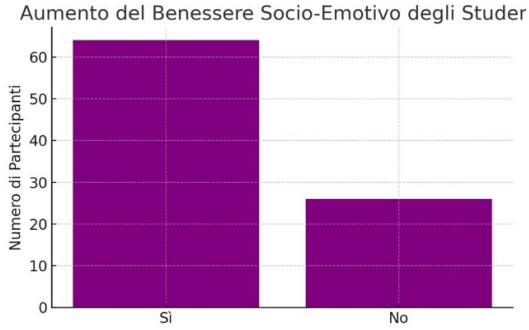


Figure 12 – Improvement in students' social-emotional well-being (yes/no).

The data suggest a general awareness of the importance of emotional skills in education, but also underscore the need to provide adequate resources and ongoing training to support teachers in this area. Through its ability to provide immediate feedback and adapt to individual student needs, ChatGPT promotes flexible and person-centered learning.

4. Discussion of research results

The exploration conducted offers an interesting and detailed picture of the characteristics of the sample, highlighting a clear female predominance and a significant variety in the training paths. The geographical distribution appears more balanced, with a good representation of teachers from different locations. These observations provide a valuable context for interpreting the research results and the dynamics that characterize the education sector.

The results highlight a strong relationship between teachers' emotional management and the effectiveness of the use of digital technologies. In particular, teachers who feel emotionally competent tend to integrate technologies more effectively into their daily practices. Emotional awareness seems to act as a facilitator in the adoption of digital tools, since teachers who are more confident in their emotional skills are also those who report fewer difficulties in using such tools.

An interesting aspect that emerged from the research concerns the role of empathy: 92% of teachers indicated that empathy is a crucial element in their profession, which suggests that a greater emphasis on emotional training could lead to an improvement in technological interactions in the classroom. Although emotional skills are recognized as fundamental to improving the

educational climate, there is still a gap in specific training and in the dissemination of structured theoretical approaches for the management of emotions in the school environment.

5. Conclusions

Research suggests that effective integration of digital technologies in teaching is deeply influenced by teachers' emotional skills. Emotions act as a mediating factor in managing technologies in the classroom, and greater awareness and emotional skills translate into easier adoption of digital tools. These findings highlight the importance of providing ongoing training to teachers not only on technologies, but also on emotional skills to improve educational effectiveness and student well-being. For future research, it is suggested to expand the sample to include teachers of different school levels and to further explore how different socio-demographic variables (age, years of experience) influence technology integration and emotion management. Furthermore, it would be useful to investigate the effectiveness of specific training interventions to improve both teachers' technological and emotional skills.

Authors' contribution

For purely formal attribution purposes, Sara Pellegrini is considered the primary author of paragraphs 2 and 3; Riccardo Sebastiani is considered the primary author of paragraphs 1, 4, and 5.

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Enhancing the CME-Continuing Medical Education: an engaging and effective MOOC experience at the University of Turin

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Abstract

Online Continuing Medical Education (CME) offers an appealing and effective learning avenue, thanks to its accessibility and flexibility, allowing learners to engage from anywhere, at any time. Massive Open Online Courses (MOOCs), with their diverse content offerings including video lectures, interactive modules, assignments, and online discussions, have garnered significant interest in the health and medicine domain. As a result, reputable institutions increasingly offer MOOCs through various online platforms, both commercial and non-commercial. The University of Turin has been providing CME since 2013, offering a wide range of training programs hosted on the Moodle platform. In 2021, the University launched a MOOC titled 'The Six Pillars of the UN Decade Against Malnutrition', developed by the e-learning team. This course, conducted in Italian, comprised eight modules with progressive access. Learners were required to complete a self-assessment test at the end of each module to advance to the next stage. To enhance course engagement, video animations and interactive activities were integrated as learning props. The MOOC commenced in November 2021 and concluded in November 2022, attracting 54,462 learners with a retention rate of approximately 77%. A Likert survey was used to gauge learner satisfaction, revealing overwhelmingly positive responses regarding the relevance of the topics, the quality of course instruction, and the value for lifelong learning.

Keywords: Continuing Medical Education, MOOCs, Lifelong Learning.

1. Introduction

Medical education is an arduous process with widespread study of very complex information across diverse subjects. In this regard CME- Continuing Medical Education bridges the gap between academic research and clinical practice, providing physicians with a well-balanced education consistent with the patient's needs and evidenced-based medicine (Setia et al., 2019, pp.805-812) Two of the main issues of CME arise from the teaching methods used and from the access to training.

In his review Bloom (Bloom BS, 2005, pp.380-385) examined the effective teaching approach, from most to least, used to conduct CME. He reported that interactive techniques show the most effective results on improving medical education, while passive ones, such as didactic presentation, printed education materials, conference or other in-person meeting, demonstrated less beneficial effects. As for the access to training, fee, traveling cost and time consuming can exert a negative impact on course attendance.

Online Continuing Medical Education (CME) offers an appealing and effective learning avenue, thanks to its accessibility and flexibility, allowing learners to engage from anywhere, at any time. Moreover, in the last years, technology improvement has allowed teachers and formers to create engaging and effective learning experiences.

Massive Open Online Courses (MOOCs) are a form of online learning where courses are accessible at little or no cost, without limits on participant numbers or prerequisites. Thanks to their peculiarities, such as the easy accessibility and capability, the availability of different contents (i.e. video lectures, interactive e-Learning modules, assignments, online discussion,

etc.), MOOCs have attracted interest both from universities and from businesses, particularly for adult lifelong learning. As a result, reputable institutions increasingly offer, in the area of health and medicine, MOOCs through various online platforms, both commercial and noncommercial.

The University of Turin has been a CME provider since 2013, offering a wide range of training programs hosted on the Moodle platform.

2. Materials and Methods

In 2021, the University launched a MOOC titled 'The Six Pillars of the UN Decade Against Malnutrition', developed by the e-learning team.

This course, conducted in Italian, comprised eight modules with progressive access. Learners were required to complete a self-assessment test at the end of each module to advance to the next stage. For the purpose of self-assessment, the multiple-choice Moodle quiz was selected. The eighth modules are:

1. The UN decade on nutrition: what is it and why?;
2. Sustainable and resilient food systems for healthy and environmentally friendly diets;
3. Aligned health systems ensuring universal coverage of essential nutrition actions;
4. Social Protection and Nutrition Education;
5. Trade and investment to improve nutrition;
6. Creating enabling environments for local food systems, including fostering breastfeeding;
7. Review, strengthen and promote “Governance” in nutrition;
8. The Mediterranean diet: an age-old example of healthy and sustainable nutrition.

The eight modules are shown in Figure 1.

Each module starts with a video introduction. In order to make the course more appealing and incentivize attendance, the animation format was chosen: two avatars, a doctor and a dietist accompany the learners along the learning path. A screenshot of the video is reported in Figure 2.
Other learning props were produced by using H5P, an external plug-in integrated in Moodle. Among the resources available inside H5P, the ‘Course Presentation’ and ‘Interactive Video', shown in Figure 3, were chosen because it enables users to create interactive props.
The former was created integrating slides with audio and multiple-choice quizzes, the latter was used to introduce the case study of three patients.
The MOOC commenced in November 2021 and concluded in November 2022, attracting 54,462 learners with a retention rate of approximately 77%.



Figure 1 - The eight course modules on Moodle.



Figure 2 - A screenshot of the animation video design to introduce the training.



Figure 3 - The eight course modules on Moodle.

3. Results

A survey based on Likert-scale questions (Likert,1932, pp-1-55) each including a 5-point range – was devised with the aim of measuring the learners' satisfaction.

The survey was completed by the 71,52% of the learners revealing overwhelmingly positive responses regarding the relevance of the topics, the quality of course instruction, and the value for lifelong learning.

Concerning the relevance of the topics the 98,72% of learners answered that it was from relevant to extremely relevant, on the educational quality the 90,36% of participants thought that it was from good to excellent and regarding the usefulness the 99,20% of learners found that it was from useful to extremely useful. In the Figure 4 the detailed results of the survey.

4. Conclusions

The MOOC "The Six Pillars of the UN Decade Against Malnutrition," launched by the University of Turin, proved to be a great success in the context of Continuing Medical Education (CME), attracting over 54,000 participants with a retention rate of 77%.

By incorporating interactive elements, animations, and progressive self-assessment tests, the course enhanced user engagement, making the learning experience dynamic and effective.

The final survey revealed a high level of learner satisfaction, with 98.72% rating the content as relevant and 99.20% finding the course useful for lifelong learning. These results highlight the effectiveness of innovative educational solutions like MOOCs in improving access to and the quality of continuing medical education.

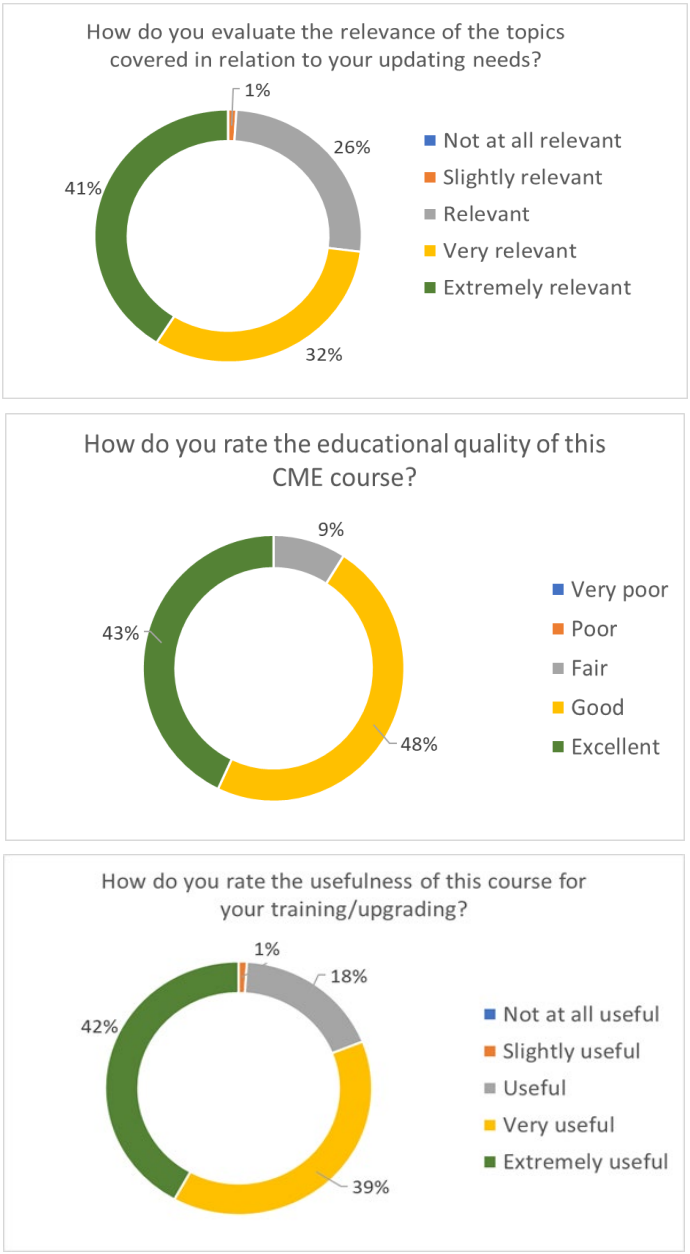


Figure 4 - The eight Detailed results of the survey.

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Enhancing clinical training in pharmacy undergraduate education: improvement of pharmacy students' soft and hard clinical skills

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Abstract

The education and training for pharmacist students in clinical pharmacy, require knowledge, specific skills, attitudes for a professional role, lack practical emphasis. University of Pavia as first integrates real clinical cases and digital education, bridging theory and practice to enhance clinical pharmacy practice education.

We implemented essential clinical pharmacy topics, online lectures, multidisciplinary-team discussion, practice in real-world scenarios, MDT role-play innovative modules (Students of Pharmacy plus Medicine), special digital simulation, Basic-Life-Support-Defibrillation. We tested these methods in teaching-rooms and communities through population screening. This approach connected theoretical knowledge and practical application. The study involved 327 students.

New Courses were introduced equipping students with practical skills for resuscitation maneuvers and cardio-metabolic-cognitive-disability screenings, and in artificial intelligence.

Implementation: Partnerships with European universities and local activities with community pharmacists.

The effectiveness of this innovative approach and satisfaction and knowledge improvement of the students were measured using OSCE, practical tests, student satisfaction surveys, and cost-benefit analyses.

The enrolment of students highlights the program's success.

The University of Pavia stands out as Italy's first institution to integrate certified practical activities, including BLSD, into its pharmacy training, thus setting a new standard in aligning education with the evolving needs of the healthcare sector. The students were satisfied with the mixed activity to bridge the gap between theory and practice. Moreover, our proposal represents an added teaching resource in the pharmacy degree curriculum and is expected to enhance patient safety. The students have perceived the project as effective training considering the achievement of the didactic objectives.

Keywords: Clinical Pharmacy, Soft And Hard Clinical Skills, Clinical Practice, Digital Education In Pharmacy And Pharmacotherapy, Multidisciplinary Team Working.

1. Introduction

In the current scenario, especially after Covid, pharmacy has become the first aid point for the citizen and the pharmacist has taken on the adjective "clinical" becoming a clinical pharmacist.

As the American college states, clinical pharmacy is an area of pharmacy that refers to the rational use of drug specialities (ACCP definition).

In this context, personalised therapy, therapeutic optimisation and pharmaceutical care have therefore begun to be discussed while keeping eyes fixed on the main subject, i.e. the patient.

The clinical pharmacist is thus defined as an expert in specific therapeutic areas with advanced clinical skills who must work as part of an interdisciplinary team with physicians and nurses.

Therefore, the pharmacist needs to acquire hard and soft skills during their education.

Hard skills are all those competences linked to a frontal and transmissive didactics, they are the competences that can be observed such as theoretical notions, linguistic, scientific, computer skills. Soft skills, on the other hand, are all those competences related to communication,

empathy, stress management, emotional intelligence, problem solving, teamwork, critical thinking, decision-making skills and time management.

In general, therefore, the aim is for each student to acquire soft skills. Thus, the focus is on theoretical didactics, leaving room for interactivity, learning through problems and experiences by introducing active didactics.

So, active didactic is introduced and it engages students in an interactive manner, promoting hands-on learning and collaboration. It stimulates critical thinking, creativity and improves understanding and memorisation of concepts.

The objective of an active lesson is to implement in almost experimental and practical terms learning contexts oriented not to the accumulation of knowledge but to the integration of this within engaging and personal, creative and responsible learning experiences whereby the student grows and increases their level of autonomy in the reworking of the acquired content and skills.

This context has led the University of Pavia to propose a new innovative teaching methodology where the teacher's role is “reduced” to that of a facilitator of learning, a mediator, who stands in the middle, between the students and the possible difficulties they may encounter along the path of learning.

The teacher, in short, remains one step behind, to intervene only where necessary to redirect the student, who remains the absolute protagonist of the learning processes.

2. Aim

Thus, the aim at the top of this project is to propose a possible innovative didactic method that includes simulations of potential realities with which the student could be confronted in the future in order to implement the acquisition of the specific skills of the clinical pharmacist.

In this way, each student, within the Pharmacy and Pharmaceutical Chemistry and Technology courses, could acquire soft skills that clinical pharmacists often lack, including communication, leadership, positive attitude and behaviour, management skills, teamwork, self-development, and self-improvement.

3. Materials and methods

Firstly, the university of Pavia proposed a course on minor diseases and remedies, a course on clinical pharmacy skills and gave students the opportunity to be selected for a mixed course in collaboration with the university of Paris Saclay and the Trinity College of Dublin on clinical pharmacist skills.

All these proposed courses were then scheduled: competence objectives were assessed by dividing them into hard and soft skills with respect to the prediction of possible future job scenarios.

Essential clinical pharmacy topics such as patient assessment, medication management and communication skills were then examined in order to assess the structure, organisation and coherence of the project to facilitate a logical progression of learning.

The innovative methodology therefore involved the creation of authentic realities.

The simulation was organised by assessing the realism and authenticity of the scenarios in order to effectively transfer the skills to real situations, which is why the integration of technology with the use of virtual patients and the heterogeneity of the clinical cases was an important factor. The students were involved and then a formative evaluation was carried out.

Simulations were also created through the use of artificial intelligence with the software my dispense. ‘My dispense’ is a software created by Monash University that creates pharmacy simulations using 760 virtual prescribers, 3771 virtual patients. The student, therefore, can develop dispensing skills in a safe environment where they can make mistakes without the serious consequences of the real world.

In addition, there were interdisciplinary role-plays where one student had the role of the pharmacist, one of the physician, one of the patient and one of the caregiver. In addition, there was a student observer who evaluated the role play and whether the colleagues achieved the set training goals e.g. on the communication level, the observer evaluated whether the pharmacist and physician colleagues were able to interact with each other in a constructive manner, whether they were able to make themselves understood by the patient in simple language and whether the patient/caregiver was comforted.

It was also important to offer practical courses where it was explained how to measure blood pressure, blood sugar, how to do an electrocardiogram, how to resuscitate a person, how to administer a vaccine.

At the end of the practical training courses, a cardio-metabolic-cognitive screening of the population was organised in order to do prevention, optimise treatment and offer the student a concrete reality by acquiring experience and skills.

The screening involved the analysis of 200 people. Different stands were organised according to the analysis performed. Patients then went to each stand where they were greeted by a pharmacy or medical student who performed blood pressure, blood glucose, cognitive or frailty tests and an electrocardiogram.

The evaluation for the attainment of competence goals included the OSCE assessment.

The OSCE assessment is an objective and structured evaluation method for assessing actual clinical competence.

So, the students were divided into groups and had to solve a clinical case.

In this way, each student had to demonstrate specific skills in a simulated work environment with standard situations. In order to offer this type of evaluation, it was necessary to choose a specific environment, provide the students with the necessary information and evaluate the achievement of the objectives defined in advance.

The assessment at the end of the blended course was able to enable the students to obtain specific micro-credentials (My Open Badge) for the skills acquired during the training course.

4. Results and discussion

In this context, several critical points were noted by observing the students.

The first critical point to be observed, on which immediate action needs to be taken in order to achieve the skills required by the pharmacist's current role, is communication. The students had a lot of trouble relating to their colleagues, using language that the patient and the operator could understand. Furthermore, the students had great difficulty in linking theory with practice in order to propose dosage changes, assess drug-drug or drug-food interactions and possible side effects of the drug. Finally, an easily solved critical issue was the identification with the real role assigned during the role play.

This project therefore led to emphasise an important need to move away from frontal and transmissive teaching to promote interactive lessons in which the student becomes an active participant and can stimulate his or her own critical thinking and put the theoretical notions acquired into practice. For this reason, it was very useful to solve simulated clinical cases and to introduce an active assessment method in which the lecturer can evaluate the learner's real skills while working.

The importance and willingness of the students to get involved, learn and acquire new skills was underlined by the number of enrolments: from twenty students in two years to 100 students per year for a total of 327 students in the last years.

5. Conclusions

Therefore, to conclude by defining future prospects, we can say that it is necessary to perfect this new teaching methodology by complementing the old methodology based on the acquisition of hard skills.

First of all, a communication course held by professionals is needed for both lecturers and students who will have to approach colleagues and patients. The introduction of artificial intelligence in the lessons will be crucial, also offering professors training in the use of software. This will facilitate the creation of safe, simulated environments in which students will dabble and learn new practical skills. The focus of the lessons must be on student learning, which must be an active part of the lesson. Therefore, an interactive and hands-on approach is planned, also introducing interdisciplinary courses and role-plays between the pharmacy, medicine and nursing courses. In this way, students, future healthcare professionals, will already begin to change their mindsets and understand the importance of interdisciplinary collaboration. In addition, training and refresher courses will be necessary for both professors and students in order to keep abreast of current working realities.

Finally, it will also be important to compare oneself with the different European realities in order to always question oneself and improve by learning new teaching methodologies, for example, to achieve both hard skills and soft skills, offering and allowing a training that is not just 180 degrees, but 360 degrees, to future healthcare professionals.

Thus, the introduction of a holistic approach to healthcare, emphasising the importance of interdisciplinary collaboration and effective communication for the acquisition of transversal skills is crucial.

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Didactic innovation for the development of skills in clinical pharmacy and clinical pharmacotherapy practice

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Abstract

University of Pavia introduced didactic innovations in its pharmacy and medicine courses to enable the acquisition of clinical skills required by the professional world.
This didactic innovation is based on new organization of the classes (onsite and online) by proposing creation of clinical cases by students to be discussed later in a multidisciplinary-team during a role play.
Therefore, the students are divided into "student's multidisciplinary-teams", composed by patient, caregiver, GP, nurse, geriatrician and pharmacist.
The role-play discussion of the clinical case by the multidisciplinary-team is initiated by interacting proactively with each other, paying attention to the language used towards the patient and caregiver in order to optimise the patient's therapy.
At the end of the interactive critical discussion, the MDT must make a final decision.
Subsequently, the MDT supported by teachers and specialists worldwide might use specific artificial intelligence software to resolve the doubts about the validity of their decision.
In addition, the students are also engaged in cardio-metabolic-cognitive screening of the population, where telemedicine is explored through the performance of the electrocardiogram sent directly to a cardiologist via software applications.
The impact of those methods was observed in the evaluation of the students' skills and the involvement of the teachers digitally.
In the future, we expect that new digital teaching methodologies will be presented through multimedia channels, enabling students to improve knowledge and strategies acquired during their course of study. This will involve evaluating methodologies used by professionals such as pharmacists, doctors, with respect to the presented clinical case.

Keywords: Clinical Pharmacy, Clinical Practice Medicine, Digital Clinicalcases. Digital Education In Pharmacy And Pharmacotherapy, Multidisciplinary Team Working.

1. Introduction

According to the World Health Organization (WHO), Europe has an estimated shortfall of around 1.6 million health and social care workers in 2024 and will be 4 million short by 2030, at which point Europe will be short of 600,000 doctors, 2.3 million nurses and 1.1 million social care staff and assistants (Mantovani & Razza, 2024, Parliamentary question).

Italy has the second-oldest population in the world, with an average age that is the highest of all countries. As of 2024, 24.3% of the Italian population were aged 65 years and older, with a consistently rising trend since 2009. The mean age of the Italian population is 46.6 years, and this figure has been increasing at a gradual rate in recent times [cycles, T. text provides general information S. assumes no liability for the information given being complete or correct D. to varying update; Text, S. C. D. M. up-to-D. D. T. R. in the Topic: Aging population of Italy. Statista].

As a consequence of their advancing age, older individuals frequently require a greater degree of medical attention, frequently from physician specialists. With the advancements in medicine, people are living longer overall and manage more chronic conditions as they age. Consequently, those who reach retirement age will require healthcare for a more extended period than previous

generations. This growing need for gerontologists and other specialists is a significant factor contributing to the shortage of general care doctors to serve the rest of the population. Accordingly, the shortage of health workers is becoming increasingly relevant.

This issue is global: the American Association of Medical Colleges (AAMC) predicts a shortage of as many as 122,000 physicians by 2032. The report that made this dire prediction also pointed out that the over-65 population will grow by 48% by 2032. Unfortunately, many working physicians will also be reaching retirement age along with the rest of the Baby Boomers (The Shortage of Healthcare Workers in the U.S. Duquesne University School of Nursing).

While the quantity of health professionals is a pressing concern, the quality of these professionals is also a significant determinant of community health.

Competence plays a great role in improving the quality of health care (Shahrbabaki et al., 2020). Unsafe health practices are one of the leading causes of disability and even death. Competent health professionals are crucial to ensure safe and high-quality healthcare services. It is estimated that the chance that unsafe practice can cause harm for the patient is 1 in 300 chances. Nearly 400,000 deaths occur annually in the United States due to several reversible adverse events, such as medication error, infection transmission, and fall events (Zaitoun et al., 2023).

In order to enhance the competence of medical and pharmacy students, who will become the future health care workers, the University of Pavia has introduced a didactic innovation in its pharmacy and medicine courses. The university was one of the first Italian universities to introduce didactic innovation in these courses to allow students to improve the theoretical knowledge learned during their studies and apply them in their practices. This article presents this new didactic activity, consisting in the role play simulation of a Multidisciplinary Team (MDT) confronted to a clinical case. Section 2 presents the aims of the exercise. Section 3 presents the method adopted. Section 4 shows the results of the simulation. Section 5 draws the conclusions and perspectives of this didactic innovation.

2. Aim

The proposed didactic activity was launched by the University of Pavia during the academic course of the faculties of Pharmacy, Chemistry and Pharmaceutical Technology, and Medicine. To define the activity, competence aims (i.e. competence to be acquired by the students during the course) were initially defined as follows: the students should get a chance to learn a new dynamic approach based on interaction and comparison with professors from all over the world. Therefore, in collaboration with the professors, students can assess the skills and knowledge learned during their respective courses while using them to fill in the gaps, so that they are prepared to take action thoroughly in any real-life context. During this study, the importance of “professionalizing and promoting new teaching techniques” is acknowledged which allows the students to obtain the necessary clinical skills alongside theory, research and new approaches worldwide.

The activity was defined to be a role play simulation of a MDT, which simulates a real scenario in which a team of practicians face a clinical case and the corresponding patient. This simulates a real case that the students may go through in the future.

This activity should help students develop communication, problem solving and teamwork skills in a multidisciplinary group.

The didactic activity was proposed to a group of 25 students of the three faculties (Pharmacy, Medicine and Industrial Pharmacy/Chemical and Pharmaceutical Technologies).

3. Materials and method

The teaching activity was planned in three parts, so the students can focus on all the goals. Firstly, a role play simulation takes place, in which students all play the same role, whereas the lecturer plays the role of the patient. In a second part, the students each have a different role and

corresponding information and behaviour to adopt for the role play simulation. In a third part, the students are asked to create clinical cases to be discussed in group. A side activity consisting of an AI-driven simulation online was also presented to the students.

3.1 Standard role play simulation

The first part involved presenting a “case report” using a digital medical record to provide objective and pharmacological anamnesis information about a patient. This enabled students to understand the patient's overall condition and to develop a clinical mind.

The lecturer (the professor) assumed the role of the caregiver. As a general rule, he should assume the role of the patient or a caregiver. Students participated by asking essential questions to establish not only a therapeutic plan but also delve deeper into the medical history. All shared the same role and eventually gave a common diagnosis and therapeutic plan.

During this simulation of interview, the answers and behaviors of the lecturer to the students’ questions were adapted to resemble those of a true patient. For example, to students using too technical terms, the lecturer would hesitate and pretend not to understand. Additionally, the lecturer would feint being worried about the current situation, with quotes as: “Is it severe?” or “Is my father gonna make it?”. As a general rule, in this part the lecturer should, to the most of his capacities, act as the patient would, without trying to help the students in any way the patient would not.

At the end of the interview, students' proposals for the diagnosis and therapeutic plan were compared with the actual actions taken by health professionals in the real case, allowing them to learn from the details missed or mistakes identified. In this explanatory phase, the students and the lecturer also shared their respective feedbacks on the interview.

3.2 MDT role play simulation

The second part of the activity is the true didactic innovation because it involves a real role-play simulation of a multidisciplinary team (MDT) scenario.

Each student was assigned a specific role and provided with a personal script to study privately for 10 minutes before the interview. The roles included in the script were the patient, the patient’s caregiver, general practitioner (GP), the specialist physician, pharmacist, and an observer.

The Patient had the role of empathizing and asking health professionals to explain technical and scientific terms often taken for granted, as developed for the first part. His ultimate objective was to describe the feelings experienced and to assess one’s own involvement.

The Caregiver’s task was to support positively or negatively the patient and health professionals through the use of information, thus simulating a real scenario.

The General Practitioner had the role of first evaluation. It was him that, through appropriate investigations, directed the patient to the specialist. He also had the role of conducting the interview. As a GP, he knew the patient well, having followed him for a long time.

The specialist Physician (in this case a geriatrician) had the role of deepening the diagnostic questions. He was in charge of a recent hospitalization of the patient and had vast knowledge in his field.

The Pharmacist had the role of evaluating the prescribed therapy, with the aim of optimizing the therapeutic plan by minimizing errors, possible ADR, and number of drugs taken.

The Observer had the role of the inspector. This role was unique in that it was totally external, i.e. the person playing this role is not part of the simulation. He was responsible for evaluating the “MDT performance” based on communication, scientific and simplified language for the patient/caregiver, ethics, health comparison and role impersonation. His participation during the interview was allowed for a maximum of three times, in which students involved in the role play could make a break to discuss any issue.

At the end of the simulation, the students shared the feedback over their specific role and their perceived position in the simulation and relations with the other roles. The Observer had the task

to present to the other students the results of his objective evaluation, highlighting the relations between the various roles and proposing possible points of improvement.

As a general rule, the simulation should be repeated several times on various clinical cases so that students can experience all the different roles. The objective is to enable them to, in the future, better empathize with patients, caregivers and colleagues.

3.3 Clinical case elaboration

In the third and final part, each student had to create on his own a clinical case, that could be either real or made up. They then had to create a single Multiple Choice Question (MCQ) related to possible solutions for the improvement of the patient's health. Some students oriented the clinical case and MCQ for example on drugs optimization whereas others focused on patient communication. The clinical cases and corresponding MCQs were then presented and discussed within the group. The objective of this third part was to give students the hand on the clinical case itself to enable them to think not only about the solution but also about the problems the medical team can face. This different approach lead to the students needing and developing a different mindset in confrontation of the problem.

3.4 Perspective for self-exercise of students

During the course of the didactic activity, an online tool was presented to the students. It consists in an AI-driven exercising tool called zorgscenar.io (https://zorgscenar.io/). This tool simulates clinical cases, and allow the students to discuss, through a prompt, with a fake patient.

Its use can provide insights for evaluation of a clinical case and discussion with a patient, allowing the students to feel safe and capable of making decisions and mistakes. Its access is also easier, as it does not require to assemble a group of students.

The use of this tool appears complementary to the MDT role play simulation, as it can be a preliminary tool to enter practical activities and role play simulations, or as a deepening tool after MDT role play simulations done in group for continuous improvement.

4. Results

As said before, this project was one of the first of its kind throughout Europe and the first to take place in Italy.

Thus, several challenges were identified after the role-play simulation, both by the students taking part in the simulation (as Patient, Caregiver, or member of the Medical team), and by the Observer's objective assessment of the role play.

Overall, the main challenges faced related to the communication methods used by the students during role play as Medical team towards "the Colleagues", the Patient and the Caregiver. Four main issues related to communications were defined:

1. The language used by the physicians and pharmacists was too scientific and professional, resulting in a lack of understanding from the Patient and Caregiver, as they were not supposed to know medical terminology.
2. Communication within the Medical team proved also problematic, with difficulties in proactive interaction and idea exchange. Each member of the Medical team showed to be focused on his questions and problematics only, leading to the interview being confused and lacking a logical structure.
3. The discussions and the decisions among the professionals were made in front of the Patient and Caregiver, which caused tension and discomfort in both parties. On one hand, this could lead to the patient feeling neglected by the Medical team, who focused on interviewing the Caregiver, which acted as an intermediary, but did not have exactly the same information as the Patient himself. On the other hand, the Medical team could not evaluate the case thoroughly while the Patient and Caregiver were afraid and nervous.

4. The students taking part in the simulation (not being diplomed practicians) presented knowledge gaps on certain aspects of the evaluation of the clinical case, causing delays in the role play and hindering communication among colleagues.

Communication issues developed above lead to delays and complications in the analysis of the clinical case, drug therapy reconciliation and therapeutic optimization.

Main issue number Four differs from the three others in that it should not present in a real clinical case, due to the knowledge of the practicians in their respective fields. However, it helped the students taking part in the role play to acquire new knowledge, and moreover to understand the benefits of a MDT in compensating one another's lack of knowledge between the different fields.

The objective of simulating a MDT confronted to a clinical case was successfully attained. This showed as the Pharmacist's gaps regarding pathologies and biological values were filled by the presence of the two physicians (GP and specialist physician), and the physicians' gaps regarding drug-drug interactions and adverse drug events were clarified by the Pharmacist. Thus, proactive communication in a MDT -though not always reached during the simulation- was found to be crucial for a critical exchange of ideas and a proactive collaboration.

Although many issues were faced during this project, students were able to see the potential in the MDT concept. It was concluded that, with enough practice, this concept can start and spread through the medical world with great benefits to both patients and professionals. In order to achieve this change, the impulse must come from the universities and be part of the students' curriculum. Therefore, the importance is stated of a didactic innovation involving students in active learning through case discussions, role-playing and the development of critical thinking – all by involving the creation of a true MDT.

5. Conclusions

In conclusion, recently, the University of Pavia has decided to teach their students the importance of prevention and attention to detail in patient care with the image of a future where the world of medicine undergoes significant changes and the elderly population increases. As we have seen, for elderly individuals these two factors are crucial to avoid errors to ensure that patients adhere to the correct treatment.

As observed from the experiences presented above, engaging with professors from all around the world allows the students to learn new therapeutic approaches and diagnostic techniques, while also enabling fellow professionals to enlarge their knowledge and stay up to date with new ideas.

The first case conducted in 2018 demonstrated that, in Italy, the concept of multidisciplinary teamwork (MDT) is recognized as crucial for treatment but not enough to spread sufficiently to make a significant impact. Students in that case seems to have inadequate effective communication skills with patients but also specifically among themselve due to the fact that they had always been taught that doctors and pharmacists were distinct figures who did not require genuine collaboration. In Italy, doctors have traditionally been viewed as the one who makes the diagnosis and chooses the appropriate treatment, while the pharmacists are seen as merely the individual who receives the prescription and dispenses the medication.

Initiating the role-play process by stressing the importance of the caregiver and the patient while placing students from both faculties on the same level has allowed us to demonstrate how often the individuals' capacity to understand goes unnoticed. The reality is that both the caregiver and the patient are neither a doctor nor a pharmacist, and the professionals usually encounter individuals who may not have formal education. That's why, using illustrative and humble language with simple words facilitates the individuals' understanding while also helping in preventing situations where the individual or their caregiver might act as they understand just to avoid embarrassment.

This approach has also proven to be of essential importance: it is fundamental not to overwhelm the patient with questions one after another providing inadequate time for responses nor should one professional put themselves in a dominating position. It is crucial to maintain one's own role,

always keeping the determination to explain the significance of therapy as a priority without being inappropriate or disrespectful to the individuals' privacy.

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Evaluating inclusion through educational robotics and animated reading: a research-action

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Abstract

Within the thematic-conceptual framework of inclusion and the welcoming of migrant individuals, the project consists of three phases: (1) the design of the intervention aimed at primary school classes and the shared learning of specific research competencies by high school students; (2) action: narration of an illustrated book to children in primary school and carrying out activities aimed at the playful consolidation of content; (3) qualitative measurement of engagement and playful consolidation among the children, depending on the tool used in the activity: in one class, the Interactive Whiteboard (IWB) will be used, while in the other, educational robotics (M bot 2) is planned. The focus, therefore, is on the potential difference between a two-dimensional technological device (IWB) and a three-dimensional robotic tool. The project implies a dual experience for both primary and secondary school students: a collaborative learning experience – in contrast to a traditional, depositary, and unidirectional teaching process – and the exploration of the link between learning and technological tools that our current onlife reality encourages us to use.

Keywords: Animated Reading, Action Research, Inclusion, Educational Robotic, School.

1. Introduction

Anthropomorphic robots are becoming an increasingly prevalent technology within educational environments, such as classrooms. These robots have transformed into an effective instrument that significantly enhances the learning experience, owing to their capability to engage children and stimulate their curiosity (Goh et al., 2007). Robots with human-like features have been employed to explore social interactions (Tanaka et al., 2007), advance language proficiency, foster learning and the achievement of objectives, alleviate anxiety (Alemi et al., 2015), augment pedagogical frameworks (Park et al., 2016), enhance problem-solving skills during instructional periods (Brown et al., 2013), and seize the attention of children (Ioannou et al., 2015). Nevertheless, given the rapid pace of technological advancements in the educational sector, scholarly comprehension and insights into how young learners interact with and derive knowledge from these robots remain profoundly limited. Despite the growing importance of this subject, research investigating the impacts of such educational engagements on children is still relatively scarce.

In this regard, the National Association for the Education of Young Children (NAEYC) has acknowledged the potential of technology and has advocated for enhanced research to deepen the understanding of technology's application in educational settings (NAEYC, 2012). In response to this requirement, numerous researchers have delved into the functionalities offered by social and humanoid robots within the educational sphere. These robots are often selected for their distinctive features, such as advanced multimedia systems equipped with microphones, speakers, and cameras, making them exceedingly engaging for young learners.

These technologies enable the robots to perform a wide array of tasks, including voice and facial recognition. Furthermore, despite the sophisticated technology embedded, the deployment of these devices does not necessitate extensive programming expertise from end-users, thereby

offering a significant advantage for application in educational settings where they can be operated even by individuals without specialized programming skills. Previous studies have also highlighted how children naturally interact with these robots, perceiving them more as learning companions rather than mere playthings (Ioannou et al., 2015).

Other research points out that children show a greater inclination towards robots over traditional learning materials like books or CDs, consequently leading to enhanced educational results (Woods et al., 2004), especially noticeable in language acquisition contexts (e.g., Georgieva Tsaneva et al., 2023). The latest advancements in the design of social robots have significantly influenced the educational potential, facilitating the development of a close and personalized engagement with users (Feil-Seifer & Mataric, 2005). For example, contemporary robots are capable of incorporating teaching strategies and forming distinct bonds with each learner (Ramachandran et al., 2017). Moreover, students can independently adjust their learning level and articulate their educational requirements to the robot (Chen et al., 2020).

Nevertheless, the cognitive dimension of learning represents just one facet. Research focusing on motivational strategies emphasizes the significance of learning's affective component; in this context, Riggs et al. (2016) argue that emotional development is foundational to cognitive growth. Hence, in programming social robots, particularly those engaging with young learners, it is essential to integrate emotional recognition capabilities alongside age-specific linguistic and cognitive skills. Indeed, social robots possess the potential to develop enhanced interactive functionalities, such as discerning emotional reactions, thereby facilitating the creation of tailored motivational approaches that accommodate the individual preferences, needs, and requirements of each child (Obaid et al., 2018).

It is within this latest trajectory that our study is situated, focusing on a new equilibrium between cognitive and affective aspects in the relationship with digital and robotic technologies. Originating from the thematic-conceptual framework of inclusion and welcoming, our research group has structured a project that unfolds in three phases: (1) the design of the intervention targeted at primary school classes and the collective learning of specific research skills by high school students; (2) action: the narration of an illustrated book to children in primary school and the implementation of activities aimed at the playful reinforcement of content; (3) qualitative assessment of engagement and playful reinforcement among the children, depending on the tool used in the activity: in one class, the Interactive Whiteboard (IWB) will be employed, while in another, the use of educational robotics (M bot 2) is anticipated. The focus, therefore, lies on the potential difference between a two-dimensional technological device (IWB) and a three-dimensional robotic tool. The project entails a dual experience for both primary and secondary school students: a collaborative learning experience – as opposed to a traditional, depositary, and unidirectional teaching process – and the exploration of the connection between learning and technological tools that our current onlife reality encourages us to use.

The focus of the research is inherently interdisciplinary and, as such, multifaceted; the principal themes at play, long under the scrutiny of the humanities, include: a) collaborative learning towards an education that is not merely "depository" but deeply lifelong (Vygotskij, 1934/2023; Freire, 1996/2014; Suchodolski, 2003); narrative as a style of knowledge and educational testimony (Bruner, 1992; 2002); the value of the group in providing experiences of identification and conflict management, in the search for common horizons of meaning, fusions of horizons (Gadamer, 1960/2000; Tajfel, 1974); and finally, the capabilities of digital and robotic technologies to enable diverse knowledge experiences on the same theme, to mediate educational content according to degrees of intuitiveness, mastery, engagement (Damiano, 2013; Dumouchel & Damiano, 2019; Rivoltella & Rossi, 2019).

2. The Research

The study we conducted is inspired and structured around four central themes:

Collaborative Learning vs Traditional Teaching: Collaborative learning, which has reshaped educational theories since the second half of the twentieth century, represents a set of innovative

practices that emphasize the active role of students in knowledge creation. This approach has evolved under the influence of various schools of thought, such as those of John Dewey and Lev S. Vygotsky. Unlike traditional teaching, where the teacher is the sole bearer of knowledge that is transmitted in a unidirectional manner, collaborative learning fosters active student engagement, encouraging the shared construction of knowledge. This method not only promotes increased interaction among participants but also develops transversal skills such as critical thinking, active listening, and collaborative problem-solving.

Interaction between Learning and Technology: The introduction of technology in education has profoundly transformed teaching and learning methods. Digital and robotic tools, such as educational apps, augmented reality, and educational robots, open new pathways to make learning more engaging and interactive. These tools enable students to explore new learning environments, providing access to global and diverse resources, and allowing for the personalization of the learning experience based on individual needs.

Narrative as a Learning Mode: Storytelling, used as an instructional method, is fundamental in education as it transforms information into experiences that facilitate learning. Through stories, students can grasp concepts more directly and lastly. Additionally, storytelling allows for the transmission of values, traditions, and life lessons, creating an emotional connection that fosters a deeper and more personal understanding of the content.

The Role of Group Work in Conflict Resolution: Group work is crucial not only for collaborative learning but also for developing social skills. When confronted with differing opinions, students learn to manage and resolve conflicts through dialogue and negotiation. This type of interaction helps foster a sense of community, promoting the sharing of meanings and common goals, while also encouraging both individual and collective growth.

The empirical analysis is based on several pillars, including: the planning of targeted interventions for primary school classes, collective learning of specific research skills for high school students, the reading of a picture book for primary school children, and the implementation of playful activities to reinforce the content. Additionally, the study qualitatively assessed the interest and engagement of children based on the tool used - Interactive Whiteboard (IWB) or educational robotics (Mbot2).

Particular attention was given to the potential differences between a two-dimensional technological device (IWB) and a three-dimensional one (Mbot2).

3. Metodology

The project was developed in three distinct phases over time.

The first phase involved 16 meetings with the fifth-year class of the Matilde di Canossa Scientific-Humanistic High School in Reggio Emilia. These sessions alternated between training and workshops on the themes of reception and research. The second phase included 3 meetings with the 3A and 3B classes from the Maria Teresa di Calcutta Primary School in Massenzatico, also in the province of Reggio Emilia. The final phase consisted of an additional 3 meetings with the fifth-year students of the Human Sciences High School, consolidating the path initiated earlier.

In the first phase, activities focused on lessons concerning migration, reception, and diversity. The students participated in a workshop featuring Piergiorgio Paterlini, author of the book *Profughi*, and Francesco Giovanni Rossi, a representative of the social cooperative “La Dimora d’Abramo”, which works in migrant reception.

The students had the opportunity to meet participants of the Afghanistan Project, who shared their testimonies. For the research component, the class was divided into four groups:

- *Literature Review*: Focused on analyzing scientific literature on the topic of work;
- *Picture Book Research*: Focused on selecting children’s illustrated books on the theme of reception;

- *Interactive Whiteboard (IWB) Activity Design*: Tasked with developing an interactive game using the Interactive Whiteboard;
- *Educational Robotics Activity Design*: Focused on designing an educational activity using the Mbot2 robot.

The last two groups created interactive games using these technologies, with the aim of comparing the effectiveness of educational robotics with that of the IWB for the learning of children aged 8 to 10. During the meetings, an observation grid was also designed for use in field activities.

Before engaging with the primary school children, meetings were held with the teachers to discuss the suitability of the educational tools. The selection of the illustrated book *Gli Intrusi* by Susanna Isern was made in collaboration with them.

The second phase involved three meetings at the primary school, organized as follows:

- *Initial Activities*: Each meeting began with icebreaker exercises. In subsequent meetings, these activities also included mnemonic recall elements to consolidate previously discussed concepts;
- *Closing Activities*: Each session concluded with a summary of the experiences and knowledge acquired;
- *Main Activities*: The first meeting featured an animated reading, designed to engage the children and stimulate their imagination; in the second meeting, a multiple-choice quiz was administered, using the IWB for one group and the Mbot2 robot for the other, to compare the effectiveness of the two tools. In the third meeting, an open-ended quiz was given to assess the children's ability to express themselves and reflect critically;
- *Group Organization*: The children from classes 3A and 3B were divided, and the high school students were assigned different roles, such as observers, timekeepers, and reporters, to ensure efficient management of the activities.

During the activities involving animated reading and digital and robotic technologies, the high school students used observation grids. Each observer monitored up to three children, recording the frequency of specific behaviors. The grid for the animated reading contained 15 items, while the one for the activities with the IWB and Mbot2—identical for both groups—comprised 23 items.

Finally, in the third and final phase of the project, we returned to the Canossa High School, where we organized two separate focus groups, each lasting one hour and involving 12 students. These focus groups aimed to explore various dimensions relevant to our study, including: 1) Ingroup-Outgroup dynamics; 2) Benefits and risks of group work; 3) Learning experience; 4) Future orientation; 5) Impact of PhD students and the professor; and 6) Consideration of the research phases. The results of the focus groups are currently being analyzed.

4. Results

The results are currently being processed. They will consist of the analysis of the data collected through observation grids and the qualitative processing of the focus group data, conducted using the Atlas.ti software, with the students from Canossa High School. Below, the dimensions explored in the focus groups are shared, along with the corresponding stimuli.

Focus group

During the focus groups, in which all the researchers took part, the following dimensions:

1. *INGROUP-OUTGROUP*: In this research, you have experienced what it means to belong to one group and not another. For example, in the experience with the refugees from Afghanistan you were still in the 5th group... can you tell us how you experienced (moods, emotions, feelings, thoughts) the sense of belonging to a group?

Stimuli for silence:

- When we divided you into four groups, we generated four specific groups and there the 5i was something different...
- During the interventions in the elementary school there was the 5th grade on one side and the two classes of girls and boys on the other...
- The 5i which welcomes strangers, that is doctoral students and other students who do not belong to the class...
- We can say that you entered and exited, continuously, in and out of social frameworks, you welcomed and were welcomed...

2. *POTENTIAL AND RISKS OF GROUP WORK*: Can you tell us, according to your experience and your perceptions, what are the potentials and what are the risks (or disadvantages) of the group work we have done?

Stimuli for silence:

- Is there anything you would like to say regarding the question of negotiation, that is, the need to arrive at a synthesis, at shared choices, in each of the phases of the research?
- A theme that some of you raised in some meetings was that of the difficulty of arriving at compromises; for example, choosing the path and the response given by a partner and consequently excluding others.

  What do you think about trust as a feeling in the group? What was your experience with this? ... "Did they trust me? Did I trust the group? How did we get this relationship? How much did the fact of already knowing each other influence you in the various phases?" Has anything changed in your interpersonal relationships after the research work? Do you think the research work introduced new knowledge among the group members?

3. LEARNING EXPERIENCE: Can you tell us if you feel you have learned new skills and, if so, which ones?

Stimuli for silence:

- What were the most useful phases of the research for you regarding your personal growth?
- And for collective growth?
- Did you also get involved thanks to previous experiences in other fields of your life?

4. *FUTURE ORIENTATION*: We now ask you to reflect on how the research experience may have influenced your future aspirations, both academically and professionally. Have new perceptions been born in you regarding your life and the things you are doing? Have you imagined new paths for your future?

Stimuli for silence:

- Did you have expectations regarding possible roads that were confirmed or not, thanks to the project?

5. *IMPACT OF THE Ph.D. STUDENTS AND THE PROFESSOR*: Another point that we care about and for this reason we ask you to tell us about it is the perception towards us, that is towards the professor and the doctoral students during all phases of the research.

How have we been helpful or not?

Stimuli for silence:

- Were there times when we made things easier and others when we made them more complicated?

- During the project, did you feel free and autonomous both in your choices and in your actions?
- Has our presence always been felt or were there moments where you would have liked us to be more present?

6. *VARIOUS CONSIDERATIONS ON THE RESEARCH PHASES*: Finally, we want to hear from you about what you think about research in general. Did you have an idea of what it meant to do research?

Stimuli for silence:

- Before the project, did you have different ideas about doing research? Have other opinions been confirmed or created?
- Another issue concerns data collection and reflection on the results. What results do you think have emerged? What results can you see and talk about after having played an active role in all phases of the research?
- Regarding the ARGO system that you know, how can we evaluate an activity of this kind?

These reflections which we now report below, still in the in-depth phase, emerged during the focus group and were introduced directly by the young women who participated. They refer to additional topics that deserve further exploration.

One of the primary issues raised concerned the mutual integration among the various groups involved in the research. Specifically, it was noted how the 5I class group actively worked to ensure the inclusion of all children in the activities, while the children themselves, demonstrating strong cohesion, were welcoming and hospitable toward the new individuals. Another significant topic that surfaced was competition. It was observed that the competition between the two teams created a heightened sense of rivalry, which, in turn, overshadowed deeper reflection on the meaning of the book.

Subsequently, it was highlighted how the research process proved sufficiently flexible to accommodate the individual aptitudes of each participant, allowing for a tailored engagement in the project. In conclusion, the discussion focused on the long-term utility of the research. It was found to be effective in fostering a deeper understanding of many participants' abilities and in outlining the potential future pathways for others.

5. Conclusions

From the observation grids completed by the students during activities carried out in primary school, interesting results are emerging that reflect diverse interaction and learning dynamics among the groups of children, depending on the technology used.

In the group where interaction was mediated by the Interactive Whiteboard (IWB), we are observing a higher level of verbal interaction among the children. Additionally, during data processing, increased attention during the explanation phases of activities is being noted, along with enhanced interaction among students even after the exercise has been completed. In the group that used Mbot2, on the other hand, frequent episodes of distraction are emerging. However, an increase in dialogue among the children regarding the ongoing activities is also being observed. In this context, interaction appears to be more characterized by physical components, reflecting a different approach compared to the group that used the IWB.

Despite these differences, at this stage, no significant variations seem to emerge between the two groups in terms of overall participation in the activity, enthusiasm, adherence to rules, execution times, and methods of using educational materials.

Finally, the scores obtained in the multiple-choice quiz, aimed at assessing content comprehension, do not show any significant differences between the two groups. This suggests that both technologies employed were effective in ensuring a similar level of understanding of the topics covered.

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xFORMAL: Reinventing Lifelong Learning in Cultural Heritage

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Abstract

The xFORMAL project, focused on Informal and Non-Formal E-Learning for Cultural Heritage, stands as a leading example in cultural heritage education. Its innovative approach combines physical exploration of museums and cultural sites with enriched virtual experiences through a mobile app. Supported by the Marie Skłodowska-Curie Actions, this project showcases how digital technology can enhance cultural heritage education, fostering interest and learning among citizens of all ages while inspiring innovation and progress.

xFORMAL is built on two fundamental principles: Metadisciplinarity, which encourages collaboration among science, technology, and the humanities through constructive dialogue, and pedagogical innovation, which utilizes interactive games to transform cultural visits into engaging learning experiences. The project places a strong emphasis on valorizing lesser-known cultural heritage that is often overlooked in formal education, using modern and accessible tools to promote its knowledge.

To further advance heritage education, xFORMAL has implemented strategies aimed at increasing public interaction and fostering partnerships with cultural organizations and educational institutions. These initiatives have enriched the educational offerings, catering to diverse interests while enhancing the dissemination of educational content and integrating the project into the formal education system. This collaborative spirit promotes mutual growth and a sense of shared accomplishment.

In summary, xFORMAL exemplifies how cultural heritage can be enhanced by merging real and virtual experiences, opening new avenues for the lifelong transmission of cultural heritage.

Keywords: Informal Education, Cultural Heritage, European Project, Educational Innovation, Citizen Engagement.

1. Introduction

Since the 1960s, learning has generally been divided into three main categories, which are now widely accepted and recognised, even by large institutions.

The European Commission describes these types of learning as follows:

- Formal learning takes place in education and training institutions and leads to recognised diplomas and qualifications.
- Non-formal learning takes place alongside mainstream education and training systems and does not usually lead to formalised qualifications. Non-formal learning can be delivered in the workplace and through the activities of civil society organisations and groups (e.g. youth organisations, trade unions and political parties). It can also be provided by organisations or services set up to complement formal systems (e.g. art, music and sports lessons or tutoring to prepare for exams).
- Informal learning is a natural part of everyday life. Unlike formal and non-formal learning, informal learning is not necessarily intentional learning and, therefore, may not even be recognised by the individual themselves as contributing to their knowledge and skills.

Informal learning is a natural part of everyday life

Unlike formal and non-formal learning, informal learning is not necessarily intentional learning and, therefore, may not even be recognised by the individual themselves as contributing to their knowledge and skills.

Informal education as a response to children's personal curiosity Despite the social and cultural stigma attached to informal and non-formal education, its role has proven to be quite relevant. In fact, school-age children spend a large proportion of their waking hours outside of school (up to 85% according to Medrich et al., 1982) and the school experience, even if it is continuous, represents only part of their personal, intellectual and social development. It is clear that formal education simply cannot fulfil all children's educational needs.

Informal education for the education of adults

In our society, the concept of education is expanding and is actually seen as a lifelong process: 'In the education debate of the last 30 years – and especially in the last decade – the concept of lifelong learning has been strategically and functionally sharpened. To a certain extent, it stands for a new way of specifying educational tasks in late modern societies' (Alheit, 2018).

Lifelong learning is no longer just an aspect of education and training but must become the guiding principle for provision and participation across the continuum of learning contexts (European Commission, 2000).

Apart from the small percentage of people who participate in university courses, informal education is one of the most important ways of meeting the educational needs of adults. A clear example of the social benefits of informal education is the willingness of adults to learn how to use new technological devices and digital applications in their everyday lives. This was already stated by Pasek in 2008, but if you look at the technological innovations of the last 15 years, this statement is even more true.

Most of these innovations required a dramatic shift in the mindset of users. If they have successfully become part of our social and personal lives, it is thanks to advances in informal education, which is less content-centred and more people-centred.

Informal learning is useful for urgent topics

Informal learning also has a crucial impact on citizens' awareness of relevant and current scientific topics that are not yet covered in formal education, such as environmental management, global warming or climate change.

Traditional science museums have been quite reactive in adapting their educational programmes to social and cultural developments. This has led to the creation of open-air museums and guided tours to provide visitors with an immersive experience. These initiatives have had a positive impact on raising public awareness of environmental issues.

Informal and formal learning: comparison of cognitive methods

Because of our cultural tradition, we are accustomed to the idea that a large part of education consists of students adapting to the subjects, schemes, timetable and methods of formal education. Relevant experiences we have all had in the field of informal education have broadened this view and opened up aspects that we would never have considered relevant before the technologisation of society. In the '80s, computers were professional tools and few had one at home. Today, every family has multiple technological devices, and we all expect them to be accessible, self-learning, intuitive, intelligent and user-friendly. Middle and high school students expect to find some of these aspects in formal education as well, and their expectations are changing the relationship between formal and informal education by linking them more closely in terms of content and methodology. This complementarity is also recognised by important institutions, as the Commission of the European Communities states: 'Until now, formal learning has dominated policy thinking, shaping the way education and training is delivered and colouring people's understanding of what counts as learning. The lifelong learning continuum puts non-

formal and informal learning more centre stage. By definition, non-formal learning takes place outside of schools, colleges, training centres and universities. It is not usually considered ‘real’ learning, and its outcomes are not of great value in the labour market. Therefore, non-formal learning is usually undervalued. Informal learning, however, is probably completely overlooked, even though it is the oldest form of learning and remains the mainstay of early childhood education. The fact that microcomputer technology arrived in homes before it arrived in schools emphasises the importance of informal learning. Informal contexts offer an enormous reservoir of learning opportunities and could be an important source of innovation in teaching and learning methods.

Osmosis between formal and informal learning

Understanding the differences and peculiarities and the gradual osmosis between these different types of learning plays a crucial role in intellectual, cultural and social development. Learners need to be aware of their specific aspects and know when it is better to rely on formal and when on informal learning. Formal education is delivered through a range of courses designed by experts in pedagogy and teaching. It is supported by a selection of highly developed materials and texts and is based on a trustworthy scientific foundation and proven teaching methods. Formal education also consists of years of intensive and methodical learning activities. It teaches epistemological procedures and cognitive strategies and clarifies how a data set should be processed in order to transform it into an information system, according to the different disciplinary epistemologies.

Nevertheless, formal education cannot cover all topics and satisfy all individual curiosities and information needs. Therefore, people rely on non-formal and informal learning to fill the gaps in both content acquisition and cognitive methods, generally with a higher level of emotional involvement. For this reason, experiences with informal and non-formal learning can have a deeper impact on cognitive attitudes and practises. Another positive aspect of informal learning environments is that they are (potentially) open to a variety of populations with different levels of interest and knowledge. For this reason, informal learning does not have to conform to predetermined standards and can be easily adapted to personal cognitive potential.

Formal and informal education have their advantages and disadvantages. In the places, opportunities and situations where they can co-exist, their positive effects can be combined and used to maximise the effectiveness of the learning experience.

According to David W. Livingstone, informal learning is the pursuit of knowledge or skills through personal choice, without mandatory requirements or curricula imposed by others. Although informal learning can take place in different situations and under different conditions, e.g. in daily life, it is possible to trigger this process through situations or events that are explicitly designed to provide informal learning experiences. For this purpose, some places are more favourable than others, and in terms of science education, these are zoos, robotics clubs, science competitions and activities such as online games. Above all, however, it is science and nature museums that best represent informal science education.

Despite a social and cultural stigma regarding the relevance and effectiveness of informal and non-formal education, its role has proven to be very important. In fact, school-age children spend a large proportion of their waking hours outside school (up to 85% according to Medrich) and the school experience, albeit a consistent one, represents only part of their personal, intellectual and social development. It is clear that formal education simply cannot fulfil all children's educational needs.

So far, formal learning has dominated policy thinking, shaped the way education and training is provided and coloured people's understanding of what counts as learning. The lifelong learning continuum puts non-formal and informal learning more centre stage. By definition, non-formal learning takes place outside of schools, colleges, training centres and universities. It is not usually considered 'real' learning, and its outcomes are not of great value on the labour market. Non-formal learning is, therefore, generally undervalued.

However, informal learning is probably completely ignored, even though it is the oldest form of learning and remains the mainstay of early childhood education. The fact that microcomputer technology arrived in the home before it arrived in schools emphasises the importance of informal learning. Informal contexts offer an enormous reservoir of learning opportunities and could be an important source of innovation in teaching and learning methods (European Commission, 2000)

Understanding the differences, characteristics and gradual osmosis between these three different types of learning plays a crucial role in intellectual, cultural and social development. Formal education is delivered through a range of courses designed by education and teaching professionals. It is supported by a selection of highly developed materials and texts and is based on a trustworthy scientific foundation and proven teaching methods. Formal education also consists of years of intensive learning activities where learning is the main occupation of the learner. It teaches epistemological and cognitive structures that are of great value, and it teaches how a set of data should be processed to transform it into an information system, according to different disciplinary epistemology.

Nevertheless, formal education cannot cover all topics and cannot satisfy all individual curiosity and information needs, so people resort to non-formal and informal learning, generally with a higher level of emotional involvement. For this reason, the experiences of informal and non-formal learning can have a profound impact on cognitive attitudes and practises and eventually even change the learning methods of formal education. As mentioned earlier, Medrich's (1982) research shows that children spend more of their day outside of school, which is only part of their personal, intellectual and social development. This can have a positive effect as cognitive processes become more flexible and adaptable. However, it can also lead to problems as the effectiveness of cognitive schemas is compromised by ineffective procedures.

Sometimes osmosis between formal and informal education gets the best of both, relying on the former for cognitive processes and methods and the latter for data collection; other times, mental schemas are negatively affected by methods acquired through an informal learning experience, resulting in a false epistemic methodology.

The integration of formal, informal and non-formal learning is the key to a successful lifelong learning process, as research by Alheit (2018) shows. Lifelong learning is at the centre of European policy and is no longer seen as just an aspect of education and training but must become the guiding principle for provision and participation across the whole continuum of learning contexts (European Commission, 2000).

According to Livingstone (1999), informal learning is the pursuit of knowledge or skills through personal choice, without compulsory requirements and without curricula imposed by others. Informal learning can take place in different situations and under different conditions, e.g. in everyday life or in environments and events explicitly designed to provide informal learning experiences (Staus et al., 2023): Zoos, robotics clubs, science competitions and online games are just some of them (Robelen et al., 2011), but what best represents informal science education are museums, whose educational function is widely recognised and whose educational offerings are mainly referred to as informal learning (Dudzinska-Przesmitzki & Grenier, 2008).

The National Science Education Standards published by the US National Research Council state that museums can make an important contribution to the understanding of science and encourage students to explore their interests outside of school (National Research Council, 1996).

Howard Gardner (1991) says that museums have the potential to engage students, educate them, promote their understanding and, most importantly, help them take responsibility for their own future learning.

A preliminary literature review conducted by Dudzinska-Presmitzki & Grenier in 2008 found that the existing literature on informal learning in museums focuses on two main aspects: how learning is influenced by intrapersonal factors such as interests, motivations, prior knowledge, personal agenda, etc. (Falk et al., 1998; Falk & Adelman, 2003) and how it is influenced by contextual factors such as the museum environment, the exhibition, initiatives, etc. (Bitgood, 2002).

Various aspects of an exhibition's design and environment have been studied in detail to enhance its impact on visitors. These include the isolation of objects, their size, informative labelling,

different types of technological instruments and multisensory applications, but also the lighting (taking into account natural and artificial light), the presence of natural elements such as plants and the noise level (Dudzinska-Przesmitzki & Grenier, 2008).

With regard to the latter aspect, the literature makes it clear that the museum environment can be more effective if it is not focussed on verbal and informative communication (Bradburne, 2001), but instead arouses visitors' curiosity and appeals to their innate learning processes (Falk, 1997, 2004; Bradburne, 2001; Semper, 1990). For this reason, it is more effective to rely on aspects that can be learned with less effort and in a more enjoyable way, using pictures, colours, interactive diagrams or panels, rather than long written texts. This is what Sue Allen calls activating a 'natural cycle of enquiry' (Allen, 2004). If the museum consists only of displayed materials and written descriptions, it can easily reduce the visitor to a passive observer. However, if it includes other types of communication that allow for different types of interaction, visitors are more interested, curious and active throughout the visit (Gammon, 1999; Dufresne-Tasse, 1992). In a case study by Shaby and Vedder-Weiss (2021), the behaviour of three children with different attitudes towards science in a science museum is analysed. This study emphasises the importance of physical interaction for a positive attitude towards science and a deeper understanding of it.

Depending on the age of the visitors, interaction can be conveyed through short and welldesigned questions, images and infographics rather than objects to touch, turn or manipulate. This can have positive effects as the cognitive processes become more flexible and adaptable. However, it can also lead to problems as the effectiveness of cognitive schemas is compromised by ineffective procedures. Sometimes osmosis between formal and informal education makes the best of both, relying on the former for cognitive processes and methods and the latter for data collection. In other cases, mental schemas are negatively influenced by methods acquired through an informal learning experience, leading to a false epistemological methodology and thus confirming that the integration of formal, informal and non-formal learning is the key to a successful lifelong learning process. Lifelong learning is no longer just an aspect of education and training but must become the guiding principle for provision and participation across the whole continuum of learning contexts (European Commission 2000). Bradburne (2001) summarises this concept as follows: 'Interactivity takes place in the mind, not just in the hands'.

One advantage of informal learning environments is that they are (potentially) open to a variety of population groups with different levels of interest and knowledge (Shaby et al.,2016). They interviewed 17 museum staff from different museums in the USA, Israel and Europe about the goals of science museums. They responded that it is about changing the public perception of science, promoting science education and reducing cultural differences between population groups. According to museum staff, science museums play an important role in changing visitors' attitudes towards science and providing an additional source of science education (Shaby et al., 2016).

The concept of 'science' can be improved and better shaped thanks to the combination of formal and informal learning, which should go beyond a simple school visit and become a collaborative approach (Monteiro et al., 2016).

Several studies emphasise the crucial role of teachers in building positive and collaborative relationships between schools and science museums (McManus, 1992; Chin, 2000; Olson et al., 2001; Jacobucci, 2006). Others focus on the importance of teachers' personal preparation, pointing out that it is up to teachers to understand the relationship between museum and school as complementary and to emphasise the museum as a response to the school's needs, so that it provides the school with the elements it does not have (Gouvêa et al., 2001).

Obstacles to the educational effectiveness of the museum visit: the different expectations of students, teachers and museum teams in relation to the proposed activities; the passivity of teachers during and after the school visit and the difficulty of dialogue between teachers and museum educators (Almeida, 1997).

According to Chagas (1993) and Szpakowski (1973), this co-operation could be improved if museum staff were aware of the topics of the schools' science curriculum, the related disciplines and subjects, and the teaching methods on which teachers rely. Indeed, the integration of informal and formal science learning still seems to be a burden that is mainly borne by teachers.

As mentioned in the introduction, formal education can provide students with mental structures and schemata, but their curiosity and cognitive needs go far beyond the boundaries of school science curricula and need to be integrated through other types of experiences. It is clear that students learn science by crossing the boundaries between formal and informal learning and moving from one to the other.

2. The case study

The European xFORMAL project

The project *Informal and non-formal e-learning for cultural heritage - xFORMAL* was inspired by an innovative form of tourist pilgrimage that allows to (re)discover heritage sites that are usually neglected by tourists and citizens. Pilgrimages have been undertaken by humanity in all historical periods (Reader, 2015). Conceptualised by D. Le Bréton (2012) as a form of communication in space and time, they are defined by S. Coleman and J. Eade (2004) as a 'culture on the move'. Most importantly, the place-based approach replaces the person-centred approach typical of private experiences. Not surprisingly, some scholars have identified parallels between pilgrimage and tourism (Graburn, 1977).

The project is a compelling case study of how cultural heritage can be effectively integrated into modern education systems, particularly through the lens of Education 5.0 and Game-Based Learning. These include the University of Genoa, Italy, which is leading the project, as well as Alteritas from Italy, the Museo de Zaragoza in Spain, the Centro Ciençia Viva from Portugal, the FEF in Finland and the Instituto Politecnico de Bragança in Portugal, Museo Nazionale Etrusco di Villa Giulia in Italy, NCLOUD from Italy, the Dante Alighieri Society of Wrocław in Poland, the University of Bordeaux Montaigne in France, the Adam Mickiewicz University of Poznań in Poland and the University of Zaragoza in Spain. This multidisciplinary team brings together expertise in the fields of cultural heritage, education and digital innovation to ensure the success of the project.

Focused on uncovering and promoting the pre-Roman history of Europe, this project offers a unique approach that combines informal learning methods with advanced technologies to engage citizens, students and educators in exploring their shared cultural landscape.

The populations of Europe in the first millennium BC, often overlooked in contemporary education, shared significant cultural, linguistic and technological commonalities. These characteristics provide an important learning opportunity that reveals Europe’s historical unity in diversity. By focusing on this under-researched period, the xFORMAL project invites participants to rediscover a neglected part of Europe's heritage and thereby develop a deeper sense of collective identity. Zygmunt Bauman (1996) analyses the change in the perception and construction of identity from modernity to postmodernity. In modernity, the challenge was to construct a stable identity, described by the metaphor of the pilgrim, a ‘restless seeker of identity’ travelling along a clear, defined path. In contrast, postmodernism rejects the fixation of identity and favours a fluid and changeable self, similar to a tourist who changes destinations and identities without permanently committing themselves. Identity is seen as a process. The postmodern challenge is thus to keep identity options open and not to commit oneself, reflecting a broader societal shift towards flexibility and changeability of personal and collective identity.

One of the central strategies of the project is to use the landscape as an active educational tool. In contrast to traditional, static approaches to history teaching, here the landscape is a living medium through which participants interact with their cultural heritage. In this environment, learners become active agents, engaging directly with the environment as they explore historical narratives and sites. This reflects Education 5.0’s focus on experiential and humancentred learning, where education goes beyond the mere acquisition of knowledge to include emotional and ethical development.

To promote lifelong learning and adaptability, the xFORMAL project utilises heutagogy, a self-directed learning approach. This methodology encourages individuals to navigate new and unfamiliar environments and helps them to develop critical thinking, problem-solving skills and

adaptability, which are essential to the Education 5.0 vision of preparing learners for the complexity of the modern world.

The innovative use of a smartphone game to cultural education is based on the principles of Game-Based Learning, which utilises the motivational aspects of games to engage learners. Through interactive puzzles, narrative adventures and mini-games, participants are encouraged to think critically about scientific methods and historical analyses, bridging the gap between entertainment and education. This playful approach not only makes learning more enjoyable, but also provides an informal learning environment that allows participants to absorb information in a fun, less structured context.

Furthermore, the interdisciplinary and cross-sectoral approach of the xFORMAL project is in line with the Education 5.0 ethos of collaborative and inclusive learning. By drawing on different methodologies and fields of study, the project enriches the learning experience and encourages participants to approach cultural heritage from different perspectives. This comprehensive framework ensures that participants acquire a wide range of skills and knowledge, from technological knowledge to cultural and ethical awareness.

In summary, the xFORMAL project demonstrates how the principles of Education 5.0 can be applied to heritage education by combining advanced technology with human-centred values. By utilising a cross-curricular approach and innovative learning methods such as game-based learning, the project successfully promotes the study of pre-Roman European history by creating a deeper connection to cultural identity while equipping learners with the skills they need for lifelong learning and responsible citizenship. This case study illustrates the potential of combining tradition and modern educational paradigms to create meaningful and impactful learning experiences.

The xFORMAL framework

The framework of the project is based on several fundamental elements, all aimed at uncovering and promoting the cultural heritage of Europe, particularly from the pre-Roman period. This focus allows for the inclusion of lesser-known minorities and aspects of history that are often overlooked in both public awareness and school curricula. The peoples of Europe in the first millennium BC shared many cultural, technological, religious and linguistic characteristics. Their unity in diversity offers invaluable lessons for modern society, both today and in the future. By selecting this historical period, the project offers two clear advantages: It creates opportunities to engage with cultural heritage and invites citizens to explore a lesser known part of their cultural landscape, reinforcing the idea of a shared European history.

At the centre of the strategy is the use of the landscape as an educational environment that plays an important role in the development of social and personal identities. The landscape is not simply seen as a static backdrop, but as an interactive medium through which information is conveyed. In this dynamic environment, visitors are not just passive observers, but active participants in the cultural landscape.

This is in line with the principles of Education 5.0, which emphasise not only technological progress, but also the ethical, social and emotional aspects of learning. Just as Education 5.0 emphasises a human-centred approach that fosters empathy, creativity and critical thinking, the project's approach to heritage education encourages individuals to connect with their cultural identity through direct experience. By fostering a sense of belonging and shared history, the project reflects Education 5.0's goal of preparing learners to engage responsibly with the world in both their personal and professional lives.

In addition, the project emphasises heutagogy, or self-directed learning, to support lifelong learning. This approach encourages individuals to develop the skills they need to adapt to unfamiliar environments and helps them to develop into open-minded and self-motivated learners. This is in line with the ethos of Education 5.0, which aims to develop well-rounded individuals who are able to navigate and succeed in a complex, rapidly changing world. The use of Game-Based Learning (GBL) to impart informal and non-formal knowledge is also in line with the playful and creative learning methods that Education 5.0 supports. Through a learning game

that combines narrative adventures with mini-games, participants can engage with scientific concepts and develop critical thinking, further bridging the gap between technology and meaningful, contextualised learning.

The game-based structure, complemented by mini-games, is only the top layer of a deeper system for fostering informal learning environments. This format not only enriches the learning experience, but also reflects the cross-curricular and cross-sectoral approach of Education 5.0, where different areas and methods are combined to create a more comprehensive and impactful learning experience. This cross-curricular framework ensures that learners benefit from a broad range of knowledge and skills, in line with the broader vision of Education 5.0, which combines advanced technology with human-centred values and a commitment to social, environmental and ethical responsibility.

By encouraging active participation in heritage discovery and fostering a deeper connection with the landscape, the xFORMAL project contributes to a more inclusive, thoughtful and sustainable approach to education. It reflects the core principles of Education 5.0 by balancing technological innovation with a deep commitment to human values, ensuring that both historical knowledge and future learning are pursued in a way that benefits individuals, communities and society as a whole.

Project Outcomes and Benefits

It is expected that the activities carried out under the project – including staff exchanges, workshops, seminars, networking events and conferences – will significantly enhance the research and innovation capacities of individuals and institutions in different sectors, with an impact tailored to the focus area of the participants.

Museum professionals, science animators and communicators will be exposed to new environments and educational frameworks through the opportunity to work in different countries and sectors. This experience will enrich their understanding of innovative methods that they can bring back to their institutions. In addition, these professionals will hone their skills in scientific methods in the areas of observation, reporting and analysis. They will also apply new approaches to social research, particularly in areas such as integration and inclusion. Researchers in the social sciences and humanities will benefit from the introduction of interdisciplinary methods that combine different approaches and perspectives. While collaboration between academic and non-academic experts from the fields of social research, science, humanities and cultural heritage is not uncommon, this project enables collaboration on two levels. Individual researchers will deepen their expertise through secondments, while collectively they will engage in analysing and consolidating knowledge and shared experiences in different fields.

For teachers and educators who traditionally focus on formal education, the project offers a broader perspective by integrating non-formal and informal learning methods into existing curricula. Their participation will significantly contribute to identifying new educational techniques and methods that can be developed in future projects to improve their teaching strategies and enrich their professional development.

Researchers in the information, communication and technology sciences will gain a deeper understanding of the needs and priorities of social science and humanities professionals and the driving forces in the various fields. This interaction will help them to better develop ICT products – such as game-based learning tools and digital platforms – that are tailored to the specific needs of cultural heritage education and dissemination.

For policy makers, schools, museums and cultural heritage institutions, the project will provide the opportunity to set clear objectives for the management of their cultural assets and territories. By setting priorities that reflect the collective needs of their communities and by better understanding existing and feasible solutions, they will be able to develop concrete proposals and actionable plans. On an individual level, the knowledge gained through this exchange will provide them with valuable new skills and methods that they can apply in their organisations, ultimately leading to more effective cultural management and preservation strategies.

3. Conclusions

The xFORMAL project serves as a bridge between tradition and innovation, demonstrating the potential of informal and non-formal learning to reshape the way we approach education in the 21st century. By utilising digital innovation and immersive learning environments, this project creates a model that goes beyond the classroom and provides dynamic and engaging opportunities for heritage exploration. This holistic approach not only enhances understanding, but also fosters a deeper emotional connection to cultural identity, which will be critical as education continues to evolve.

Looking to the future, the xFORMAL framework provides a roadmap for integrating informal learning into more formal educational structures. As we move towards Education 5.0 with its emphasis on human-centred, experiential learning, the findings from this project can inform collaboration between schools, museums and cultural institutions in creating more adaptable, flexible learning environments. The integration of game-based learning and self-directed approaches such as heutagogy is likely to play a central role in helping students and lifelong learners develop the critical thinking and problem-solving skills necessary to thrive in an increasingly complex world.

The project's digital tools, particularly the mobile app and interactive games, offer scalable solutions for the future of cultural and educational engagement. These tools democratise access to knowledge, make learning opportunities available to a wider audience and ensure that the communication of cultural heritage is both inclusive and relevant. This opens the door to a new kind of learning environment — one that is accessible, interactive and tailored to the needs of a digitally connected generation.

In the long term, the partnerships and networks created through xFORMAL have set a precedent for future collaboration between educational and cultural institutions. This cross-sectoral approach will be crucial as we continue to develop new ways of integrating informal learning into formal education systems. The success of this project lays the foundation for future initiatives that can further strengthen the role of cultural heritage in shaping not only educational outcomes, but also personal and collective identities in a rapidly changing world. By promoting a lifelong learning ethos that values both formal education and informal learning experiences, xFORMAL offers a forward-looking model that is focused on the future of education. In the face of the new challenges facing society, this approach will be instrumental in ensuring that learning remains relevant, accessible and closely linked to both personal development and global citizenship.

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· Section 5 ·
Digital Citizenship and Media Literacy

Prebunking strategies in teachers' digital education: results of an exploratory survey

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Abstract

The paper aims to present the qualitative-quantitative results of an action-research training course that involved 30 primary and secondary school teachers from Istituto Comprensivo 2 in Mondovì (Asti) on the topics of digital sources, manipulated images and artificial intelligence. With this activity, the aim was to explore the impact of prebunking techniques, outlined by Ecker, Lewandowsky, Cook et al. (2022), but proposed here in the reformulation outlined by Bruno and Moriggi (2023), so as to allow a meaningful application of this methodological device to support innovative teaching/learning experience. Similar to debunking, this methodology, developed in the psychological field in the terms of an "attitudinal inoculation" (Cook, Lewandowsky & Ecker, 2017), aims to expose learners to different communicative and linguistic modes and logics, allowing them to gain direct experience of the most widespread and effective narratives of the unreliable. The ultimate goal is to generate an "immunity-effect" – that is, a critical awareness capable of intercepting and decrypting the main deceptive persuasion techniques and constellations of unfounded beliefs. The experimental training, after a plenary session, was structured into three immersive workshop meetings, each dedicated to one of the three thematic areas specified above. A pre-training and a (similar) post-training questionnaire focused on knowledge and skills related to the thematic areas addressed were administered to participants and also to a control group not involved in the course in order to measure the impact of the training intervention.

Keywords: Training of Trainers, Prebunking, Disinformation, Artificial Intelligence, Digital Education.

1. Introduction

This paper presents the qualitative and quantitative findings of an action-research training program involving primary and secondary school teachers from Istituto Comprensivo 1 and 2 in Mondovì (Asti, Italy). The training covered essential subjects of critical media literacy, including analysis of digital sources (news, websites and visual contents) as well as the basics of generative Artificial Intelligence. The program design was based on the "trans-literacy" approach (Frau-Meigs, 2012), bringing together Media and Information literacy, Data Literacy, AI Literacy: "Rather than treating them as separate literacies [...] this holistic approach [...] responds to the felt experience of people as they navigate information cultures (media, documents, data), build their knowledge, form their identities, and make their choices" (Frau-Meigs, 2024).

The training was part of an overall effort to improve teachers' digital literacy skills, enabling them to orient themselves and design and implement learning experiences in an increasingly digital environment. The didactic innovation we are thinking of here, beyond the mere updating of tools and technical knowledge, aims at sharing tools and methodologies functional to creating an epistemologically structured educational environment in order to stimulate the development of a critical (and therefore conscious and responsible) approach among school actors – thus contributing to transforming the school institution into a cultural agency better equipped to understand and manage the educational challenges of a complex technological and cultural transition.

It is also necessary to contextualise what has been stated so far within the documented need for professional development in media literacy education (McNelly et al., 2021). Especially if one takes into account the fact that there is currently no mandatory integration of critical media

literacy into teacher training programs. Although professional development workshops do exist, there seems to be a clear need to provide more structured and long-term support in order to enable teachers to effectively and efficiently integrate critical media literacy within the various curricula (Trust et al., 2022). In pursuit of this goal, the United Nations recently stated that member countries should commit, by 2030, to incorporating media and information literacy into school curricula "to ensure that all users have the skills and knowledge necessary to interact safely and critically with content and information providers and to increase resilience against the harmful impacts of misinformation and information" (United Nations, 2024).

2. Re-mediating Prebunking

The primary objective of this activity has been to explore the impact of prebunking techniques, as outlined by Ecker, Lewandowsky, Cook et al. (2022), but with a re-mediation proposed by Bruno and Moriggi (2023a, 2023b). As known, prebunking – in a complementary way to debunking – aims to preemptively expose learners to potential misinformation tactics before they encounter them in realworld scenarios. This approach thus builds a kind of "cognitive resistance" or "immunity effect" against misinformation.

The training course was designed to provide a meaningful application of this methodological approach to support innovative teaching and learning experiences. The concept of prebunking was originally developed in the psychological field as an "attitudinal inoculation" (Cook, Lewandowsky & Ecker, 2017). The methodology aims to expose learners to various communicative and linguistic strategies. Through this exposure, learners gain direct experience of the most widespread and effective narratives of unreliable information. The ultimate goal is to foster a critical awareness among educators, equipping them to intercept and decrypt the main deceptive persuasion techniques and constellations of unfounded beliefs prevalent in digital media.

The horizon within which the action research in question took shape in the planning phase and materialized in the implementation phase can be defined as an exercise in re-mediation of prebunking strategies and techniques – as they have been codified by Ecker, Lewandowsky, Cook et al. (2022) – in an educational and training context (Bruno & Moriggi, 2023a, 2023b). By remediating prebunking, we actually mean preemptively exposing the recipients of the training to exemplary disinformation tactics before they can experience them in "real" contexts. This exposition contributes to build a sort of "cognitive resistance": an "immunity effect" against the different narrative-argumentative strategies in which disinformation can be variously declined.

The training course was designed by trying to recontextualize an effective translation of this methodological approach in the educational-training field. The aim was to share with the course participants a cultural perspective and a set of technical tools through which they could begin to conceptualize and experiment in their classroom learning experiences that take into account the new ontology (both in terms of resources and critical issues) of the current datafied society (Schäfer & van Es, 2017).

The concept of prebunking was originally developed in the psychological field in the terms of "attitudinal inoculation" (Cook, Lewandowsky & Ecker, 2017). As mentioned above, this methodology aims to expose course participants to various unreliable communication and linguistic strategies, however intuitive and persuasive. Through such exposures, participants directly experience the most widespread and effective narratives with which unreliable content and information are proposed and conveyed. The ultimate goal of this approach consists precisely in progressively generating a critical awareness to recognize in "reality" the strategies and persuasive effects of narratives that they had the opportunity to experience "on their skin" in the protected context of simulations designed in the training context.

As we will analyze in more detail in the following paragraphs, in this specific case we have substantially made use of "passive" prebunking activities (1 and 2), with an additional "active" part (3). Typically, these exercises involve the administration of texts (or videos) to the students in which two key elements appear: 1) a sort of "forewarning" that alerts on the potential and

possible manipulation techniques that the subject could encounter in his daily experience of a given type of medium (or of an entire media or postmedia ecosystem); 2) a “preventive refutation”, or the sharing of functional strategies to “unmask” and therefore manage the forms of disinformation presented in (1).

It is important to underline here that the standard start of a passive prebunking activity was integrated and compensated by a series of activities (3) in which the course participants in small groups worked on case analyses, applying a circumstantial approach in order to “reconstruct” the genealogy of a news item (or, in any case, of a potential manipulation/disinformation) by going back to the facts and sources from which it would have started to take shape. This circumstantial approach - which embodies a central point of the remediation of prebunking in the educational and didactic field – can be considered as a further declination (and application) of media-archaeology (Huhtamo & Parikka, 2011). Both in the sense of an approach that, keeping its gaze on the present of a potential hoax, archaeologically reconstructs – and therefore possibly unmasks – the unreliable narration and/or content that has been encountered. But also in the sense of a media attention to the "nature" of the disformation (or manipulation) that inevitably evolves together with the contexts and technological devices that can produce it. The choice of such methodological compensation – as it will be seen in the continuation of the present contribution - seems useful to make the effect of the preventive inoculation described above even more effective (here in the specific case of a passive eid prebunking exercise), but it is hoped that it can also contribute to containing that “informative decay” – that is, the extinction within a few weeks (about nine) of the cognitive advantage produced by preventive inolculation – that represents one of the main critical issues of prebunking (van der Linden, 2023).

3. Materials and Methods

The experimental training program took place in Istituto Comprensivo 1 and 2 in Mondovì (Asti) from January 2024 up to May 2024. The primary goal was to share with teachers methodologies and operational “recipes” that facilitate navigation within the infosphere (Sheppard, 1971; Floridi, 2017), enabling them to adopt – through immersive and interactive activities replicable in the classroom – the principles and dynamics of multicodical narratives that permeate our daily experiences through various connections (Rose, 2021).

The training programme started with a plenary session, during which the overarching themes and objectives were introduced. The plenary session was followed by the three workshops to thoroughly examine various thematic areas – digital news sources, visual sources, and artificial intelligence for pedagogy – carefully chosen to initiate a training phase that is intended to facilitate the development of a tangible digital citizenship project. These workshops were designed to be highly interactive, engaging participants in hands-on activities that mirrored real-world scenarios they might encounter in their professional practice. The plenary session was open to all the teachers of the school (120), while the following workshop meetings have been attended by a group of 30 teachers.

To assess the efficacy of the training, a pre-training questionnaire and a post-training questionnaire were administered to the participants (n=26). Additionally, a control group (n=24), which did not participate in the training, was also assessed using the same questionnaires. This allowed for a comparative analysis to measure the impact of the training intervention. These questionnaires focused on four different sections: information (1) on demographics and (2) on media consumption habits; (3) self-perception of the issues at the centre of the course (e.g. how do you define fake news, what is the difference between disinformation and misinformation, etc.). The fourth section (4) – which is more central to the results shared in this paper – presented the teachers with 9 examples of digital content, asking them to assess their reliability first through a closed multiple-choice answer (e.g.: which of these two sites do you consider more reliable? Has this image been modified or not?) and then to justify with a textual answer the reason for their choice.

The quantitative answers have been coded with a score of 1 (correct) or 0 (incorrect).

The qualitative answers have been coded on a scale from 1 to 5: 1 not sufficient; 2 incomplete; 3 sufficient; 4 good; 5 very good.

In order to determine the final score, it was decided to assign a weight of 25% to the quantitative response (since users can often answer randomly in multiple answers) and a weight of 75% to the qualitative response (since by asking for a reason, we could better understand whether or not a teacher possesses a specific competence).

The section (4) of the questionnaire focused its attention on the ability to assess 9 typologies of digital content, based on real-life case studies:

1. Reliable/misleading source
2. Reliable/misleading news content
3. Sponsored content
4. Verified profile
5. Satirical content
6. Decontextualized photo
7. Doctored photo
8. AI-generated text
9. Effective Prompt.

In this paper we will focus only on three abilities: recognizing (1) reliable/misleading source; (6) decontextualized photo; and (9) effective prompt.

Based on this methodology and the theoretical premises, the research questions posed in this paper are:

1. *how effective are prebunking techniques in improving teachers' abilities to critically evaluate digital content?* This question explores the primary focus of the training intervention: whether exposing teachers to prebunking techniques enhances their critical thinking and digital literacy skills, specifically their ability to identify reliable sources, recognize manipulated images, and construct effective AI-generated prompts.
2. *how do the post-training outcomes of teachers who participated in the prebunking workshops compare to a control group of non-participants?* This comparative question assesses whether the prebunking intervention leads to measurable improvements in digital literacy compared to a control group that did not undergo the same training.
3. *to what extent do teachers' qualitative justifications for their evaluations of digital content demonstrate a deeper understanding of digital literacy concepts after the prebunking training?* This question addresses the qualitative aspect of the assessment, examining whether teachers' justifications for their answers reveal an enhanced critical awareness and understanding of digital content.

4. Results

A comparison of the results in the pre-post questionnaires shows a marked improvement in the teachers' ability to evaluate a reliable source, recognise a modified image and identify the characteristics of a well-written AI chatbot prompt.

These improvements are clearly confirmed by the results recorded in the control group: among the teachers who did not participate in the training programme, no significant differences were noted in the pre-post questionnaire.

Specifically, for the capacity to discern a credible digital source, the participants exhibited a score of 1.32 (out of 4) prior to attending the workshop on digital sources. This score aligns closely with that of the non-participants in the workshop (1.25 out of 4), so affirming the significant homogeneity of the initial conditions between the participating teachers and the non-participants.

After the training, these results are clearly improved for the course participants (2.54 out of 4), whereas for the control group of non-participants, no significant improvement over the first questionnaire was noted (1.38 out of 4) (Figure 1).

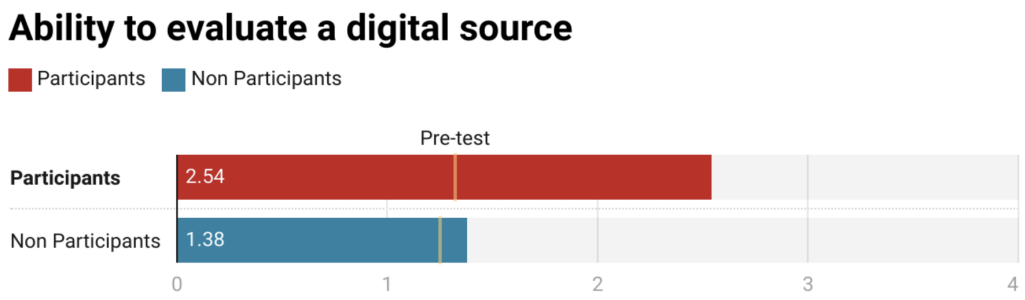


Figure 1 - Ability to evaluate a digital source pre and post questionnaire.

With regard to the ability to recognise a shared image out of the original context with the purpose of deception (Figure 2), results are in line with the previous ones. The course participants were barely able to recognise a decontextualised image before the training (score 1.17 out of 4), whereas they improved markedly after the training (2.56 out of 4). The results of the control group are also consistent, with no significant difference between the former (1.11) and the latter (1.34) questionnaires.

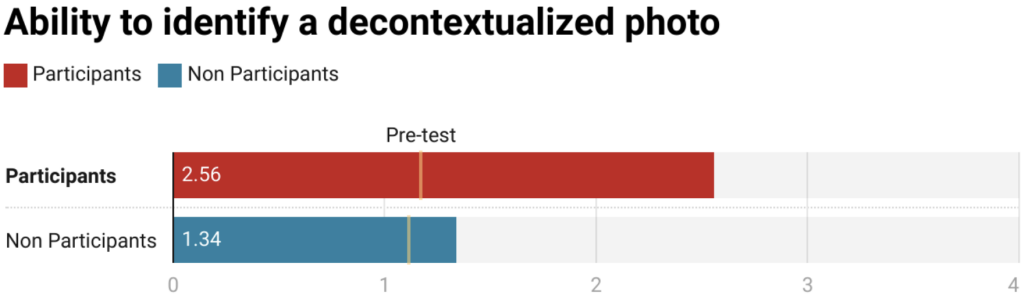


Figure 2 - Ability to identify a decontextualized photo pre and post training.

During the third workshop, we introduced the basics of generative artificial intelligence, focusing in particular on the skill of creating an effective prompt for chatbots such as ChatGpt, Microsoft Copilot and Google Gemini, with the aim of co-designing a lesson to be carried out in the classroom. If before the workshop only 0.75 of the participants knew the rules for an effective prompt, afterwards this figure rose to 2.32. The control group was always below sufficient, both for the first questionnaire (1.11) and the second (0.8) (Figure 3).

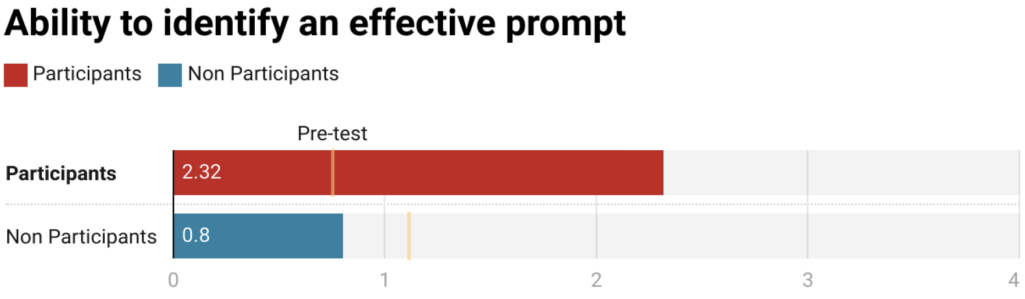


Figure 3 - Ability to identify an effective prompt pre and post training.

5. Conclusions

The findings of this study confirm the effectiveness of prebunking techniques in enhancing teachers' digital literacy, specifically in the areas of identifying reliable sources, recognizing decontextualized images, and generating effective AI prompts. By exposing participants to

misleading narratives and communicative strategies through an immersive, hands-on approach, the training successfully fostered a "cognitive resistance" to misinformation, as hypothesized in the prebunking model outlined by Ecker et al. (2022) and reformulated by Bruno and Moriggi (2023a).

The comparative analysis between the participants and the control group underscores the value of this proactive method. While the control group showed no significant improvement across the evaluated skills, the participants exhibited notable progress in their ability to critically assess digital content. This result aligns with prior research suggesting that media literacy interventions are crucial for equipping educators with the tools needed to navigate today's complex media landscape (McNelly et al., 2021; Trust et al., 2022).

Moreover, the study emphasizes the importance of integrating critical media literacy within teacher education programs, as suggested by international frameworks (United Nations, 2024). By fostering critical thinking and digital competencies in educators, prebunking strategies can contribute to building a more resilient and informed society.

Future analysis will focus on several key areas: completing the analysis of the remaining six content typologies; investigating the correlations between variables such as demographics, media habits, knowledge, and skills; expanding the sample size to include a broader range of educators. Additionally, validating the long-term effects of prebunking interventions will be crucial to understanding how durable the improvements in critical digital literacy are over time.

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Project on “Licence for digital citizens” by Umbria regional school Office

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Abstract

This contribution introduces the “Licence for digital citizens” training course, promoted and coordinated by Umbria Regional School Office in collaboration with EFT Umbra and Corecom Umbria, implemented and managed by a working group of specialised teachers. Aimed at students of primary, lower and upper secondary schools, it is carried out by teachers who can make use of a free kit of materials prepared by experts and designed for each school level.
Teachers are also provided with a course on the platform S.O.F.I.A. in which 450 participants are currently enrolled.
The project involves parents as well with materials appropriately selected for them and through an educational pact to be shared with their children. In the school year 2023/2024, 43 primary schools, 80 lower secondary schools and 30 upper secondary schools from seven Italian regions joined the project, which is intended as a support to implement a regulatory dictate on essential tasks such as Digital Civic Education (L. 92/19), prevention and combating cyberbullying (L. 71/17), improving digital skills (European Recommendation,22 maggio 2018) on the basis of which all contents and topics have been proposed.
As a whole, the project is a vertical path: each segment includes specific topics suited to the age group of recipients and organised into modules, each of which is independent of the others and complete in itself.
At the end of the course, students who have passed the test can participate either in person or online in a regional or local event to officially receive their licence.

Keywords: Digital Competence, Driving Licence, School Project, Digital Citizenship, ICT.

1. Introduction

In recent years, the concept of digital competences has gained ground and found a specific definition in the Recommendation of the Council of Europe on key competences for lifelong learning. A framework has been identified, the DigComp (https://ec.europa.eu), currently DigComp 2.2, which identifies the key elements of digital competences in 5 areas. This implies that schools are responsible for building specific learning paths for students to develop and improve these skills.

It is in this educational context that the project ‘Licence for Digital Citizens’ is set up, with the specific aim of supporting schools in responding to the regulatory dictate on essential tasks such as Digital Civic Education (L. 92/19), preventing and combating cyberbullying (L.71/17 and subsequent amendments), and developing digital skills (European Recommendation 23 November 2023 European Year of Competences).

2. Resources, methods and development of the project “Patentino per cittadinanza digitale”

The “Patentino per cittadinanza digitale” is a training course aimed at primary, lower and upper secondary schools, carried out by teachers using a kit of materials prepared by experts and designed for each school grade (patentinocittadinidigitali.it). It is therefore intended as a training rather than a certification on the basis of shared standards.

The name, “patentino”, was chosen to be close to the sensitivity of young students, to evoke the idea of a driving licence, as a tangible sign of a path of preparation, of a test passed and of its positive outcome, as it happens for any licence in life. Receiving the licence represents both a personal and a public feedback for each student, a recognition by the educating community, an official moment in which personal growth is shared with others and combines with a sense of responsibility – resulting from a new acquired awareness – not only towards oneself, but towards the entire community. Students in fact receive their licence at a public regional event in which they participate in person or online if schools are unable to attend. Moreover, these official events are organised in public and attended by representatives of local institutions.

The purpose of this project is also evident in the choice of title: "for digital citizens". The whole project actually aims to inform and train students (as well as the adults at their side) to enable them to become "prosumers": both responsible producers and aware consumers.

The intention behind the initiative is to intercept the youngest age group in which autonomous use of the network is already widespread (9-15 years old). Promoted and coordinated by the USR for Umbria, implemented and managed by a stable working group [1]appointed by the office [1], its aim is prevention to be achieved through training and awareness of multiple and various social actors. Strong points of this project are that it is free, replicable, widespread throughout the territory, constantly updated and rich in content as well as the variety and richness of the resources provided, the quality of sources, flexibility of activities, full adherence of the topics to the provisions of Law 92/19, Law 71/17 and subsequent amendments and to the guidelines of the DigComp 2.2 framework.

This initiative includes in its process a self-training course for teachers, work with students, evaluation by tests, delivery of licence, and final monitoring.

To successfully achieve these results, the USR Umbria provided participating schools with a kit in which, for each topic, resources are made available to teachers, students and their parents. At the end of this educational path, students who have passed the test can participate in a regional event, on which occasion they are awarded the digital citizen's licence.

A *Vademecum* is given to primary school parents, while for secondary schools a Parent-Child Educational Pact is proposed with a view to parents becoming custodians and a support to their children rather than guardians of rules or even their censors.

The provided resources are divided into modules so that to ensure maximum flexibility: for each module teachers are free to decide timing of lessons and which resources to use according to the teaching needs of the class.

Specifically, three modules have been proposed for primary schools: “Let's get to know the Web!”, “Digital resources for studying”, “Videogames, AI and online social relations”.

For lower secondary schools the course has been structured in four separate modules: “How I use my device”; “Digital well-being”; “I do protect myself”; “My devices”.

Finally, for the first two years of upper secondary schools, the following four modules have been proposed: “I write, post, share and create to feel good: how I use my device”; “I do protect myself on the net”; “I am vigilant”; “I write, post, share, and create: I become protagonist!”.

All modules are structured with teaching work in mind: they clearly state both didactic and educational objectives, suggest questions, propose recreational activities, provide ready/editable slides as a guide and support in lessons, resources for teacher training and resources to work with students and engage parents.

Constant updating is a key feature for a project that aims to train in digital skills. The working group annually reviews the resources included and complete them with the most recent issues, implements content with the latest updates, and introduces new ideas in the wake of a constant evolution of reality and the digital world.

Ongoing improvements focus on legal liability they might incur with online actions, on cybersecurity issues, on the relationship between Artificial Intelligence and the citizen’s life.

In updating the project, the focus always remains on the training of young citizens: resources are prepared and selected based on the age of the recipients, designed to educate in functional and

respectful relationships, and to help young people become more and more protagonists in their onlife as they grow up.

In compliance with the teaching autonomy of teachers, multiple and various resources are provided for each topic, leaving each teacher free to organise single activities on the basis of inclusion and subsidiarity.

The resources proposed are all free and their sources highly specialised: Telefono Azzurro, Save the children, Generazioni Connesse, Polizia Postale, Google, Facebook, Benessere Digitale and other dedicated websites. Some resources are original, produced with experts or by the Working Group. The project lasts one school year, starting in October with its presentation and accompanying teachers step by step up to the test and the final event when certificates are delivered to students.

Intended as a support to teachers and with respect for teaching autonomy, schools are provided with a Syllabus that, in the abundance of themes and resources, enables them to outline their work defining the essential topics for students to pass the final test. For each module, keywords are also provided to focus on the essential elements and questions are suggested as a starting point for the topics to become an opportunity for personal reflection, an occasion for comparison or a debate and a chance to be open to change.

The test (a multiple choice questionnaire administered online through a dedicated platform) is prepared by the Working Group and proposed in different versions: a standard one and one for students with SEN provided to schools in advance to be adapted to the needs of each single student. At the request of the schools, versions in Ukrainian and English were provided. Teachers individually administer the online test to their students on specific days set by the school itself within a three-week window. During this time frame, students who failed or were absent at school are allowed to do the test again: to be intended as an assessment for the evaluation of an educational process, aiming to reinforce the students' learning process, it is not designed to be selective.

Moreover, this test often represents the first "exam" experiences in students' school and life path, thus playing a very important role in their growth.

The final event is public: representatives of students, teachers and parents participate in person, actively involved in short interviews, while all the other classes participate in connection. The presence of witnesses allows students to meet significant experiences.

In the presence of the educational community, possibly attended by representatives of local institutions, the event ends with the delivery of certificates, an official sign of the course having been successfully completed.



Figure 1 - Patentino.

In the school year 2023/2024, 156 schools of the three levels of education from Umbria and six other Italian regions joined the project with a total of 12,137 students taking the final test. The

high number of participating students was made possible thanks to the high number of teachers who trained and worked in classes, thus bringing with it a number of parents engaged by schools in the educational process.

The final monitoring proposed to teachers through an online questionnaire and their final reports at the end of the training course for teachers on the S.O.F.I.A. platform, although partial (91 referents for an equivalent of 55% and 287 teachers answered the questions) and subjective, still returned interesting feedback. First of all, the project was perceived as transversal, involving in 59% of the participating schools the whole council of all classes, 27% only in some classes, in 12.5% of schools only one teacher was involved. The reason can be found in a particularly demanding workload and in the amount of hours to be dedicated to the project with the consequent reduction of some activities. Where the entire class council took part actively, in 82% of the cases.

Technology teachers were involved (with peaks of 91% in primary school), in 82% of the cases Science teachers, in 78% teachers of humanities subjects, in 29% Art teachers, in 21% Music teachers, in 18% Religion teachers, in 17% of the cases Physical Education teachers. These data return the pedagogical and formative character of the project, not limited to providing information, but rather able to raise reflections, to suggest behaviours and actions, to stimulate comparison starting from different points of view.

This is confirmed by the fact that 90% of schools involved the Teachers' Board in joining the project, thus encouraging its expansion in the school and its inclusion in the PTOF; 97.2% of schools expressed their intention to take part again for the new school year.

Some features were especially appreciated, such as: clarity of communication (with an overall score of 4.7 out of 5), respect of the deadlines set by the organisation (with an overall score of 4.7 out of 5), ease of finding useful information (with an overall score of 4.7 out of 5), alacrity in offering assistance when necessary (with an overall score of 4.8 out of 5). These data highlight the importance of standing by schools by accompanying them on this educational journey, thus enabling a time frame as stated by Prof. Feruglio of the Nomandelfia school (Tuscany) in a spontaneous letter sent at the end of the project: "*The course has proved to be extremely interesting both for the teaching materials used – of high quality and usability, able to offer a variety of insights to teachers – and for the time scheduling, that made it possible to meet the planned timetable and complete the program in time to fulfil the upcoming end-of-year school commitments, thus ensuring a satisfactory educational experience".*

Another relevant aspect resulting from the support offered to schools is the dialogue with teachers: at first, many of them contact us just looking for information and support, but then a dialogue ensues, a true sharing, and a narration of episodes in which we do feel the same astonishment they feel when faced with the positive response of their students. And often, students proved to be interested, involved, proactive and ready to open up to others with an attitude that beyond the boundaries of the lesson itself and positively affects social relations among classmates and between teachers and the class.

The project also proved to be useful for the training of teachers: "*as far as knowledge is concerned, it was also a formative experience for us teachers and for parents"*, Prof.ssa Grandi of the IC Bosco Chiesanuova (Veneto) wrote; and Prof. Iliano of the IC Bevagna Cannara: "*as teachers, the digital licence was a precious opportunity to improve our digital skills"*.

Another relevant aspect to be mentioned is the involvement of families in the project: every year the Regional School Office proposes a dedicated online meeting, inviting an expert to address some issues on the challenges related to an 'onlife' existence in managing parental education, considering that parents are the ones who deliver devices, set the rules and, above all, the ones who every day provide either functional or dysfunctional examples on the use of digital devices. The meeting is also an opportunity to inform them about the project and its goals.

In the last school year, 99% of schools invited parents to take part in the event, 92% also sent families a communication to inform them of the school's participation while introducing them to the project; 86% of schools involved students in raising awareness in their own families, with peaks of 95% in primary schools and a drop to 78% in secondary schools. Furthermore, 26% of

schools met parents online, and 25% met them by organising in-person events. The appreciation of families, where involved, clearly emerges from the reports of the attending teachers: as Prof. Conti of the I circolo di Spoleto wrote, "*some students reported positive feedback from parents, who complimented the participation in the project and thanked for the materials provided".*

Interest and gratitude were also evident in some occasional events where the Regional School Office was invited as an institutional presence as well as an interlocutor ready for dialogue with participants, were they teachers, students or their families. And each time their grateful welcome was followed by a constructive discussion.

Finally, I would like to emphasise as a merit of the project the ability to turn the rich European reflection (DigComp 2.2, Recommendation of the Council of the European Union of 22 May 2018), and regulations on digital citizenship (L. 92/19 and Guidelines for the teaching of civic education Ministerial Decree 183/2024, L. 71/17 and subsequent amendments) into age-appropriate insights for the different school orders and likewise into tools in the hands of teachers who, consciously or not, can lead students to an adequate level of digital citizenship - as required today - and to that state of prosumers which is essential for a complete social inclusion and active citizenship. A Technical Scientific Committee has been recently established to support the process of a constant re-thinking of the project in order to make the proposal more and more relevant in promoting training experiences for digital citizenship in a European key.

[Technical Scientific Committee: Floriana Falcinelli, Università degli studi di Perugia; Francesco Mezzanotte, Dirigente Tecnico, USR Umbria; M. Rosaria Fiorelli, Docente, USR Umbria; Lisa Baldella, Docente, USR Umbria; Giulia Battistini, Docente USP La Spezia; Massimo Belardinelli, Ambassador Indire, già Dirigente scolastico; Stefania Bocconi, Ricercatrice ITD - CNR Genova; Stefania Cornacchia, Dirigente Scolastica; Antonio Fini, Dirigente Scolastico; Natalia Morelli, Dirigente scolastica, Ministero dell'Istruzione e del Merito; Elena Mosa, Ricercatrice, Indire; Ezia Palmeri, Dirigente, Ministero dell'Istruzione e del Merito; Sandra Troìa, Esperta in competenze digitali.]

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Digital literacy for the inclusion of adult citizens of protected classes

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Abstract

Digital skills are a key point of the European Policy Agenda. However, the digitalization process struggles to catch on and it contributes to the event of social exclusion, that involves persons who live on the edge of society, such as those not included in the work circuit. To support the transition, CEIS Formazione, is promoting Digital Literacy Projects in order to work on the development of active citizenship skills, including the digital form, to overcome the distrustful attitude of citizens and to help the ones without technological instruments to support this literacy. The projects are addressed to unemployed adults, in protected classes between the ages of 40 and 65, through directive-interactive teaching.

Talking about lifelong learning outside school or work contexts requires careful and deep reflections about the learning outcomes and didactical strategies to be implemented and support individual learning in adulthood, that is characterized by a strong motivation for self-determination and to become aware of personal characteristics, and how those characteristics correspond to society ideals. Moreover, it is important for the former to establish a relationship that can lead to a climate of mutual trust and respect, emphasizing both the individual's and group's characteristics. At the same time, it is essential to find out the individual's learning possibilities and how these could become learning opportunities in the group, also to put them at the service of the group in a peer education perspective.

Keywords: Adults, Integration, Training, Long Life Learning, Data Literacy & Education.

1. Introduction

The European Union recommends the development of digital competences for all citizens, with the ultimate goal of promoting the development of a digitally capable, aware, responsible society. In defining these competences, reference is made to DigComp 2.2, (European Commission, Translations of DigComp 2.0 in the European Skills, Competences and Occupations classification - ESCO, 2022), the European framework developed as a starting point for framing the skills needed for the competent use of digital tools and the digital universe, which identifies five macro-areas such as information and data literacy, communication and collaboration, digital content creation, security and problem solving. It thus emerges that digital competences are a fundamental part of the European political agenda, which cultivates the idea of at least 80 per cent of citizens achieving basic skills (Vuorikari, 2022). A new citizenship profile is emerging with increasing clarity, combining psychological characteristics and digital skills that support and protect the development and growth of the individual. It becomes resilient, social, creative, and democratic (Garbui, Mauri & Mazzotti, 2023), because to educate for digital citizenship implies cultivating three essential qualities: resilience, openness to the territory, and creativity in dealing with complexity. These qualities not only define a good digital citizen, but also serve as the foundation for building a digital citizenship education curriculum, promoting a deep and dynamic understanding of digital reality, its impact on life and relationships, and the continuous evolution of human identity in the digital context. Moreover, the change in the environment in which lifelong learning and, in particular, specialised training for the world of work take place require targeted intervention to enable citizens to learn and keep up to date also through online courses delivered by LMS platforms, today an increasingly used tool for long life learning.

Digital competences thus take on the multiple role of purpose and tool and become one of the foundations for promoting motivation and lifelong learning, which are indispensable for coping

with the complexity of today's and future demands. This concept is central both for the Organisation for Economic Co-operation and Development (OECD), as stated in the 2023 'Education at a Glance' report, and for the United Nations, which includes it in the 2030 Agenda for Sustainable Development. LLL is essential not only for individual development, but also for the progress of organisations and society. (Schroot, 2024). Several researches confirm the importance of transversal skills, among which digital skills, can help individuals develop problem solving and mental structures to deal with unknown situations effectively (Trinchero, 2017; Rosa, 2024). However, very little research has been carried out in adulthood precisely because of the importance of acquiring these skills early on, i.e. at school age. The current bibliography is mainly concerned with the age of compulsory education.

In fact, the digitisation process struggles to take hold and contributes to social exclusion phenomena (Chianese & Marescotti, 2022) which involve people on the margins of society, such as those not included in the work circuit, who are not directly involved in the transformation, or forced towards it by the need to change and adapt to the new reality that combines the real and the digital. In fact, this objective requires a great deal of effort on the part of citizens, since it involves working simultaneously on a wide range of skills, from the practical use of ICTs to the development of critical thinking and responsible and participatory use for digital citizenship (Navarro-Lalanda & Sforza, 2021). On the other hand, they enable access to information and services on a daily basis, allow people to fight loneliness and isolation by keeping in touch with family and friends. Learning new skills, including computing, can stimulate the mind and help keep cognitive abilities active. Online games, puzzles and educational programmes are excellent tools for exercising memory and reasoning. In addition, the continuous updating and use of technology can delay cognitive decline. E-skills are of crucial importance to improve quality of life, foster social inclusion and maintain independence (Brodnik et al., 2021; European Commission, 2022).

CEIS Formazione's project, in collaboration with the Employment Centre, aims to promote digital literacy in order to lay the foundations for the digital citizen, to work on the development of active citizenship skills, and to overcome the mistrustful attitude of citizens, who, on the one hand struggle to become familiar with the new platforms and are discouraged by the too many simultaneous demands for change and learning, and on the other hand lack the technological means to support this literacy. This project is part of the GoI programme (Ministro Lavoro Politiche Sociali, 2024) which is a reform action envisaged in Italy's National Recovery and Resilience Plan (Mission 5, Component 1) (Governo Italiano, 2021) to upgrade active labour policy services. In particular, the programme includes an integrated service offer, based on cooperation between public and private services.

It includes paths of accompaniment to work, retraining or professional re-qualification, and paths in network with other territorial services (social, social-health, reconciliation, educational) in the case of complex needs, such as those of persons with disabilities or fragility.

2. Materials and Methods

The project is designed for unemployed persons of different gender, over 18 years of age, followed by the employment centres of the provinces of Modena and Bologna and participation is on a voluntary basis. The objectives were formulated on the basis of DigComp 2.2:

> *«the framework who came out defining digital competence as a combination of 21 competences grouped in five main areas: Information and data literacy; Communication and collaboration; Digital content creation; Safety; and Problem solving. At the beginning the "Proficiency level" in the project is settled on "Foundation", afterwards it is revised to improve the skills of each person, or to adjust the different levels that may have emerged in individual competence areas» (European Commission, 2022, p. 3).*

The project is proposed directly by the operator, who personally invites each participant, listing the potential learning objectives of the course. Once the applications have been collected, the groups are divided into 6/8 persons per group. This division is determined by the availability of the future trainees. The trainer receives a list of the participants including name, surname and age. In designing the course, it was decided to involve teachers who were familiar with and competent in designing and moderating the working group, capable of accompanying the learning process of the trainees, of applying collaborative and constructive teaching strategies, at the expense of teachers who were more attached to the notional lecture.

The course lasts 40 hours and is divided into 4-hour lessons on close days.

The first meeting is therefore dedicated to getting to know the individual participants, to an initial approach to group work and to observing their digital skills. In addition, through a short focus group where the objectives of the training course are explained, the suggestions, expectations and personal experiences of the participants are collected.

The subjects are welcomed into classrooms equipped with the appropriate instruments for direct experimentation to observe their confidence and ability to use the hardware. The operating system chosen is Windows10 with the Office package including text editor and spreadsheet.

Each student chooses a computer, which he or she will customise and use throughout the course, where he or she will work on customising the profile, such as setting up the desktop, e.g. choosing the font size, icon distribution, brightness, the use of any voice synthesisers to support the 'screen reader', preparing the toolbar with links to the programmes that will be used most and choosing the functions proposed by the operating system that may seem most appealing, choosing icons and creating personal folders and documents. In addition, in the early stages, online activity is introduced with games mediated by open source gamification platforms such as Kahoot! and Genially, creating small tournaments both individually and in teams with questions of varying complexity on the topic of digital citizenship itself. The decision to use this technology derives from the direction that the CEIS Formazione project takes from the 'National Strategy for Digital Competence' (Ministro Innovazione Tecnologica Digitilazzazione, 2020), with particular reference to point E of the intervention lines concerning digital inclusion. In this document it is specified that in order to promote digital inclusion, actions for disadvantaged social groups must be prepared through the simple use of the most widespread technologies, which in the case of the project are represented by the training organisation's computer, but also by digital devices such as the trainees' personal mobile phones and tablets.

This first observation phase, together with the focus group become the resources used by the trainer for the formulation of the course objectives, so that they can be S.M.A.R.T. and customised.

The teaching strategies that the project uses to promote the achievement of the objectives are interactive-directive, simulative (Bonaiuti, Calvani & Ranieri, 2016), game-based learning and collaborative, promoting mutual aid, collaborative learning and guided discussion.

The objectives are constantly evolving and changing, because through direct, experiential, participatory and collaborative learning, participants can directly challenge themselves and demonstrate a greater inclination towards one digital aspect than another. It is also intended to give learners the opportunity to express their opinions and viewpoints, involving them directly to stimulate the dialogical process and intrinsic motivation (Rott & Schmidt-Hertha, 2024). Assessment has a significant impact on individuals and their learning journey. It can facilitate the acquisition and development of new knowledge and skills. It also supports learners in understanding their own learning styles, helping to make them more autonomous and confident in their educational process. Validation of competences, or assessment of qualifications, allows students to express their skills when seeking new learning or employment opportunities (European Commission, 2019).

Learning takes place gradually and with immediate feedback aimed at supporting and stimulating intrinsic motivation. As they are far removed from the world of education and training, the meetings are based on a repetitive schedule that is agreed and shared with the group at the start of the project. The lesson is divided into practice moments, moments of discussion on the

activity, group work and dispensing moments included in the summative evaluation of each project. However, the two activities that remain unchanged are the initial moment of reception and repetition of the skills acquired in the previous lesson and the final moment of comparison and sharing on the daily work in which the micro-objectives of the next lesson are decided.

Below is a table with the planning referring to one day's work.

Table 1 - Example of a work planning.

Thursday 10/08/2023 Meeting n. 6 4 hours – from 9.00 am to 1.00 pm Venue: Bologna, Villaggio del Fanciullo			
MACROAREA	Learning outcomes	Activity	Assessment
Information and data literacy	☐ Final test on word or excel ☐ Final test on how to find information on internet to do research and to share results ☐ Self-assessment on selfimprovement ☐ Presentation about their own digital and technical skills	☐ To copy a word or excel document ☐ Explanation of the assignment for presenting their digital skills ☐ Lesson about how to create their presentation about digital competences	1. To be able to copy a given document 2. To list personal digital competences 3. To do research on the internet
Communication and collaboration	☐ To share their digital competences identifying the level they have reached ☐ To list the netiquette rules	☐ To share and to present the google presentation using meet application ☐ To see and to discuss about a video on netiquette rules	1. To create a digital presentation and to share it during an online call using Google Meet
Digital content creation	☐ To create a presentation about their digital competences	☐ To create a presentation using a format given by the teacher ☐ Lesson about different digital instruments ☐ Lesson about file extensions	
Safety Problem solving	☐ To demonstrate to have acquired base knowledge about internet security, privacy, problem solving and artificial intelligence	☐ Final Multiple choice test	1. To identify the characteristic of internet security, privacy 2. To solve small problems using the internet To deal with IA
Awareness about personal competences	☐ To think about possible improvement on their digital competences	☐ To give feedback about competences and to discuss about how to improve personal level	1. To show personal digital competences

In the left-hand column are the relevant competence areas and in the second column the expected learning outcomes. The trainees do not intervene in these two areas, which they know are part of the overall course objectives, but they can order the activities in column 3 and consequently, the assessment tests. Each activity is prepared according to the expected 'proficiency level' and thus with a different degree of difficulty.

All course material is stored in a virtual Google Classroom and remains available to the trainees, both for future reference and for immediate feedback on the work they are doing.

Awareness of one's own abilities is a delicate, but fundamental moment in planning and is reinforced both through moments of summative evaluation, self-assessment and sharing of

results, or through discussion with fellow students, also through game-learning platforms such as Kahoot or Genially. Where necessary, online tools are used which, in addition to including notions and games that convey learning through playful activities, stimulate participants in increasing eye-hand coordination through the use of computer hardware such as keyboard and mouse.



Figure 1 - The digital skills podium.

3. Results

The use of digital platforms, mediated by both computer and personal devices, made it possible to smooth out initial resistance on the use of electronic devices and to introduce more complex theoretical topics, proposing reflection based on the answers received in the games, e.g. knowledge with respect to privacy, data protection and digital identity. It therefore becomes possible for the trainees to become aware of the final objectives of the course and their personal starting level with respect to them, to take note of their own competences, reasoning individually on the intermediate learning stages into which each objective can be broken down, and then agree together on the lesson topics and the scanning of the training days. The repetition of a consolidated scheme in each lesson, also agreed and decided collectively, puts the participants at ease, who, in the classroom routine, consolidate basic skills in the use of devices, starting from the switching on and use of the PC, passing to the creation of folders and documents, to the use of the Google account and all the environment connected to it, up to managing a video call to conduct a short presentation of oneself, prepared in advance in the previous lessons, sharing the screen and animations.

In forty hours of the course, the class is transformed into an active, living laboratory, exchanging opinions and skills, with mutual help and support. At the end of each day, the learning assessment is used as a tool for self-assessment and reprogramming of subsequent lessons, to deepen and review topics and concepts that may seem distant from the direct experiences of those involved, yet very relevant in everyday life.

Collaborative teaching, the peer education strategy and formative assessment have a significant impact on the intrinsic motivation of each student, fostering a gradual evolution in their attitude to participate in the course, moving from a passive role to an active one, aware of their responsibilities in the training process. The suspension of judgement promotes a climate of exchange and confrontation in a network interaction scheme, which leads the group to work together, to support each other in order to achieve the learning objectives, each according to his or her abilities.

This makes it possible to reflect on the importance of participant motivation in a teaching and assessment context. According to Deci and Ryan's (1999) theory, intrinsic motivation and evaluation in the sense of feedback or rewards, have a clear connection that shows how the type of evaluation received influences the quality of a person's motivation. Motivation can be divided into intrinsic and extrinsic. Intrinsic motivation is the drive to perform an activity for the pleasure and satisfaction derived from the activity itself, rather than from external rewards as in extrinsic motivation. Deci and Ryan argue that motivation develops when three needs are satisfied: for autonomy, i.e., feelings of being in control of one's emotions; for competence, i.e., the feeling of being capable and having mastery of the activity; and finally, for relatedness, i.e., feeling connected and recognised by others. Evaluation and external rewards can thus influence motivation but not always in a positive way. For example, informative evaluation reinforces through feedback the sense of competence and autonomy by increasing intrinsic motivation. On the other hand, evaluation by rewards or punishments is perceived as a form of control that diminishes intrinsic motivation because the individual perceives his or her learning as being guided by external factors that reduce the sense of autonomy.

Supporting the participants during the evaluation directly affects and increases motivation, also influencing a greater awareness with regard to responsibility in the training process and stimulating the willingness to expand individual characteristics. The differences between the self-assessment tests administered at the beginning and end of the course show this awareness and the increased knowledge with regard to one's own learning possibilities stimulates comparison and reflection on possible future developments with regard to the self. It follows that the summative assessment also provides a stimulating direct comparison that elicits the impetus for more in-depth studies and further training.

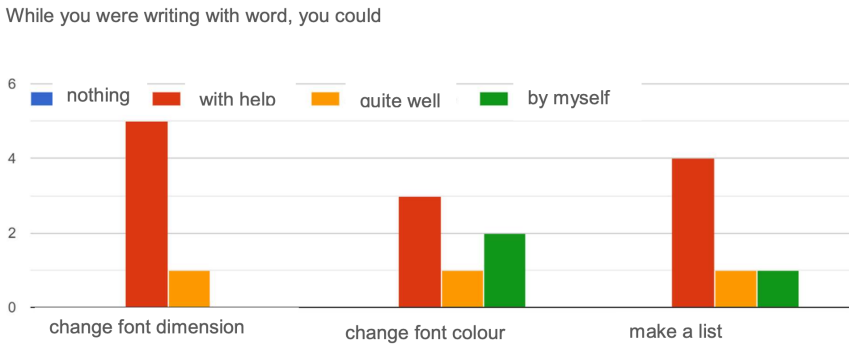


Figure 2 - Graph showing the results of the self-assessment test of a working group after the first lesson on Microsoft Word (N=6).

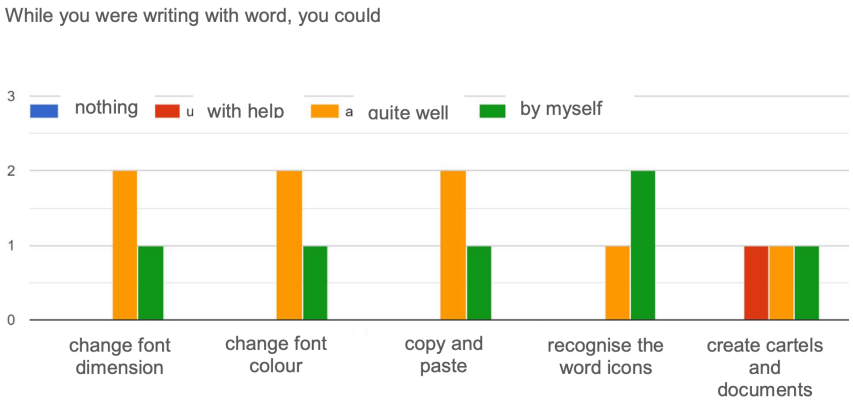


Figure 3 - Graph showing the results of a group self-assessment test on Microsoft Word at the end of the course (N=6).

The work on digital literacy, building the basics and the first rudiments of citizenship stimulates curiosity and attention towards further education, and the trainees often request further training to consolidate, deepen and broaden their knowledge.

The project thus achieves practical learning objectives with respect to the first notions of digital literacy and elicits awareness with respect to the trainees' responsibilities in terms of lifelong learning and citizenship. The digital is observed both through the tools of participation in the course and in everyday life, and through the hybrid connotation it has given to everyday reality. The debates, observations and personal experiences shared offer the possibility of analysis from an expert point of view, that of the teacher, who encourages re-examination, attention to characteristics and works to create the skills for a simple but sufficiently critical analysis of tools and situations, and from a close point of view, that of those who act and interact with technological tools on a daily basis, the trainees.

4. Conclusions

Given the theoretical premises and the context in which the projects are implemented, the choice of involving the learners in the design of the course days and entrusting the training to teachers experienced in collaborative teaching strategies proved to be the right one. In fact, fostering homogeneous learning in a non-judgmental and non-competitive climate allows the trainees to face a new and distant environment, and to transform initial resistance into enthusiasm for learning, leading to the personal achievement of the objectives proposed in the project.

Undoubtedly, talking about lifelong learning, of Long Life Learning, in contexts outside the school or work contexts, requires careful reflection on the objectives and didactic strategies to be implemented to support individual learning in adults, which is characterised by a strong drive for self-determination and the search for confirmation with respect to one's own idea of oneself and what society expects (Chianese & Marescotti, 2022). It is advisable not to forget that each adult individual has developed a personal idea with respect to his or her own abilities and the demands he or she feels able to fulfil, as well as with respect to the characteristics with respect to his or her own learning style. These realisations can generate a sense of inadequacy and consequent fragility with respect to the constant learning expectations resulting from the changes in flux towards which they are pushed by the digital society. Moreover, the majority of adults enrolled in job centres have not acquired the appropriate skills for self-directed learning, remaining excluded from the processes of inclusion and participation that training aims to promote. (Chung & Elliott, 2015).

It is advisable to provide time to support people in becoming aware of their real abilities and potential, it is necessary to establish a trainer-student contact that can lead to a climate of mutual trust and respect, emphasizing the individual and group characteristics, as well as the learning possibilities of the individual and the individual in the group, also placing them at the service of the same in a peer education perspective. Active individual and group experimentation allow us to work on the role and functions of the individual and the process of digital literacy becomes both a means and an objective. In the new society led by Information and Communication Technologies, digital adaptation concerns, among other things, both citizenship, which becomes digital also through the declination of the rights and duties (Navarro-Lalanda & Sforza, 2021) proper to each citizen, such as participation in collective life, informed information and the dissemination and sharing of new ones, and the ability to develop skills for continuous training to combat the disinformation and new challenges (Chianese & Marescotti, 2022). The idea, therefore, is to take advantage of classroom training in small groups to experience a first form of active citizenship mediated by digital tools, through active participation in the life of the class group, where everyone feels like a member in the making and a resource for others, the transition and digital transformation become the stimulus to continue to grow and train to become active citizens, that are formed and inform and mature awareness of the change and digital transformation of society. Digital citizenship education must go beyond the acquisition of technical skills and aim to form citizens capable of critical thinking, acting ethically and understanding the deep impact of the

digital world on lives and on society (Garbui, Mauri & Mazzotti, 2023). In the meetings it was possible to observe this drive for change and the progressive growth of a collaborative, non-judgmental climate, supported by ICT as a tool for interaction with reality outside and inside the group.

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Digital communication and hybrid intelligence: the impact of generative AI on lifelong and recurrent higher education

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Abstract

The aim of this paper is to underscore the significant elements of an approach to lifelong and recurrent higher education in universities that enables the best possible response to the impact of generative AI systems on intellectual and creative professions. For the analysis, reference will be made to professions in digital communication, which consistently experience conditions that tend to precede and extend into other professional domains. For these professions, generative systems are delineating the coordinates of a veritable paradigm shift that impacts the foundations of the professional dimension. These systems can function as true intelligent assistants, offering new modes of information retrieval and producing code, images, videos, text, voice, and music. Building on the concepts of Hybrid Intelligence and Hybrid Work, we arrive at an analysis of the Jagged Technological Frontier and the maturity levels across different categories of available tools. In this perspective, a set of references emerges for the design and management of Master's programs, starting with those related to digital communication. These references pertain to: the relationship between the breadth of fundamental knowledge and the depth of specialized knowledge; the introduction of Hybrid Intelligence, Hybrid Work, and Prompt Design among the core competencies; the acquisition of general knowledge and operational skills in co-designing and implementing with the aid of systems, both individually and in groups; the anticipation of the most innovative forms of on-the-job learning; and the forms of connection between Master's programs and the Third Mission.

Keywords: Hybrid Intelligence, Generative AI, Lifelong Learning, Master, Digital Communication.

1. Introduction

Generative AI systems are exerting a significant impact on the professional realm of knowledge workers, digital creatives, and, more broadly, all highly skilled professionals. The concepts of Hybrid Intelligence, Hybrid Work, and Hybrid Intelligent Systems, together with their practical applications and implications, convey the profound reasons for this impact, as they reveal the foundations of a new relationship between digital technologies and intellectual work, marked by the shift of technology from a tool to a partner, an intelligent assistant.

The concept of the “jagged technological frontier” underscores that the human-AI partnership has inherent and continuously shifting boundaries that influence the achievable outcomes.

> *“Hybrid intelligence, also known as human–AI (artificial intelligence) collaboration, is a concept that combines the strengths of both human intelligence and artificial intelligence to achieve better outcomes than either could achieve alone” (Petrescu & Krishen, 2023, p. 1).*
> *“Because the brain and artificial intelligence use substantially different algorithms, each excels in ways that the other completely fails. Machine learning algorithms outperform humans in detecting complicated and subtle patterns in vast data sets. However, the brain can process information effectively even when there is noise and ambiguity in the input — or when situations change unexpectedly. This is why humans and AI must collaborate and join forces as hybrid intelligence” (Chowdhury, 2022, p.1).*

The Hybrid Intelligence concept was joined by that of Hybrid Work and Hybrid Intelligent Systems.

> *"The traditional understanding of Hybrid Work, so far, has predominantly focused on the spectrum of inperson and remote work. Two recent developments, along with the increasing proportion of remote Work, are changing the nature of work: the quickly expanding use of (generative) AI applications, and the growing advancements in virtual world technologies and platforms. […] the synthesis of these developments will vastly impact traditional work models and practices. This transformation warrants a critical rethinking of the traditional understanding of hybrid work".*
> *(Richter & Richter, 2024, p. 1)*

> *"Hybrid Intelligent Systems (HIS) represent a novel paradigm in artificial intelligence, synthesizing diverse AI techniques to create more powerful and adaptable systems. […] The integration of multiple AI paradigms in hybrid intelligence systems is driven by the recognition that no single approach can comprehensively address the intricacies of all tasks. By combining rule-driven logic, which excels in explicit knowledge representation, with the learning capacities of machine learning algorithms, hybrid intelligence systems aim to bridge gaps and overcome limitations inherent in individual methodologies. This integrative approach not only improves performance but also provides a foundation for addressing real-world challenges that often demand a multidimensional understanding" (Manish Verma, 2024, p. 1).*

Human–AI (artificial intelligence) collaboration depends not only on the evolution of available tools but also on the intensity and quality of experimentation with these tools in professional settings, within an inherently uncertain context.

A rigorous experimental study conducted by researchers at Harvard Business School explored the productivity and work quality outcomes achieved by 758 consultants from a global consulting firm. These consultants partnered with generative AI resources to complete tasks spanning various domains: creativity, analytical thinking, writing proficiency, and persuasive skills. The final report states:

> *"capabilities of AI create a "jagged technological frontier" where some tasks are easily done by AI, while others, though seemingly similar in difficulty level, are outside the current capability of AI. For each one of a set of 18 realistic consulting tasks within the frontier of AI capabilities, consultants using AI were significantly more productive (they completed 12.2% more tasks on average, and completed tasks 25.1% more quickly), and produced significantly higher quality results (more than 40% higher quality compared to a control group).*
> *Consultants across the skills distribution benefited significantly from having AI augmentation, with those below the average performance threshold increasing by 43% and those above increasing by 17% compared to their own scores. For a task selected to be outside the frontier, however, consultants using AI were 19 percentage points less likely to produce correct solutions compared to those without AI.*
> *Further, our analysis shows the emergence of two distinctive patterns of successful AI use by humans along a spectrum of human-AI integration. One set of consultants acted as "Centaurs", like the mythical halfhorse/halfhuman creature, dividing and delegating their solution-creation activities to the AI or to themselves. Another set of consultants acted more like "Cyborgs", completely integrating their task flow with the AI and continually interacting with the technology" (Dell'Acqua et al., 2023, p. 2).*

The substantial impact of generative AI on the professional sphere of highly skilled professionals manifests across multiple dimensions, including productivity, work quality and quantity, execution time, organizational structure, professional qualification and training, as well as job satisfaction.

2. A useful reference: Professions of Digital Communication

The professional sector of digital communication, which has been significantly and rapidly impacted by digitalera innovations, serves as a particularly useful reference for discussing the impact of Hybrid Intelligence for two key reasons. First, within this sector, even if unevenly distributed, a broad and comprehensive experimentation with generative AI has been undertaken, fostering substantial experience with available resources. The second reason lies in the fact that many factors previously experienced in this field — such as the evolution of technology from a tool to an integral cultural component of an interdisciplinary approach, project-based culture, instability, precariousness, and the rapid obsolescence of knowledge — have gradually extended to other professional domains.

This experimentation was initiated because generative AI systems directly engage all core professional competencies of this field: Information Literacy and Digital Documentation, Text Writing (synthesizing, style, etc.), Translation, Code Production, Multimedia Content Production, including Graphics, Images, Videos, 3D, and Audio — particularly Writing and Performing Music and Lyrics — as well as Speech Recognition and Synthesis.

In digital communication, content creation is central.

> *“Large language and image AI models, sometimes called generative AI or foundation models, have created a new set of opportunities for businesses and professionals that perform content creation. Some of these opportunities include: (1) Automated content generation: such as articles, blog posts, or social media posts. This can be a valuable time-saving tool for businesses and professionals who create content on a regular basis. (2) Improved content quality: AI-generated content can be of higher quality than content created by humans, due to the fact that AI models are able to learn from a large amount of data and identify patterns that humans may not be able to see. This can result in more accurate and informative content. (3) Increased content variety: AI models can generate a variety of content types, including text, images, and video. This can help businesses and professionals to create more diverse and interesting content that appeals to a wider range of people. (4) Personalized content: AI models can generate personalized content based on the preferences of individual users. This can help businesses and professionals to create content that is more likely to be of interest to their target audience, and therefore more likely to be read or shared” (Davenport & Mittal, 2022, p. 1).*

Regarding the capabilities of generative AI systems, which are fundamental for delineating the boundaries of the “jagged technological frontier”, it is possible to contingently define the maturity level of various applications and their outcomes, recognizing that they are in a constant and non-linear state of evolution. Currently, there is a shared convergence among scholars and practitioners that places the highest level of maturity on activities such as text-to-text, image-to-text, text conversion, and translation, while slightly lower levels of maturity are attributed to text-to-code, code repair, and app building. Following these, in decreasing order, are text-to-speech and speech-to-text, image/text-to-3D rendering, text-to-video, image-to-video, and video upscaling. Closing the ranking with the lowest maturity index are song and video game building. From evaluations regarding the potential and maturity level of these systems, it is evident that a significant portion of activities performed by digital communication professionals can already rely on sufficiently mature tools, all of which are rapidly evolving. Particularly noteworthy in this regard is the case of Midjourney, a "text-to-image" system, which in just over a year has progressed from limited-precision graphic outputs to photorealistic results.

A simple example, which includes specific prompt questions usable on ChatGPT, demonstrates that it is possible to instruct AI systems to perform tasks characteristic of various specializations: (a) Act as a PR specialist: Generate a press release and a CEO statement to promote a product; (b) Act as an SEO specialist: Generate 10 frequently asked questions about organic products, help me write a blog post, and format everything with an SEO focus; (c) Act as a copywriter: Write tweets to launch the blog post, a launch post on LinkedIn, create three captions for Instagram, and rewrite them; (d) Act as a content strategist: Write a 4-week structured content plan for my company; (e) Act as a graphic designer: Design a logo that represents... Create a mockup... Generate animated images; (f) Act as a programmer analyst: Create the code to publish a website.

3. The impact of generative AI systems on digital communication professions

As typically occurs when highly innovative technologies emerge, companies are faced with decisions on whether, how, and to what extent to integrate them into their production processes. This choice depends on various factors.

Generative AI systems possess distinctive features that support their rapid and widespread impact on the work environment.

First, “the effective capabilities of AIs are novel and unexpected, widely applicable, and are increasing greatly in short time spans. Recent work has shown that AI performs at a high level in professional contexts ranging from medicine to law [...] and beats humans on many measures of innovation”. Second, these systems have “the ability to directly increase the performance of workers who use these systems, without the need for substantial organizational or technological investment”. Finally, “the effects of AI are expected to be higher on the most creative, highly paid, and highly educated workers” (Dell’Acqua et al., 2023, p. 3).

The decision by companies operating in the field of digital communication to adopt these systems is largely influenced by the desired quality of the outputs to be produced. This choice essentially revolves around whether to produce outputs of medium-to-high quality or to maximize originality and innovation, allowing more room for individual creativity while avoiding work practices that might standardize the products.

In any case, the decision is not about whether to adopt these systems, but rather about how and to what extent, since, regardless of the type of product, every digital communication company engages in tasks and activities that fall within the continually shifting “jagged technological frontier.” For these reasons, all companies are experimenting with the use of these systems, and many are beginning to steadily adopt tools and platforms that directly or indirectly incorporate or mediate access to generative AI systems.

The experiences conducted thus far and the contextual analysis suggest profound changes in the practical aspects of the profession, affecting work organization, work processes, and the necessary competencies required to practice it.

Although the adoption of these systems does not require substantial organizational and technological investment, it is evident that there are inevitable impacts on work organization, the roles of individual professionals, team relationships, internal communication practices, and task distribution.

For example, the production of internal tools like storyboards and mockups may no longer be solely entrusted to specialists. Moreover, an increasingly collaborative partnership between humans and AI encourages the individualization of tasks and could alter dynamics between senior and junior staff.

> *“An immediate concern arising from these findings is that, for instance, tasks within the frontier may cease to be delegated to junior workers, potentially leading to long-term training deficits” (Dell’Acqua et al., 2023, p. 18).*

Other consequences affect methodologies, work processes, and the integrated use of tools. Diverse phenomena tend to converge: while resources such as DALL-E and Midjourney are used to create semi-finished materials that are then refined with photo editing software, such as Photoshop, Photoshop itself and many software and platforms widely used are integrating or connecting features based on generative AI in their new versions. Finally, two broader consequences emerge, whose impact remains difficult to assess. The first concerns the balance between STEM and humanities skills within work teams, and the second pertains to creativity, previously discussed regarding potential organizational choices around the adoption of these tools. Generative AI, after all, relies on past data and, if used inappropriately, can result in output of average or even mediocre quality. It is worth noting that diverse perspectives currently coexist among creative professionals: some disdain the intrusion of AI, while others make extensive use of these repositories of existing knowledge and experiences, seeking useful insights and inspirations to innovate and to enhance their originality.

4. The Impact of Generative AI on Lifelong and Recurrent Higher Education

Generative AI resources do not merely expand the already vast array of digital models and tools available to digital communication professionals; they have the potential to drive a genuine paradigm shift within the professional domain of digital communicators, and, given that these professions have often served as trailblazers for others, it is reasonable to anticipate that this shift will progressively extend into other sectors.

It is therefore essential to initiate a reflection on how institutions responsible for high-level professional training, as well as continuous and recurring education, can best respond to emerging knowledge and skill requirements. For these purposes, their role remains central and strategic.

In this regard, in a previous article (Boniolo, 2024), I highlighted, referencing various scholars, how economists, sociologists, and experts in organization, labor, and professions agree on the centrality and critical role of advanced professional education and continuous, recurrent training. Many researchers in these fields, albeit from different perspectives, emphasize the vital importance of ongoing education for economic and social development, agreeing that it represents a fundamental and distinctive aspect for the future of education as a whole.

In that same article, I outlined the elements of a model for managing continuous and recurrent training activities within Italian universities. Building on that framework, I believe that the current analysis of the impact of generative AI on the professional landscape of digital communication specialists affirms the core elements of that model and suggests certain integrations, emphases, and additional guidelines.

The first confirmation pertains to the need for a more complex and flexible institutional model for continuous and recurrent training, one that entails multiple interventions over time and can connect formal, non-formal, and informal learning paths. Only in this way can the robustness of formal courses be enhanced through various forms of on-the-job learning, while also leveraging innovative training and self-training models and tools that emerge from innovation itself, such as communities of practice and, more broadly, collaborative peer-to-peer learning.

> *“Navigating the frontier requires skills that must be developed through formal education [...] fieldbased training [...], and professional development that is independently motivated by employees” (Dell’Acqua et al., 2023, p. 18).*

The Master’s program, following an undergraduate or graduate degree, builds a solid foundation for selfdirected learning by merging a scientific, theoretical, and methodological approach with practical, applied experiences. Corporate culture and dynamics impacting the professional sphere contribute to the growth and reinforcement of interdisciplinary, social, and behavioral skills. Collaborative peer-to-peer learning compensates for disparities related to specialization and

product focus, fostering opportunities for knowledge and skill development through cross-functional, participatory collaboration.

To integrate these components into a lifelong learning approach, this process must begin in the Master's program design phase and include a structural connection between Master's programs and the Third Mission. The Third Mission encompasses a range of activities involving the scientific, technological, and cultural transfer and the productive transformation of knowledge. It is based on the direct interaction of universities with civil society and the entrepreneurial sector, and explicitly includes activities related to lifelong learning and public engagement (such as conferences, lectures, public events, and presentations). Similar to Master's programs, the Third Mission requires systematic interaction between universities and companies, startups, funders, investors, as well as collaboration with structures providing intermediary and support services: incubators, science and technology parks, consortia, foundations, and associations for technology transfer. This integration should overcome the current reality in which, despite overlaps in objectives and stakeholders, Master's programs and the Third Mission generally run parallel, intersecting only occasionally at the initiative of individual researchers.

Alongside the confirmation of this foundational structure, the analysis conducted thus far indicates a need for additional integrations.

To achieve high-quality results with generative AI systems, critical thinking skills, robust domain-specific knowledge, and specialized competencies developed through substantial practical experience are essential. These considerations reveal a set of guidelines for the design and management of university Master's programs. To outline these, we will refer to an updated curriculum proposal for the Master's in Digital Communication Design at the University of Turin (Figure 1).

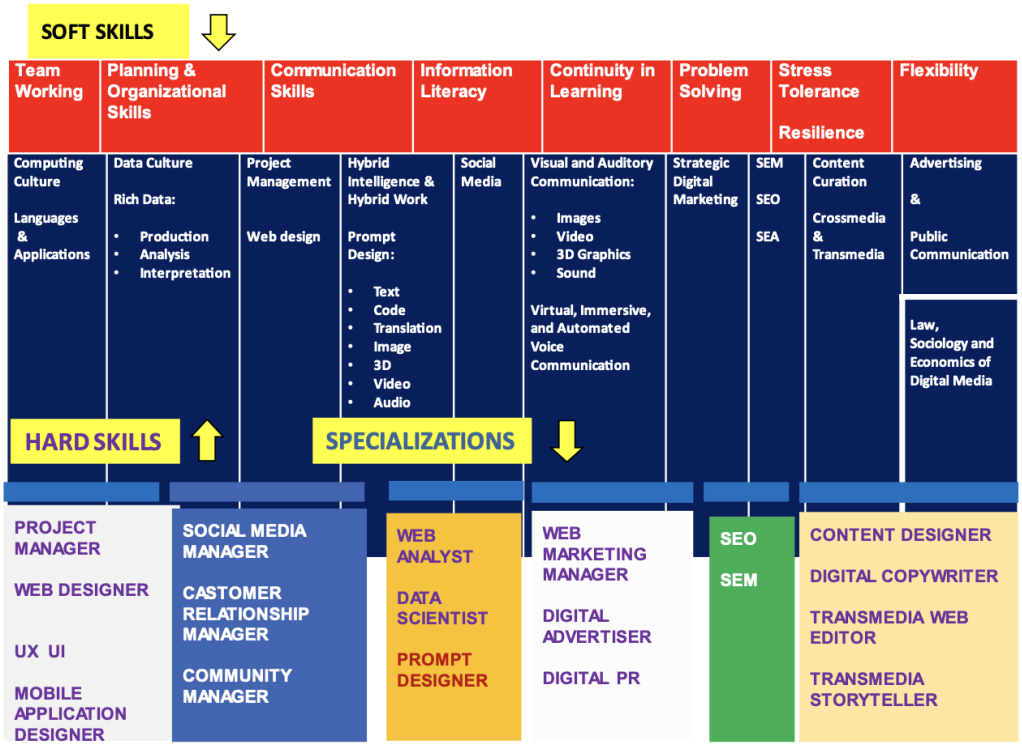


Figure 1 - Competences and Specializations of the Master in Communication Design.

First, the nature and outcomes of interactions with these systems suggest that cultivating breadth and robustness in foundational knowledge should take precedence over deep specialization.

Second, competencies in Hybrid Intelligence and Hybrid Work should be explicitly included among core skills, along with Prompt Design, understood as a body of general and applied

knowledge on the operation and application of generative AI systems. Similarly, in courses covering topics directly influenced by these systems, dedicated modules and practical experiences in Hybrid Intelligence — i.e., human–AI collaboration — and Hybrid Work should be incorporated.

Specifically, design competencies should include both general aspects of interaction with systems and handson experiences in co-designing and co-implementing with these systems.

This approach tests critical thinking skills and independent judgment, discourages a passive use of these systems, and strengthens awareness that their use demands continuous verification of the truthfulness, accuracy, coherence, and ethicality of responses. It consequently encourages a broader utilization of alternative resources for documentation and knowledge verification.

Thirdly, alongside fostering individual proficiency in the use of such systems, it is essential to promote collaborative skills within groups to prevent fragmented practices and internal competition within work teams, which remain crucial to the success of any design and production activity, particularly in digital communication.

Fourthly, the educational pathway should prepare participants to engage in unique and innovative forms of experiential learning, such as participation in communities of practice and peer-to-peer exchanges: “the best ways to use these AI systems are not provided by their developers and appear to be best learned via ongoing user trial-and-error and the sharing of experiences and heuristics via various online forums like user groups, hackathons, Twitter feeds, and YouTube channels” (Dell’Acqua et al., 2023, p. 3).

5. Conclusions

The significant impact of generative AI on the professional domain of knowledge workers, digital creatives, and, more broadly, all highly skilled professionals is primarily due to the versatility of these systems, which can be applied across a wide array of professional activities, enabling the completion of tasks across various domains such as creativity, analytical reasoning, writing proficiency, and persuasive skills. Additionally, it hinges on their ability to directly enhance the performance of workers who use these systems without requiring substantial organizational or technological investment.

AI capabilities establish a “jagged technological frontier,” where certain tasks are easily managed by AI, while others — despite appearing similarly complex — remain beyond AI’s current reach. Practical usage experiences suggest that the boundaries of this frontier are already wide enough to yield high-quality outcomes in the professional context.

Emerging experiences in the field of digital communication demonstrate that many core activities and tasks within this professional sector — such as Digital Documentation, Project Management, Web Design, Writing (summarization, style, etc.), Translation, Code Production, and Multimedia Content Production — graphics, images, video, 3D, and audio — can be effectively carried out through a human-AI partnership. Many of these tasks fall within the boundary of the “jagged technological frontier.” Beyond this frontier lies the pursuit of maximum originality and innovation, which underscores the complex relationship between this partnership and creativity, a relationship marked by diverse perspectives and attitudes among creative professionals themselves.

Furthermore, experiences to date and contextual analyses suggest profound changes in the practical aspects of this profession, impacting work organization, workflows, and the essential competencies required for effective practice.

Since the evolution of knowledge and competencies remains central, the nature, timing, diversity, and significance of changes influencing the professional domain of knowledge workers and digital creatives indicate a rapid evolution in their professional profiles and the requisite knowledge and skills. “Navigating the frontier requires competencies that must be developed through formal education [...] on-the-job training [...], and self-motivated professional upskilling by employees” (Dell’Acqua et al., 2023, p. 18).

To address these changes, continuous and recurring training is strategically important, particularly through institutional pathways and tools designated for this purpose within academia, such as Master's programs and

Third Mission initiatives. This underscores the need for a more structured and flexible institutional model for lifelong and recurring training within Italian universities, involving multiple, time-distributed interventions and integrating formal, non-formal, and informal learning pathways. Only in this way is it possible to enrich the robustness of formal courses through diverse forms of on-the-job learning, while also enhancing innovative training and self-learning models and tools emerging alongside technological advances, such as communities of practice and collaborative peer-to-peer learning.

To integrate these components into a lifelong learning approach, this process should be initiated as early as the design phase of Master's programs, structurally linking Master's curricula with Third Mission initiatives. In terms of Master's program design, the development of human-AI interaction suggests, first, that it is essential to prioritize breadth and robustness of foundational knowledge over depth in specializations. Second, Hybrid Intelligence and Hybrid Work should be explicitly included among core competencies, as well as Prompt Design. Third, both individual and group capabilities in using these systems should be cultivated. Fourth, the educational path should prepare participants to engage in unique and innovative forms of experiential learning, such as participation in communities of practice and peer-to-peer exchanges.

This work represents an initial reflection. Numerous research topics remain open, particularly concerning the evolving impact of generative AI systems on work and the resulting demand for training. Among the topics related to the impact on work are the balance between STEM and humanities skills within work teams, the effects on creative work, the implications for medium-skilled specialists, and the shifts in work organization within design and production teams. Regarding the demand for training, it will be essential to monitor the evolution of perceived needs by companies and practitioners, as well as the approaches implemented to address these needs effectively.

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· Section 6 ·
Diversity, Equity, and Inclusion

ICF and Artificial Intelligence: personalisation techniques from an inclusive perspective in the Asklea chatbot

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Abstract

In recent years, the topic of artificial intelligence (AI) has gained increasing importance in research and applications, also in the educational and didactic sphere. One of the aspects investigated in this field is the evaluation of the impact of devices incorporating AI components on learning processes and inclusion, within innovative educational contexts. Analysing the case of conversational chatbots, the report will highlight how such devices are still not designed for interaction with pupils with special educational needs, and even more so with disabilities, excluding them from use and in fact constituting a barrier from an inclusive perspective. In order to intervene on this aspect, IRCIT(International Research Center for Inclusion and Teacher Training) and the company Talent (a training organisation accredited by MIUR and active for years in the field of technological research) have undertaken a collaboration aimed at creating a conversational chatbot capable of interacting with students with all types of functioning: through specific prompt engineering techniques applied to the system message and based on the ICF coding found in school documentation, IRCIT and Talent are working on the development of AskLea, a chatbot capable of adapting communicated imagery, ways of expressing oneself, types of concepts, vocabulary, syntax and emotional tone to the functioning characteristics of different disabilities. In this way, this tool can be used within inclusive and special education, to allow pupils with disabilities to use it directly – and not through the support teacher – in the teaching-learning processes addressed to them.

Keywords: Artificial Intelligence, Chatbots, Personalization, Inclusive Education, ICF.

1. Introduction

In recent years, there has been an increase in studies and research in education and neuroscience aimed at studying the impact of artificial intelligence (AI) on learning processes, within innovative educational contexts. From these it emerges how AI, applied to education, identifies an emerging and priority area for promoting inclusive, engaging and effective learning environments, such as, for example, *smart classrooms* and the dual-teaching experiences possible in them, in which “cobots” flank the classroom teacher as “co-workers” in the role of tutor or peer-educator (Panciroli, Rivoltella, 2023).

As the European Commission's Communication on Artificial Intelligence points out, the term “artificial intelligence” refers to “all those systems that exhibit intelligent behaviour, capable of analysing their environment and performing actions with a certain degree of autonomy, in order to achieve specific goals” (European Commission, 2018). On the other hand, the term “generative”, often associated with “Artificial Intelligence”, indicates all those software programmes that produce content from information, sounds or images, based on Deep Learning, i.e. an artificial architecture that simulates the human brain based on a significant database and substantial computing power and memory capacity; It outlines “a field of research that is based on the creation of learning models on multiple levels, with particular reference to the learning of verbal and visual data that are not provided by humans, but are learned through the use of statistical computing algorithms with the aim of understanding the functioning of the human brain” (Panciroli et al., 2020, p. 5).

Deep Learning is the basis for Intelligent Tutoring Systems (ITS) in education, used as tools for simulating personalize one-to-one tutoring. Through ITSs, it is possible to monitor a student's performance as well as to customise teaching actions on the basis of adaptive processes aimed at the respective learning style: selecting suitable contents and activities; providing cognitive support through explanations, suggestions and feedback in real time; stimulating interaction and active learning; promoting collaborative learning.

AI-based conversational learning chatbots are indicated by several *systematic literature* reviews as one of the most effective ITS applications that can act as virtual teaching assistants. They can provide effective support both to students, assisting with study and homework, configuring a personalised learning experience and contributing to the development of specific skills; and to teachers, increasing the interactivity of lessons, providing design cues and facilitating the preparation of teaching materials (cf. Labadze, Grigolia & Machaidze, 2023).

The authors of this contribution are members of the IRCIT (International Research Centre for Inclusion and Teacher Training), an inter-university research centre directed by Prof. Gianluca Amatori, whose aim is to promote and carry out scientific research activities in the field of school and social inclusion and teacher training. Among IRCIT's various collaborative relationships is the one with Talent, a training organisation accredited by the Ministry and a company that has been active for years in the field of technology applied to education and training. The focus of the research activity promoted by IRCIT and Talent is to structure, test and validate generative Artificial Intelligence systems in the perspective of *inclusive* education.

One of the projects at the centre of this collaboration is AskLea, a conversational chatbot designed as a study support, aimed at primary, secondary and university students. Unlike other conversational chatbots, AskLea is based on precise educational and pedagogical principles: it does not solve exercises or generate solutions in the student's place, but rather supports and stimulates him in his learning process through the deployment of personalised tutoring. Although, in general, conversational chatbots are designed to dispense - as we said- personalised support to students, the level of personalisation envisaged is not designed to be extended to the non-normotypic functioning of pupils with special educational needs or, even more so, with disabilities: in everyday teaching practice, the latter remain de facto excluded from the use of such tools, being able to access them only indirectly, through a classmate or a teacher.

The research question on which this contribution is based is therefore the following: is it possible to remove this barrier so that a conversational chatbot such as AskLea can be used without impediments within inclusive and special education, enabling pupils with disabilities to interact directly within the teaching-learning processes aimed at them?

On this line of research, it soon became evident that this type of interaction requires a precise and “profound” chatbot setting, capable of guaranteeing an adaptation, for example, of the imagery communicated, the ways of expressing oneself, the type of concepts used, the vocabulary, syntax and emotional tone, to the functional characteristics of subjects with different functionalities.

Such detailed personalisation must necessarily be based on an equally detailed description of the pupil, capable of meeting the following characteristics:

1. be based on *non-contingent* and *unambiguous* elements, with the risk of otherwise being of little use, in the first case, and little comprehensible to the AI model underlying the chatbot, in the second;
2. be precise and centred on the *actua*l functional characteristics of that type of disability and, at the same time, of its peculiar actualisation in that specific student with a disability;
3. be scientifically *reliable*, i.e. coming from competent subjects and not the result of improvisation by non-expert personnel;
4. be easily *available*, so that it can be effectively implemented in everyday school reality.

The only type of description capable of satisfying the parameters listed above has been identified by us as that found in the ICF Key Functioning Profiles, which accompany the school and work process of people with certified disabilities: these profiles, in fact, are – by definition – compiled in a standard and unified (and therefore unambiguous) language, they use precise codes/descriptors centred on detailed elements of the person's functioning, they are easy to find because they are

present in the school documentation and they are drawn up by competent subjects, such as the specialists present in the multidisciplinary assessment unit provided for by Italian legislation.

2. Materials and Methods

Having identified the Functioning Profile as the source of information about the student with disabilities, the problem shifted to the technical side: how to set up the conversational chatbot's interactions with this student to make them appropriate to his functional characteristics?

On the basis of these premises, it is evident how on a methodological level our research is now at the beginning of the iterative process of *User Experience Design*, based on the phases of *exploration, design* and *validation.*

In the first *exploration* phase, instead of the usual investigations aimed at defining the *user experience* – such as qualitative interviews, focus groups or shadowing – we defined the categories of needs of our target-users (students with disabilities) on the basis of the most common characteristics detectable in the ICF functioning profiles regarding the various types of disabilities (for example, for intellectual disabilities, thinking linked to the concrete-operational dimension, difficulties in maintaining attention, attentional focus, thought form, cognitive flexibility, etc.).

Thanks to these functioning "constants" emerging from the ICF profiling of the different types of disability, it was possible to identify the needs of the target users and, consequently, the areas of "technical" intervention on the AskLea chatbot, bypassing the *concept testing* phase typical of *user research*.

The subsequent design phase therefore started from the need to effectively set up AskLea's interactions with such users on the basis of these "constants". In order to be able to pursue this objective, they necessarily had to influence the basic setting of the chatbot, intervening with specific *prompt engineering* techniques applied to the *system message*.

In general, *prompt engineering* is a mode of intervention aimed at improving the capabilities of LLMs on a wide range of common and complex tasks, such as answering questions. In our specific case, the information inherent to such "constants" necessarily had to flow into what are termed "system prompts", i.e. the "hidden" instructions provided to the AI model in a special interface (system) so as to determine the dialogical modalities between the user (the one who makes requests to the chatbot) and the so-called assistant (the textual output of the chatbot issued by the AI model) (Figure 1).

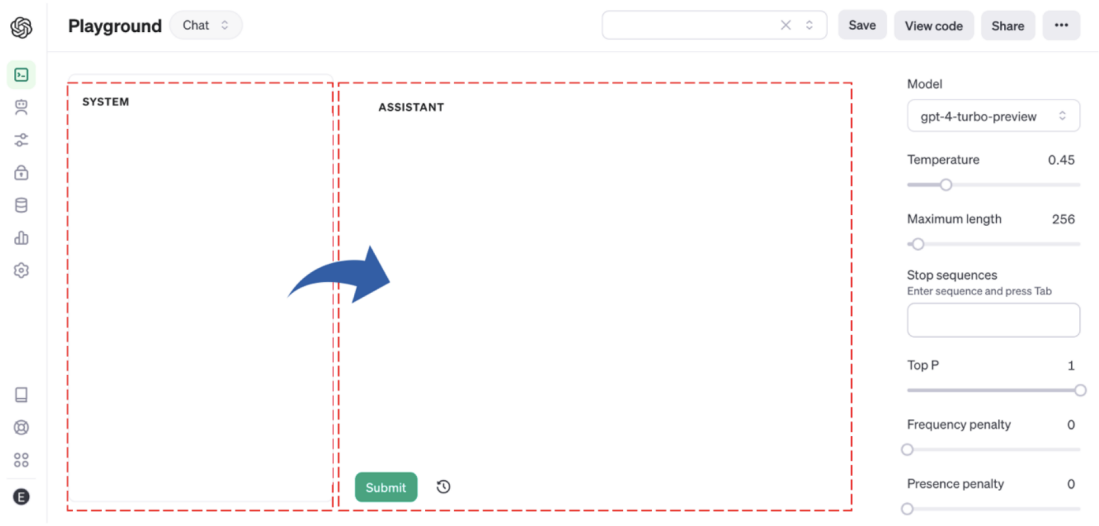


Figure 1 - The prompt and the system message: hidden instructions.

Since on a procedural level it is unthinkable to envisage an intervention by the chatbot operators in relation to the functioning profile of each pupil, it became evident that the "system prompts" should have a – so to speak – dual nature, comprising:

1. a *fixed, closed, basic* part, set up by the chatbot manager and valid for each interaction with students with disabilities (definition of the role, context, model behaviour rules, etc.)
2. a *variable, open part*, implementable from the outside by means of input provided by the user inherent to the functional characteristics of that particular student with that disability.

Thanks to these open fields of the prompt, certain authorised users (such as, for example, class teachers) become able to customise the IA model from the outside by entering both general data referring to the pupils (name, years, class) and – especially – specific data, such as ICF codes. For this purpose, a special graphical interface has been designed for each student in the class (and, even more so, for those with disabilities), in which the teacher can easily enter all the aforementioned information: this thus complements the system prompt, which in turn sets up the interaction between the virtual assistant and the disabled pupil in a customised manner suited to their specific functional characteristics (Figure 2).

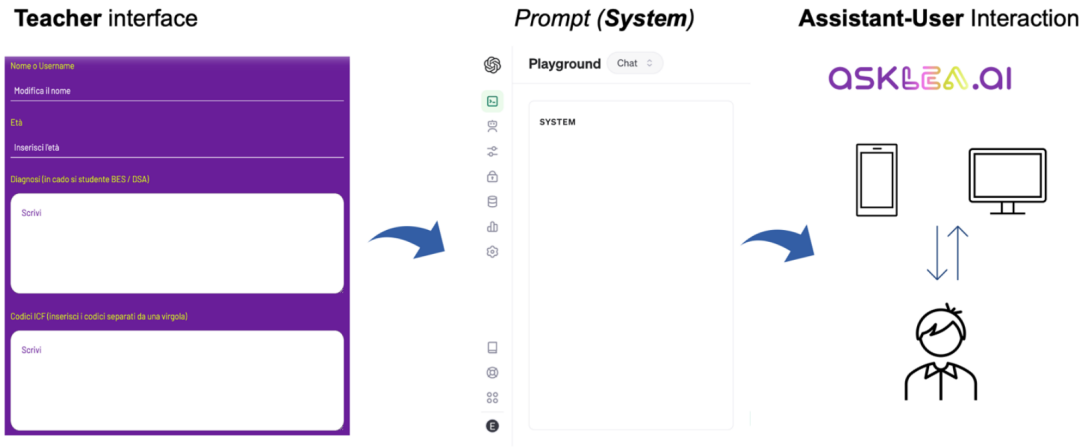


Figure 2 - Example of prompt engineering aimed at customising the basic output with reference to ICF codes.

Thanks to the addition of a special slot inserted in the graphical interface, the teacher is given the opportunity to further intervene, adding to this description endowed with precision and reliability – given the standard and codified language of the ICF – also a free description of the student, centred on other and complementary aspects such as, for example, interests, passions and character peculiarities. With regard to the design of the personalisation modalities of the AskLea chatbot, another intervention is planned at the system level, aimed at orienting the AI model towards the textual analysis of the students' requests, so as to adapt – in an alternative and complementary way to the ICF codes – the assistant's outputs to the students' conceptual and linguistic peculiarities.

In the school year 2024-2025, the large-scale *validation* phase based on the mixed methods approach will be launched, with the aim of providing an in-depth, multidimensional analysis through the integration of quantitative and qualitative data. In preparation for this, a preliminary *try-out* step was conducted during the current school year, aimed at defining the reference sample and validating the methodological tools used; within this, we started a reconnaissance on the actual usability of AskLea as a generic support (not specifically aimed at students with disabilities), in order to implement the research design.

This reconnaissance was conducted using questionnaires inspired by the System Usability Scale (SUS), a standardized questionnaire used for the assessment of perceived usability (Lewis, 2018), with the aim of verifying the proper functioning of a digital product: it consists of 10 items that measure ease of use, effectiveness and user satisfaction.

We started from this questionnaires to assess both technological usability with reference to the degree of usability and ease of use of the AskLea chatbot, and didactic-pedagogical usability to assess its usability in terms of learning support.

In the validation phase to be launched in the coming school year, the usability of AskLea as a support for students with disabilities will be tested through the Accessible Usability Scale (AUS). Inspired by the System Usability Scale (SUS), the Accessible Usability Scale consists of ten questions administered at the end of a user experience to calculate a score.

The analysis of the usability data will follow the SUS scoring method (Brooke, 2013) and AUS.

Within the quality-quantity dichotomy is the mixed methods approach, whose methodological structure is characterized by various research strategies to explain and analyse the phenomenon from different perspectives “the pragmatic principle guiding the mixed methods theory is to increase the investigative force and to avoid the weaknesses of individual approaches” (Mortari, 2009).

In this synergetic research-action approach, Bryman (2006) describes some peculiarities:

1. credibility and reliability: the integration of quantitative and qualitative data fosters greater accuracy in the results acquired by triangulating information from different sources as a validating reinforcement of the research;
2. deep understanding of the context: mixed methods allow the complexity and multidimensionality of the phenomena under investigation to be grasped, providing a more comprehensive and nuanced view of the context in which they occur. Through the analysis of quantitative and qualitative data, researchers can better understand the relationships between the different variables at play, identifying factors not always evident with a monomethodological approach; comprehensiveness of data: the synergistic use of quantitative and qualitative methods allows a wider range of data to be collected, providing a more complete overview of the object of study. Quantitative data provide a more structured overview, while qualitative data offer a deeper understanding of the individual experiences, experiences and motivations of the subjects involved.

The present empirical study therefore aims at reconstructing the data “according to a multi-perspective view, making use of more varied research questions, with a broader spectrum as we seek to exploit the strengths of both qualitative and quantitative research” (Maugeri, 2022, p.127). An exploratory strategy will be pursued with the aim of surveying the research objects in depth, which will be articulated, as reported by Trinchero and Robasto (2019), in closely interconnected phases. A quantitative survey will be conducted to collect structured and measurable data which will be analysed using statistical techniques to validate the hypotheses and quantify the relationships between the variables involved. The results of the quantitative analysis will provide an overview of the phenomenon under study and will help to circumscribe the areas of greatest interest for further in-depth qualitative investigation using tools and methods such as interviews, focus groups and observations in order to grasp the nuances that cannot be fully captured by quantitative data; this step will favour the development of new hypotheses and research questions. This will be followed by a final phase of integration and synthesis of the results obtained from the quantitative and qualitative analyses, which will be presented in a coherent and synergetic manner with the theoretical reference model in order to triangulate the data and reinforce the validity of the research, build a more complete understanding of the chatbot and identify further and new connections between the various aspects analysed.

On the basis of an in-depth literature review on the topic, a battery of structured questionnaires with closed and open-ended questions will be developed. The aim of these instruments is to investigate and assess first of all the levels of practical application of the chatbot from an inclusive, didactic and structural point of view; as well as the self-perceived competences of the user in relation to the use of AI in relation to the knowledge possessed, the skills developed and the attitudes manifested by the individuals in relation to the specific field of interest. The use of both closed-ended and open-ended questions will ensure a broad and comprehensive data collection; closed-ended questions will allow for easily analysable quantitative data, while open-

ended questions will encourage the emergence of more articulate responses by offering a deeper understanding of the experiences and opinions of the individuals involved.

The research will involve a sample of about 100 students of each school level and grade: from primary school, attended by pupils aged between 6 and 11, to first and second stage secondary schools, attended respectively by pupils aged between 11 and 14 and between 14 and 18, for a total of over 300 students. To these is added another sample of approximately 100 university students.

In addition, since the tool is designed and structured not only as a teaching support for students but also for teachers, in order to foster the deepening and personalisation of learning by improving teaching effectiveness and creating a more inclusive, engaging and motivating teaching context, about 100 inservice teachers, including support teachers and inclusion contact persons, will be involved. The data collected will be analysed using statistical and qualitative techniques to identify the strengths and weaknesses of the teaching tool and to understand its impact on student learning. The results of the experimentation will be presented in academic journals of international relevance and will help to shed light on the effectiveness of the teaching tool under investigation, providing valuable information for its implementation in diverse educational contexts.

3. Results

In order to be able to answer the initial research question, based on the possibility of removing barriers to the participation and direct use of conversational chatbots for pupils with disabilities within inclusive and special education, we implemented a series of *prompt engineering* interventions – both generic and ICF-based – at the level of the system message. Beyond the individual cases, what is relevant is the logical progression of the same as well as the different reaction of the AI model to the variables inserted each time as new elements. The first type of *prompt engineering* intervention was based on the gpt 3.5 turbo AI model, with the temperature level – the degree, so to speak, of “creativity” of the assistant's output – set to the low-medium level of 0.45 (the range is 0-2).

The system prompt provided indications of the school grade (secondary school), the student's name and age (13 years), as well as reference to a generic 'middle-grade intellectual disability'; on this basis, the user was then asked to briefly state the science topic “the digestive system” and to answer the user's questions “in a manner *appropriate* to his or her disability”.

The output generated by the assistant was characterised by being very short (well below the set number of tokens) and, above all, by the use of *many specific terms*, which are not commonly used, not linked to concrete-operational thinking and not explained (e.g. “gastric juices”, “nutrients”) and, therefore, not very suitable in the case of intellectual disability.

The second type of *prompt engineering* was based on the AI model “gpt 4 turbo preview” with the same temperature level as the previous one (0.45). The system prompt provided the same prompts as the first example.

In this case, the output generated by the assistant was longer and set out in points (answers to guiding questions); but the most notable aspect was that the answers contained many similarities related to concrete-operational thinking (the body “like a factory”; the oesophagus “like a chute”, the stomach “like a big pot”), closer to the conceptual universe of intellectual disabilities, as well as fewer specific terms not explained.

The third type of *prompt engineering* was set up in the same way as the previous one, with a new element introduced this time in the system prompt, through the addition of some generic ICF codes (b117.3, d310.32 and d330.32) without description, compatible with “average grade intellectual disability” and introduced with the instruction to adapt the answers to the student's functioning by “considering” them (Table 1).

The output generated by the assistant showed interesting changes. The text, which was longer than the previous one and was still presented in points (answers to guiding questions) contained,

in several cases, the ICF codes entered in the system prompt, with the correct description attached (proving that they were part of the *dataset* of the chosen AI model, and therefore perfectly "interpretable" by it); the similarities linked to concrete-operational thinking were more numerous and, symmetrically, the specific terms used were almost absent, some being explained by the addition of a synonym.

The fourth and final type of prompt engineering intervention was again set up like the previous one, with several detailed ICF codes added to the prompt (b117.3; b1400.3; b1402.3; b1440.2; b1601.3; b1602.2; b163.2; d310.32; d330.32; d160.3; d1632.3; b1643.3) (Table 2).

Table 1 - Generic ICF codes in the third type of prompt.

b117.3	Intellectual functions. General mental functions needed to understand and constructively integrate the different mental functions, including cognitive functions and their development throughout life.
d310.32	Communicating with - receiving - messages in the spoken language.
d330.32	Talking

Table 2 - Generic and specific ICF codes in the fourth prompt type.

b117.3	Intellectual functions
b1400.3	Maintenance of attention. Mental functions underpinning concentration for the time needed.
b1402.3	Multiple attentional focus. Mental functions that allow one to focus on two or more stimuli at the same time
b1440.2	Short-term memory
b1601.3	Form of thought. Mental functions that organise thought with respect to coherence and logicality.
b1602.2	Thought content. Mental functions pertaining to the ideas present in the ideational process and what is conceptualized
b163.2	Basic cognitive functions
d310.32	Communicating with - receiving - messages in the spoken language
d330.32	Talking
d160.3	Focusing attention
d1632.3	Hypothesis
b1643.3	Cognitive flexibility. Mental functions involved in changing strategies, or switching from one mental set to another, particularly involved in problem solving
e330+3	People in positions of authority. The teacher substantially facilitates the child's learning

The output generated by the assistant was approximately the same length as the previous one but, this time, with a further and noticeable increase in similarities based on concrete-operational thinking, the absence of specific terms not explained, and the use of only two specific terms, explained not through synonyms but through as many similarities based on concrete-operational thinking (Figure 3).

Similar *prompt engineering* tests were carried out with variations inherent to subject and discipline, age and school order/grade: the type of reaction of the AI model to the ICF codes was in line with those described above, confirming their usefulness for effective and timely personalization.

The results of this study on AskLea have several implications for education and the integration of virtual resources in the classroom. It is an engaging and easy-to-use resource that can effectively support teaching-learning activities, in all its phases and in all the different declinations of personalisation. A customised conversational chatbot in the manner shown above can be an indispensable support for the *student with disabilities* in order to develop, even on an individual basis, knowledge and skills to be poured into group teaching activities with classmates.

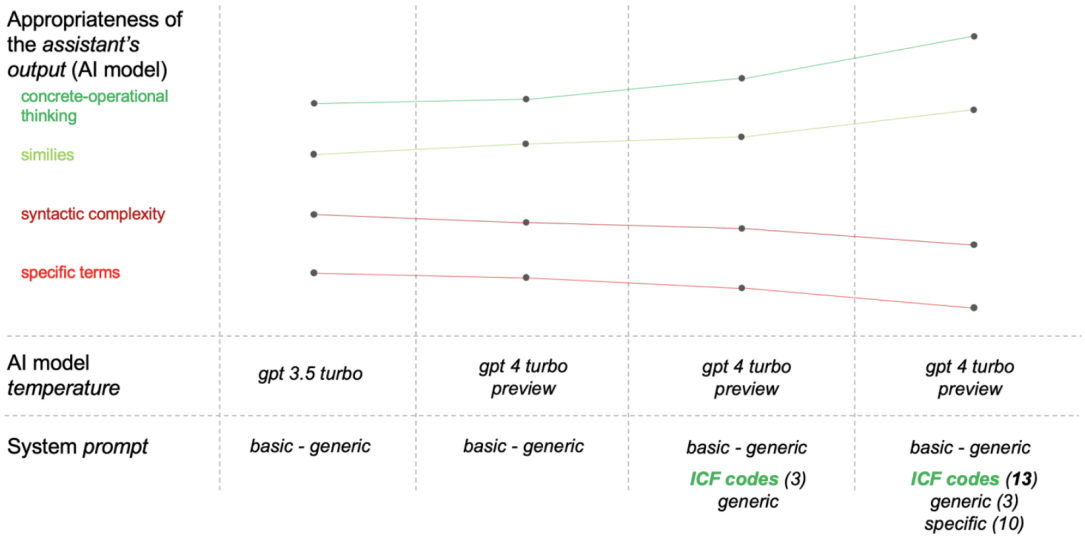


Figure 3 - The various types of prompt engineering and the assistant's response in relation to ICF codes (intellectual disability).

It can also be a support for the teacher in his or her teaching activities: the chatbot, in fact, should not be thought of as a substitute for the teacher, but as an aid to the same in providing materials and cues for didactic interaction, within a communicative and relational triangulation that envisages different modalities and directionality; and also in offering modes of interaction suited to the type of disability, especially in the case where the teacher does not have many skills in this regard, as, for example, in the case of a teacher in charge of teaching support, but not specialised, or in the case of a curricular teacher with little – or no – knowledge of special and inclusive teaching, especially when he/she cannot count on the help of a colleague specialised in teaching support. In this sense, the chatbot may be a valid tool to partially compensate for these cases of *systemic* deficiency in the Italian school.

But, in a broader sense, it can be considered a *systemic support tout court* because it is also useful at home, especially in the – very frequent – cases of parents or family members with manifest difficulties in providing help to their child in their learning process.

Following these initial phases of the experimentation carried out, several suggestions emerge for further avenues of future research. One of them will necessarily have to focus on *prompt engineering* interventions at the system level and in an ICF key also with reference to other types of disabilities: the most appropriate levels of customisation have been recorded with regard to cognitive disability (which in any case represents one of the most widespread disabilities), but there is still a need to work towards adequate and punctual customisation also with reference to the "constants" emerging from the functioning profiles of other disabilities. Also the reference, at the prompt level, to other types of didactic activities will be necessary, addressing not only the request of informative output to the chatbot (at the knowledge level) but also the performance of graded and progressive exercises (at the skill level) as well as the review of topics (addressing the request of input to the user).

Another promising area of investigation is the implementation in AskLea of AI systems capable of operating a visual 'translation' of text into images (text to image) (as in the case, for example, of DALLE 2, developed by OpenAI) or of operating a similar visual 'translation' of text into video (text to video) (as in the case, for example, of Sora, also developed by OpenAI). This would further increase the inclusive scope of the AskLea chatbot, providing teachers and students with the possibility of having at their disposal, in an immediate and facilitated manner, a multiplicity of means of representation and expression from the perspective of Universal Design for Learning (CAST, 2011), as well as opening up interesting perspectives regarding the learning of students with disabilities in which visual perception plays a decisive role, as, for example, in autism spectrum disorders.

This study undoubtedly has its limitations. Indeed, it was chosen not to rely on controlled usability tests typical of user research but to assume the needs of students with disabilities on the basis of the "constants" emerging from their ICF-based functioning profiles. Therefore, it is possible that valuable information was lost with regard to actual usability in authentic contexts, which, on the other hand, presented the problem of information gathering in the case of, for example, students with disabilities relating to abstract thinking. Subsequent validation phases of the AskLea chatbot will provide valuable information regarding the degree to which barriers to use have been removed, the degree to which it is actually used within inclusive teaching activities in the classroom or for individual study at home. Future research should investigate these factors in order to offer practical guidance to teachers and parents/educators on how best to use AskLea for school/inclusive and home/individual learning.

4. Conclusions

This study focused on the first exploration phase and the subsequent *design* phase of a conversational chatbot (AskLea) capable of offering personalised tutoring for students with disabilities in schools of various levels (from primary school to university).

On the basis of the above, it is evident that the response of the AI model underlying the chatbot to a greater and more detailed description of the functioning of the student with disabilities provided by ICF codes was clear and relevant, allowing the generation of outputs much more suited to the characteristics of the same.

The subsequent *validation* phase, planned for the next school year 2024-2025, will involve a broad sampling of students of all school levels, and in-service, curricular and support teachers. The feedback that will be collected through both qualitative and quantitative usability tests, as well as through mixed methods design, will allow the chatbot to be further improved, widening its scope as a 'systemic' support able to intervene on some critical points of the school universe, such as, for example, in providing teaching materials and interaction methods suitable to the type of disability in the case of teachers in charge of teaching support, but not specialised, or of curricular teachers with little knowledge of special and inclusive teaching; or in the case of parents or family members who have difficulty in supporting their son/daughter with disabilities in their learning process.

The presence in schools of functioning profiles drawn up in detail and in an ICF key by specialists, as well as the increasingly desirable training of teachers in the skills required to draw them up, are prefigured as necessary preconditions for an increasingly effective and widespread use of AskLea within a communicative and relational triangulation.

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Towards inclusive higher education: a comprehensive approach to enhancing accessibility for blind and visually impaired students in the TOLC context

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Abstract

The TOLC (Test Online CISIA) is an online test used by Italian universities to assess the readiness of prospective students for university studies. It's a crucial gateway to higher education in Italy, currently presents a barrier for blind and visually impaired students. This online assessment, delivered through multiple-choice questions, lacks accessibility features that hinder equal participation. The test is administered electronically, and the questions are presented in a multiple-choice format. However, the TOLC test and its preparatory materials are currently inaccessible to blind and visually impaired students. This paper will discuss the importance of accessibility for blind and visually impaired students and will outline the specific challenges faced by these students when taking the TOLC test. The paper will also propose a number of recommendations for making the TOLC test and its preparatory materials more accessible.

Keywords: TOLC Test, Inclusion, Blind Student, Higher education, Visually Impaired.

1. Introduction

In the dynamic and evolving landscape of higher education, the quest for inclusivity and accessibility has emerged as a central imperative. The pursuit of higher education represents a transformative journey for individuals seeking to expand their knowledge, refine their skills, and contribute meaningfully to society. However, for blind and visually impaired students, this path can be fraught with challenges due to barriers in accessing and participating in educational opportunities. In the context of standardized testing, these barriers can be particularly pronounced, as traditional assessment formats often fail to accommodate the diverse needs of students with visual impairments. The TOLC serves as a crucial gateway to higher education in Italy, but there remains a significant need to further enhance accessibility for blind and visually impaired students.

The rapid expansion of higher education in the past two decades, as well as the growing diversity of providers and technological models for delivering education, have made higher education accessible to more students globally. Yet significant barriers remain for many vulnerable groups. A better understanding of inequality as well as new paradigms, strategies and a renewed political will for 'leaving no one behind' are required. Structural equity policies at all levels throughout the education system, as well as extraordinary measures when needed, should ensure that students from any background with the potential to succeed are fully integrated with equal opportunities into higher education (UNESCO, 2020). Higher education is, by definition, selective. The Declaration of Human Rights states that higher education shall be equally accessible to all on the basis of merit.

The ET2020 Working Group on Higher Education organised a peer learning activity in April 2019, which concluded that while social inclusion is high on the agenda in EU Member States, there are very few national strategies and comprehensive approaches with long-term policy commitments on social inclusion in higher education. Higher education inclusion policies should be part of a broader framework of cross-sectoral policies. Developing, strengthening and expanding higher education institutions' links with schools is key to improving inclusivity.

The concept of inclusione in higher education Is influenced by muiple factors on a worldwide scale (Scavarda et all, 2023).

2022 study highlighted that inadequate digital accessibility directly impacts the academic performance of students with disabilities (InclUDE, 2022).

2. Methodology

The methodology employed in this research encompasses a comprehensive literature review, conducted in the format of a scoping review utilizing the PRISMA method, complemented by semi-structured interviews with experts in the field and industry practitioners. The review was conducted using the following string:

2.1 TOLC or *CISIA* AND *accessibility*

The semi-structured interviews involved 10 experts in the field of typhlology, both from the practical and legislative spheres, as well as from the technical field.

The questions focused on the state of the art of the platform's accessibility, the reasons why it is not accessible to screen readers, what has been done so far, and what is being done to address the lack of technology capable of recognizing the autonomy of blind or visually impaired candidates.

3. Results and Discussion

While the scoping review yielded 44 results, of which only few met the inclusion/exclusion criteria, the semi-structured interviews produced interesting findings, which can be summarized as follows:

1. a series of regulations that deem it discriminatory to allow access to TOLC exams with the help of a sighted person.
2. an attempt by an Italian research group to make the platform accessible.
3. the platform was not designed with accessibility in mind from the outset.

We will discuss the results obtained in order. First, it is necessary to understand the conditions faced by blind individuals when they take an admission exam in Italy. In all cases encountered during interviews, the practice was to be accompanied by a sighted person who dictated the questions and answers to them, all in separate classrooms or confined spaces compared to their peers. It is important to remember that we are talking about individuals who possess computer skills equivalent to their colleagues, having been taught since childhood. Additionally, performing tasks under these conditions can be distracting.

It is crucial to recognize that blind individuals often possess computer skills comparable to their sighted peers. Many have been trained in assistive technologies from an early age, enabling them to navigate digital environments effectively. However, the traditional examination format does not leverage these skills. Instead of utilizing accessible digital platforms that allow for independent completion of exams, the current system relies on outdated methods that do not reflect the capabilities of blind candidates.

The challenges faced during admission exams extend beyond immediate academic concerns; they have long-term implications for the futures of blind individuals. When candidates are not assessed fairly or equitably, it can limit their access to higher education opportunities, ultimately affecting their career prospects. A lack of representation in academic settings can perpetuate stereotypes and hinder societal progress toward inclusivity.

Blind and severely visually impaired people currently do not have access to the TOLC test because the system on which it is programmed does not include the specific functions that respond to speech synthesis, the ability to select from the keyboard, and Braille readers. The non-

accessibility of the test violates the right of the blind to access the test under conditions equal to those of other candidates, and all due to a structural programming problem.

Here are three significant Italian laws that ensure the accessibility of digital products for people with disabilities:

- *Laws 04/2004*: Requirement to procure accessible solutions. A purchase contract that does not include provisions for accessibility requirements is considered null and void.
- *Law 67/2006*: Direct discrimination occurs when, on the grounds of religion, personal beliefs, disability, age, or sexual orientation, a person is treated less favorably than another person would be, has been, or could be treated in a similar situation.
- *Law 206/2003*: Indirect discrimination occurs when a provision, criterion, practice, act, agreement, or behavior that appears neutral may put people who profess a particular religion or ideology of another nature, people with disabilities, people of a particular age, or of a particular sexual orientation at a particular disadvantage compared to other people.

During the interviews, which in the case of blind and visually impaired people focused on questions such as “What difficulties did you encounter during university admission?" or "Are you satisfied with the accessibility services?”, a strong dissatisfaction emerges even before starting the university path.

In the case of experts in the field who participated in the interview, the focus was instead mainly on technical issues related to the platform's programming and then on what seems like a future hope. Seems a good challenge for academics and IT experts to build a new similar platform, accessible for BLV people.

Figure 1 below presents several examples of university entrance exam procedures for blind individuals in other countries, selected based on the availability of this information online. The modalities differ either by the complete accessibility of the software or by the availability of braille tests. In no case is a sighted person allowed to read the exam to them. Therefore, the solution remains the creation of a new accessible software, which seems to be in the pipeline at some research centers, but will require institutional support to be implemented (Figure 1).



Figure 1 - Examples of university entrance exam procedures for blind individuals.

As we can see, accessible software is achievable and indeed a reality in many countries around the world. Therefore, it is up to us to make it happen here. Certainly, we should avoid replacing

traditional braille with digital alternatives in an era where technological advancements cater to the specific needs of people with disabilities.

Assistive technologies can significantly enhance education for students with visual impairments. However, their integration has critical gaps, particularly in online examinations. Implementing computer-based testing (CBT) systems adds another layer of complexity to the logistical challenges related to resource allocation. This is particularly relevant considering the number of BVI students compared to the total student population (Al-Eidarus, 2024). At the University of Macedonia, a webbased examination system has been developed to facilitate access for visually impaired students from any computer with internet connectivity. Blind users require only screen reading software, while lowvision students can access information through reading, listening, or a combination of both methods (Papadoupolos, 2014).

Computerized Adaptive Testing (CAT), a product of scientific advancements and new technologies in the field of measurement and evaluation in education, may be considered beneficial in reaching more valid and reliable test results for students with visual impairment. CAT renders more reliable test results in less time with fewer items that are well-matched to the ability levels of students. When these basic properties of CAT are considered, we can state that the use of CAT in assessing the ability levels of students with visual impairment may provide a significant step in attaining fair and comparative test results (Senel, 2018).

4. Conclusions

The concept of inclusivity in standardized testing, such as the TOLC, has become increasingly paramount in recent years. The traditional model of one-size-fits-all assessment has been challenged by a growing recognition of the diverse needs and experiences of students. An inclusive TOLC, therefore, is not merely a matter of fairness; it is a fundamental right that ensures all students have an equal opportunity to demonstrate their knowledge and potential.

Building an inclusive TOLC requires ongoing efforts and collaboration from various stakeholders, including academic institutions, policymakers, and disability advocacy groups. By investing in research, promoting awareness, and fostering international partnerships, we can create a truly inclusive testing environment that empowers all students to succeed. The creation of an inclusive TOLC requires a collaborative effort involving multiple stakeholders. Academic institutions, policymakers, and disability advocacy groups each play a crucial role in shaping the testing environment. Academic institutions are responsible for developing inclusive curricula and ensuring that the test content reflects a diverse range of perspectives. Policymakers play a vital role in providing the necessary funding and legislative support for inclusive testing practices. Disability advocacy groups advocate for the rights of students with disabilities and provide valuable input on the design and implementation of inclusive assessments.

As technology continues to evolve, we can expect to see innovative approaches to testing that cater to a wider range of student needs. Adaptive testing, for example, can adjust the difficulty level of questions based on a student's performance, providing a more personalized and equitable assessment experience. Additionally, the growing emphasis on digital literacy and online learning presents opportunities for creating more accessible and inclusive testing environments.

In conclusion, building an inclusive TOLC is a complex and ongoing process that requires the commitment and collaboration of all stakeholders. By investing in research, promoting awareness, and fostering international partnerships, we can create a testing environment that empowers all students to succeed. The future of education depends on our ability to ensure that every student has an equal opportunity to demonstrate their potential.

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EFFIMERA – BEYOND TIME.
The use of immersive technologies, game-learning, artificial intelligence for accessible and inclusive enjoyment of temporary exhibitions of contemporary art

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Abstract

The project "EFFIMERA – BEYOND TIME" aims to utilize innovative technologies such as virtual reality, augmented reality, and artificial intelligence to make temporary exhibitions of contemporary art from the 20th century accessible and inclusive. Starting from the historical context of art exhibitions, the project aims to explore and reconstruct exhibitions from the second half of the 20th century, no longer accessible, such as Concetto Pozzati's first exhibition in 1968. Through research and documentation of existing materials, interviews, and the creation of multimedia content, an accessible web app will be developed for both computers and smartphones, allowing users to virtually explore past exhibitions enriched with interactive, educational, and experiential features. The project aims to serve as a research tool for the history of exhibitions, revive past exhibitions, create connections between museum institutions, make obtained content available, and enable accessible, educational, and engaging art experiences. Project phases include research and documentation, technology and framework development, and testing and evaluation. Technologies used include virtual reality, augmented reality, and artificial intelligence through the implementation of a web app.

Keywords: Accessibility, AI Education, Interactive Education, Virtually Explore Past Exhibitions Art, Contemporary Art.

1. Introduction

Art exhibitions, as we know them today, are a relatively recent phenomenon in cultural history. Originally, artworks were the exclusive domain of aristocratic elites, kept in Wunderkammer as symbols of power and prestige. In the 17th century in Rome, some masterworks were displayed publicly during religious celebrations, yet retained a ceremonial tone reflecting the wealth of their noble owners (Haskell, 2000). The French Revolution marked a decisive turning point: royal collections were opened to the public, thus inaugurating the modern museum concept with the establishment of the Louvre.

The turning point in art exhibition concepts occurred in 1876 with the Salon des Refusés, an exhibition that marked a clear break from traditional academic art. Universal Expositions, which began in the 1850s to showcase the latest scientific and technological discoveries on an international scale, also began including exhibitions of artistic, cultural, and ethnographic nature. This highlighted a growing interest in public engagement.

With the advent of the 20th century, the evolution of art exhibitions intersected and influenced the development of the artistic movements themselves, while the role of the audience became increasingly relevant, creating new needs and dynamics. Exhibitions became more creative, as demonstrated by the Futurists' exhibitions and the first international Dada fair, held in the early 1900s. Later, major events such as the International Exhibition of 1938 and the First Papers of Surrealism in 1942 showcased the artistic aspect of the event, merging the artist's role with that of the exhibition curator. The importance of the public continued to grow over time; however, museums and contemporary art exhibitions tended to become increasingly elitist and exclusive in an attempt to maintain the prestige of art. Despite this, accessibility and enjoyment of art were

recognized as a fundamental right, as emphasized by the 1948 Universal Declaration of Human Rights and the Italian Constitution. Between the 1960s and 1990s, curatorial and artistic practices evolved rapidly and diversely, generating ephemeral events, which today are often only fragmentarily documented, making their historical reconstruction complex.

With the advent of digital technologies, exhibition documentation has become more straightforward, although a fully integrated digital approach to documenting and enjoying artworks remains a distant goal.

1.1 Technological Evolution

The use of technology in artistic enjoyment is crucial, especially when it provides access to exhibitions, collections, and artistic performances that would otherwise be inaccessible. This need has intensified as technologies have become an integral part of daily life, although their cultural impact, particularly in terms of accessibility, remains limited. This limitation became evident during the Covid-19 pandemic (2020–2022), which amplified the need for new methods of remote cultural enjoyment to make art more accessible to everyone.In this context, the ability to revisit recent exhibitions, often poorly documented, through virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) takes on significant cultural and educational value. Reconstructing past temporary exhibitions using innovative technologies represents a significant evolution in how cultural heritage can be preserved and shared. Although temporary exhibitions are, by nature, ephemeral events that fade over time, digitalization and immersive techniques allow the public to experience artistic and cultural events of the past as if they were present, overcoming the physical limits of time and space.

1.2 The Project

"Effimera – Beyond Time" aims to revive, analyze, and enhance temporary exhibitions from the second half of the 20th century, using advanced technologies to reconstruct recent artistic events. Temporary exhibitions, by their ephemeral nature, often leave weak traces in collective memory and historical sources, creating a void in understanding and accessing the previously displayed artistic heritage. This lack of in-depth documentation and the ability to revisit such events limits both historical research and the cultural and artistic experiences of new generations.

The reconstruction of these exhibitions allows for the recovery of artistic experiences that are at risk of being lost, providing a more comprehensive view of the history of curatorial practices and artistic dynamics during critical periods. Additionally, it encourages reflection on the role of temporary exhibitions as spaces of artistic and curatorial experimentation, fostering a deeper understanding of the trends and innovations that characterized the latter half of the 20th century. Through the use of digital technologies, the project aims to transcend the limits of traditional documentation, creating a virtual archive that enables these exhibitions to be relived in a contemporary context. In an era where digital is redefining how we access culture, "Effimera – Beyond Time" opens up new perspectives for the enjoyment and study of past art, allowing for a direct connection between history and the possibilities offered by interactive and immersive technologies. This project not only contributes significantly to preserving the historical memory of ephemeral exhibitions but also lays the foundation for a dialogue between past and present that enriches the contemporary cultural landscape. Through an interactive experience, users can not only view the artworks but also move within the exhibition space, interact with the environment, and learn information via AI, enhancing the experience with historical and critical details.

1.3 Case Study

The project focuses on reconstructing the first retrospective of Concetto Pozzati, held in 1968 at the Salone Farnese in the Pilotta Complex in Parma (C. A. Quintavalle, 1968). This exhibition was a significant event not only for Pozzati's work but also for the development of curatorial practices and modern museology in Italy. The 1968 exhibition marked the beginning of a series of temporary exhibitions that accompanied the birth of the Centro Studi e Archivio della Comunicazione (CSAC) at the University of Parma, founded by Carlo Arturo Quintavalle.

CSAC became an important archive of contemporary art, design, photography, and architecture materials, as well as a research center for studying exhibitions, their organization, and their cultural impact.

The importance of Pozzati's 1968 exhibition lies not only in the artistic value of the works displayed but also in the crucial role it played in shaping a new exhibition model for contemporary art in Italy. Pozzati's works, oscillating between conceptualism and social criticism, were particularly suited to an innovative exhibition context like that of the Pilotta. The exhibition explored themes such as the perception of reality through media, the nature of visual language, and the dialectic between tradition and modernity (Pozzati, C., Quintavalle, C. A., 1968), themes that resonated deeply in Italian society at the end of the 1960s.

Concetto Pozzati left a significant mark on the artistic landscape, and the virtual reconstruction of his first retrospective offers a unique opportunity to revisit the works in their original exhibition context, providing the contemporary audience with a direct look at a cultural event that would otherwise be lost.

The project is part of the research activities of EXHIBIT – Laboratory Center for Studies on Exhibition History, an initiative of the University of Parma aimed at researching and documenting ephemeral exhibitions. The laboratory operates at national and international levels, promoting research on the history of exhibitions through projects, publications, digital platforms, conferences, seminars, and documentary exhibitions. It also supports teaching activities in undergraduate and doctoral programs, participating in third-mission initiatives. Through these activities, it contributes to enhancing archives and collections related to exhibition history, with particular attention to solutions offered by digital humanities (EXHIBIT – Laboratory Center for Studies on Exhibition History Acocella A., Casero C., Veratelli F., 2024).

2. Materials/Tools

The reconstruction of the 1968 exhibition is based on a combination of sources, including the original exhibition catalog, photos from the inauguration preserved at CSAC, documents, and works present in the Concetto Pozzati Archive in Bologna. In addition to physical documentation, the project includes the collection of firsthand testimonies, including interviews with those who participated in or witnessed the exhibition, providing a more detailed and multifaceted picture of the event. These sources will be integrated into the digital project, allowing users to access not only visual and textual information but also oral accounts that enhance understanding of the historical and cultural context.

2.1 Digitization

The thorough research of documentation and testimonies will allow preserving and making accessible an ephemeral artistic event that would otherwise be limited to memory or physical traces. These sources will be used to create an immersive experience through the use of virtual reality (VR), augmented reality (AR), and artificial intelligence (AI).

To develop the web app dedicated to reconstructing Concetto Pozzati's retrospective exhibition, various digital technologies will be used, resulting from an interdisciplinary approach that combines art, computer science, and museology. This project is based on synergy between technical expertise and archival resources, with the goal of creating an immersive, interactive, and, above all, faithful-tooriginal experience.

The first step involves acquiring and digitizing historical data, which is still in progress. Part of the research was conducted at CSAC in Parma to acquire and evaluate the available documentation, and at the Concetto Pozzati Archive in Bologna, which holds the primary materials for reconstructing the exhibition. The Pozzati Archive has provided period photographs and newspaper articles with critical texts that accompanied the event. These materials, particularly the archive photographs, have been the starting point for further research.

To study the exhibition layout, the original venue of the event, the Pilotta Complex in Parma, was involved. Additional period photographic documents were acquired, and photographic surveys of the Sala del Trionfo were initiated, which will be used for the 3D modeling of the exhibition spaces, scheduled shortly.

2.2 Technologies Used

Advanced 3D modeling software, such as Blender, will be used to accurately reconstruct the architecture of the Sala del Trionfo, the former Farnese Hall in the Pilotta, respecting the actual proportions and specific features of the exhibition space. The creation of 3D models of the exhibited works will be based on photographs and technical documentation, striving to match the size, color, and aesthetic details of each piece.Once the spaces and works are reconstructed in 3D, VR and AR systems will be integrated to allow users to immerse themselves in the virtual exhibition space. VR will offer a fully immersive experience, enabling free exploration of the environment and viewing the works from different angles. Users will be able to navigate physically or virtually within the exhibit, experiencing a setup that simulates the spatial arrangement and perception of the works. Additionally, the web app will provide remote access to the virtual exhibition, ensuring an experience that can be enjoyed globally without geographical limitations.

Augmented Reality (AR) will complement and enhance the exhibition experience by offering additional interactive content to visitors. Using devices such as smartphones, tablets, or computers, users can frame specific artworks to access extra information. This digital overlay will not only enrich the visual experience but also offer a deeper understanding of Pozzati’s creative process and the exhibition's historical context. In the Sala del Trionfo at the Pilotta in Parma, it will be possible to view the works in their original placement, creating augmented reality layers over the current exhibition layout.

Another crucial aspect of the project is artificial intelligence, which will play a key role in personalizing and enhancing visitors’ interaction with the exhibition. An AI-powered “virtual guide” will be capable of answering visitors' questions in real-time, providing contextual information about the works and the artist’s life, adapting the content based on the visitor's interests and knowledge level. This adaptive intelligence will allow users of different cultural backgrounds or experience levels to enjoy a more engaging and personalized exhibit experience. AI could also suggest custom thematic paths, guiding visitors through the exhibit based on specific preferences, such as artistic techniques, historical periods, or the symbolic meaning of the works.

The web app will be developed using Verge, a framework that allows seamless integration across various devices, including desktop computers, tablets, and VR headsets. The goal is to ensure a smooth and accessible experience, regardless of the device used. Special attention will be paid to accessibility: the interface will be intuitively designed to allow for easy navigation even for those unfamiliar with VR and AR technologies. User testing with pilot groups will provide valuable feedback for optimizing usability and enhancing interaction.

3. Methodology

The project is developed through innovative methodologies and multidisciplinary approaches that intersect across several fronts.

3.1 Historical/Artistic Approach

One of the main aspects of the project is the historical and artistic investigation, focusing on the evolution of exhibition practices and the role of the public over time. This approach includes the study of the history of exhibitions and the analysis of curatorial transformations that have influenced the presentation of contemporary art, especially in the latter half of the 20th century. In this context, changes in curatorial practices will be analyzed, which not only redefine exhibition modes but also impact how the public interacts with the works and interprets artistic messages (Parry, 2010). The 1968 retrospective of Concetto Pozzati represents a significant case study, as it

marks the beginning of a period of temporary exhibitions that led to the foundation of CSAC in Parma. Reconstructing this event through innovative technologies offers an opportunity to reflect on how the role of the public has evolved over time and how new technologies can further transform the contemporary museum experience.

3.2 Documentary and Technological Approach

Another crucial aspect of the project involves the acquisition and study of documentation related to the 1968 exhibition. This includes a careful survey of existing archival materials housed at the Concetto Pozzati Archive in Bologna, CSAC in Parma, as well as the digital acquisition of images, catalogs, curatorial notes, and other historical documents that help reconstruct the exhibition context. In addition to physical documentation, the project includes gathering direct testimonies, including interviews with those who contributed to the exhibition's realization or who attended the event, providing a more detailed and nuanced picture of the exhibition. These sources will be integrated into the digital project, allowing users to access not only visual and textual information but also oral narratives that enrich the understanding of the historical and cultural context. The precise digitalization of the documentation and testimonies will preserve and make accessible an ephemeral artistic event that would otherwise be confined to memory or physical traces.

3.3 Integration of Technologies: A New Standard for Ephemeral Exhibitions

By combining VR, AR, and AI, the project aims to establish a new standard for documenting and experiencing ephemeral exhibitions. Temporary exhibits often risk falling into oblivion once they conclude, with few traces left for future audiences to study or enjoy. Through this technological innovation, Concetto Pozzati's exhibition will not only be reconstructed and preserved but also made accessible to a contemporary audience, laying the foundation for new ways of engaging with the history of art and exhibitions.

This multidisciplinary and technological approach paves the way for a more dynamic and democratic experience, where interactivity and personalization become central elements of museum engagement. Additionally, this methodology could be applied to other historical exhibitions, creating a new form of archival access to cultural heritage that extends beyond permanent collections to embrace temporary exhibits, expanding the concept of the museum into the digital realm.

4. Expected Outcomes

4.1 Innovation and Museum Experience: The Future of Temporary Exhibitions

The "Effimera – Beyond Time" project aligns with a broader context of museum innovation, where the use of immersive technologies is redefining the very concept of exhibition experience. Temporary exhibitions, by nature, challenge traditional methods of preservation and art appreciation, requiring a more dynamic and interactive approach. The use of VR, AR, and AI not only enables the reconstruction of past events but also opens new perspectives for the design of future exhibits, creating an exhibition environment where digital interaction enriches the real experience. This "virtual exhibition" model could offer museums, especially those focusing on contemporary art, a way to preserve and showcase temporary events, allowing the public to explore exhibitions that would otherwise be inaccessible due to their ephemeral nature or geographic limitations. Furthermore, digital technology enables museums to transcend the physical limitations of exhibition spaces. In a virtual setting, there are no spatial or temporal boundaries, allowing for new and creative ways to connect artworks, historical contexts, and cultural information. This exhibition format represents not only an academic and curatorial challenge but also an unprecedented educational opportunity, engaging a global audience and promoting a broader dissemination of contemporary culture.

The project presents several key goals aimed at integrating academic research, accessibility, experiential learning, and playful interaction to offer a new form of access to temporary exhibitions.

4.2 Research Tool

One of the primary objectives of the project is to become a research tool for the scientific community. Through the reconstruction of the exhibition and the collected documentation, researchers will be able to study the relationships between the artworks, the exhibition layout, and the historical context. Particular attention will be given to analyzing curatorial practices, the communicative role of the exhibition, and how it interacted with the public at the time. Access to a virtual reproduction of the original exhibition will allow scholars to examine not only the individual works but also the spatial and temporal dynamics that influenced the audience's perception. Researchers will be able to explore how curatorial choices affected interaction with the artworks and how visitors interpreted artistic messages, offering a complete view of the exhibition as a complex cultural phenomenon.

This tool will be particularly useful for studies related to exhibition history and museum dynamics, allowing for detailed analysis of exhibitions that might otherwise be lost. Additionally, the availability of materials in digital format will facilitate information sharing among scholars internationally, promoting collaboration and innovation in research.

4.3 Accessibility

A fundamental aspect of the project is its focus on accessibility for all audiences. The goal is to ensure that the virtual experience is accessible not only to people with various disabilities but also to those without a specific cultural background. This will be achieved through an intuitive interface designed according to international accessibility guidelines, such as the Web Content Accessibility Guidelines (WCAG).

Special attention will be given to people with visual disabilities, who will be able to access audio descriptions of the artworks and the exhibition environment, as well as those with motor disabilities, who will have simplified navigation systems available. Additionally, content accessible through voice commands will be developed, facilitating interaction for those who may have difficulty using technological devices.

To ensure effective accessibility, field tests will be conducted in collaboration with specialized associations, such as the Istituto dei Ciechi Francesco Cavazza in Bologna, to identify and resolve potential issues related to the web app and the virtual exhibition. This inclusive approach not only broadens the exhibition's audience but also promotes a more equitable model of cultural engagement, taking into account the diverse needs and abilities of visitors.

4.4 Experiential Learning

Another central objective is to provide an engaging and stimulating learning experience through the use of virtual reality (VR), augmented reality (AR), and artificial intelligence (AI). The project aims to create an immersive environment where users can "enter" the exhibition and interact with the works in a direct and dynamic way. This approach represents a break from traditional museum experiences, where visitors typically observe artworks passively.

Through VR, users can immerse themselves in the exhibition space in an exceptionally realistic way, fully experiencing dimensions, perspectives, and the arrangement of artworks, as if physically present at the original exhibition. With AR, they can explore the current museum environment enriched by the reconstruction of the 1968 exhibition dedicated to Concetto Pozzati. AI will act as a virtual guide, offering additional information and answering users' questions, adapting responses based on each visitor's interests and level of expertise. This will enable personalized learning, promoting a deeper understanding of the artworks and the historical and cultural context in which they were presented.

4.5 Gamification and Interaction

To enhance engagement, gamification elements will be integrated to stimulate interaction and learning. Users can participate in challenges, quizzes, and games related to the displayed artworks, earning points or virtual rewards for completing tasks such as recognizing iconographic

details, interpreting artistic messages, or solving artwork-related puzzles. This playful component will increase visitor interest and motivation, offering an alternative way to interact with the exhibition contents and stimulating new perspectives. Gamified activities will help engage a younger audience, who can explore contemporary art interactively and enjoyably, promoting learning through play.

4.6 Territorial and Artistic Connections

Another goal of the project is to create territorial and artistic connections between the collections of the Centro Studi e Archivio della Comunicazione (CSAC) in Parma and other cultural institutions in the Emilia-Romagna region. This network will expand access to artworks, virtually connecting exhibitions and collections that would otherwise be physically distant.

Through the web app, visitors can explore works and documents housed in other museums and archives in the region, creating a virtual cultural route that links different institutions and enhances the region's artistic heritage. This collaborative approach promotes the sharing of cultural resources, broadening the audience and fostering greater awareness of local artistic heritage.

4.7 Archiving and Data Collection

All documentation acquired during the project will be systematically archived and made available to scholars and researchers. The digitization of archival materials, oral testimonies, and virtual reconstructions of the 1968 exhibition will be a valuable resource for future studies on exhibition history and curatorial practices. Additionally, the project includes data collection on user interactions with the application, providing insights into preferences and effective modes of engagement. These data will offer valuable insights into audience preferences, artworks and content that generate the most interest, and the most effective ways of engagement. This information will be useful for improving the exhibition experience and for developing more effective curatorial and communication strategies in the future.

4.8 Enhancing the Museum Experience

The analysis of data collected from user interactions will enable museums to improve accessibility and engagement, making exhibitions more visitor-friendly and stimulating. By analyzing this data, curators can tailor content and presentation modes to audience needs, providing a more personalized and dynamic museum experience. This knowledge will also contribute to a deeper understanding of contemporary art engagement methods, offering valuable insights for the design of future exhibitions and cultural events.

5. Discussion: the role of digital technologies in Cultural Heritage Preservation

The project “Effimera – Beyond Time” highlights the importance of integrating virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) into the preservation and enhancement of cultural heritage, sparking a discussion on how these technologies could transform contemporary museology. The virtual reconstruction of past temporary exhibitions not only preserves unique artistic events but also makes them accessible to a global audience, overcoming limitations of time and space. However, the introduction of these technologies raises a range of reflections and challenges that deserve in-depth analysis.

5.1 Heritage Preservation through Virtual Reconstruction

The digital reconstruction of temporary exhibitions allows for the preservation of artistic events that might otherwise remain confined to collective memory or be documented in a fragmented manner through photographs, catalogs, and critical texts. In the case of Concetto Pozzati's 1968 retrospective exhibition, this project provides a unique opportunity to experience the original setup, recreating not only the artworks but also the exhibition context, curatorial choices, and the

event's atmosphere. This type of reconstruction is especially valuable for scholars and curators, who can analyze spatial and relational details among the artworks, studying how the setup influenced audience perception at the time. However, digitizing cultural heritage is not limited to mere preservation. Through virtual and augmented reality, users can explore the exhibition dynamically, interactively, and with context, encouraging a deeper understanding of both the works and their historical setting. Artificial intelligence, with its capacity to tailor content based on user preferences and skill levels, enhances the experience by providing additional, personalized information, facilitating learning and sparking curiosity. This approach transforms the experience of art from a passive observation into an active and engaging process, making the visitor a participant in the exhibition experience.

5.2 Challenges of Digitalization: Accuracy and Historical Fidelity

Despite its advantages, the process of digitalization and virtual reconstruction presents significant challenges, particularly regarding historical accuracy. Faithfully recreating a past exhibition requires careful analysis of archival materials, photographic and documentary evidence, as well as critical interpretations of the era. The challenge lies in balancing historical precision with the technical limitations imposed by digital platforms. For example, accurately recreating the perception of the exhibition space or the quality of light requires the use of advanced 3D models and high-quality immersive technologies. However, the available technological resources can sometimes limit the aesthetic and sensory quality of the virtual experience, creating a gap between the original and its digital reproduction.

Another challenge concerns the selection and interpretation of sources. Often, digital reconstructions rely on incomplete or partially deteriorated archival materials, requiring a certain degree of interpretation in reconstructing the exhibition virtually. For this reason, it is essential that the digitalization process involves historians, conservators, and technicians and is carried out as comprehensively as possible to ensure the most accurate and faithful representation.

5.3 The Balance between Technological Innovation and Artistic Fruition

Another critical aspect to consider is the delicate balance between using innovative technologies and preserving the artistic essence of the exhibition. While VR, AR, and AI enhance the museum experience, there is a risk that excessive emphasis on the technological aspect may distract from the enjoyment of the artworks themselves. Technology should thus be seen as a means to amplify interaction with art rather than an end in itself.

Immersive technologies should be designed to integrate with and not overshadow the art, facilitating comprehension of the works and providing new interpretative tools without compromising their authenticity. For instance, AI can offer in-depth explanations about artworks, but to avoid oversimplifying interpretations, it is necessary to conduct a thorough and meticulous survey of critical sources, artist autobiographies, and custom machine learning training to provide accurate historical and artistic information, leaving room for personal reflection and the visitor’s free interpretation.

5.4 New Opportunities for Museology and Artistic Research

Despite the challenges, integrating technologies like VR and AI opens new avenues for the future of museology and artistic research. Digital exhibitions, first of all, make it possible to create dynamic archives accessible to researchers and scholars worldwide, facilitating academic sharing and collaboration on an international level. Additionally, the virtual format allows for experimentation with new forms of curatorial storytelling, exploring innovative exhibition methods that go beyond the physical and logistical limitations of traditional exhibitions.

From an educational perspective, these technologies are an extraordinary tool for bringing the public closer to contemporary art and cultural heritage. The ability to offer immersive and personalized experiences makes art more accessible, stimulating interest and active participation even from those without a specific background in art. Furthermore, using interactive technologies

such as gamification and educational quizzes promotes learning through play, making the museum experience more engaging and enjoyable for younger audiences.

6. Conclusion: Towards a Digital Future for Contemporary Art

The digital reconstruction of Concetto Pozzati's anthological exhibition offers new perspectives for the fields of museology and cultural conservation. Integrating advanced technology with artistic heritage is not only a way to preserve the past but also a pathway toward innovation and the experimentation of new forms of interaction between the public and works of art.

As highlighted, this project could serve as a model: for preserving the memory of artistic heritage by creating an ever-expanding digital archive, enabling a more profound experience of past art events than purely historical knowledge can provide; for cultural engagement, by offering new methods of access and dissemination of artistic knowledge in contemporary society, surpassing the boundaries of time, space, and knowledge. In this way, digital accessibility opens new avenues for art education and cultural diffusion, fostering an ongoing dialogue between the public and the artworks; for research and collaboration among scholars, generating a virtuous circle that can stimulate exponential growth in knowledge and research.

Despite its numerous advantages, this approach also raises important challenges. One of the primary concerns is historical fidelity in digital reconstruction: ensuring that the virtual environment is a faithful representation of the original space requires careful research and a rigorous selection of sources. Additionally, the need to continuously update digital technologies entails a constant commitment of human and financial resources.

On the other hand, the opportunities offered by this approach are numerous, allowing experimentation with new forms of curatorship, redefining the roles of museums and galleries in the digital era. This convergence between the physical and digital realms could represent one of the most promising evolutions for the future of museology.

The project "Effimera – Beyond Time" marks a significant step in this direction, laying the groundwork for a future in which technology becomes a key element in promoting and spreading culture, making it more accessible, engaging, and interactive. This new paradigm not only strengthens the link between art and technology but also opens a continuous dialogue between past and present, tradition and innovation, offering endless possibilities for the preservation and transmission of artistic knowledge

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Educational Robotics: a promising alliance for inclusive computational thinking and CS education

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Abstract

The pervasive role of technology in society is driving a shift in educational priorities, positioning Computer Science (CS) and Computational Thinking (CT) as essential skills. While significant progress has been made in developing tools and methods for CS/CT education, a gap remains in effectively addressing the needs of students with special requirements. This systematic review analyzes interventional studies from 2015 to 2024 focused on CS/CT education for students with special needs in compulsory education. Findings highlight the benefits of Educational Robotics (ER) in promoting engagement, problem-solving, and executive functions. Insights also suggest a positive impact on social-emotional skills, emphasizing the importance of inclusive, technology-mediated learning environments.

Keywords: Computational Thinking, CS Education, Special Needs education, Inclusion, Educational Robotics.

1. Introduction

In the context of 21st-century transformations, one of the greatest challenges lies in redefining the skills that educational systems must prioritize in curriculum development. Within this framework, Computational Thinking (CT) and Computer Science (CS) have emerged as essential for preparing future generations (Angeli, 2020). These competencies are becoming increasingly relevant, not only in daily life but also in current and future career paths. As technology-driven professions expand, prioritizing CT and CS education is critical to equip all students, including those with special needs, with the skills necessary to thrive.

Efforts in research and education have aimed at identifying effective methods to support students in developing these essential skills. However, despite considerable progress in developing educational content, methodologies, and tools for CS/CT education, a gap persists in making these approaches accessible to students with special requirements. While an abundance of literature and resources exist for general student populations, much of it overlooks the specific needs of students with disabilities, posing a barrier to achieving genuinely inclusive education. Additionally, a persistent misconception – that the use of digital tools inherently creates accessible learning environments – often leads to missed opportunities to fully support diverse learners.

To address this, we conducted a systematic review analyzing interventional studies from 2015 to 2024 that involve CS/CT education targeted at students with special needs within the scope of compulsory education. The research questions aim to identify the most successful types of interventions, their benefits, and the overall impact based on the underlying educational approaches.

The findings highlight the widespread use of educational robotics (ER) as a tool to foster inclusion and engagement among diverse learners. This approach has been shown to improve problem-solving skills and executive functions. Interventions designed for CS/CT education support metacognitive aspects, with tangible interfaces playing a pivotal role in facilitating these processes.

Studies targeting specific categories of special needs, such as Autism Spectrum Disorder, have observed a positive impact on social-emotional skills, providing insights for enhancing technology-mediated inclusion in educational settings. Envisioning a future with an increasing

number of technology-related jobs, prioritizing CS/CT education for students with special needs could significantly contribute to their future prospects and help them fulfill their potential.

2. State of the Art

Computational Thinking was first introduced by (Papert, 1980) and later refined by Wing, who described it as "*The mental process of formulating a problem and expressing its solutions so they can be effectively implemented by an external executor both human or artificial*" (Wing, 2011).

This definition highlights CT as fundamentally a linguistic act: it involves articulating and structuring a solution in a way that enables an external actor to execute it. This characteristic underpins both CT and CS, which share the goal of developing precise, communicable instructions. However, CS encompasses the broader domain of automated information processing, computation, and the theoretical principles behind these processes. Differentiating CT from CS allows us to more effectively address their unique educational implications. While studying CS inherently fosters CT skills, teaching CT does not necessarily require deep CS knowledge.

CT is built on five essential components: decomposition, abstraction, pattern recognition, algorithm design, and debugging (Figure 1). The power of CT lies in the transferability of these components, making them valuable for problem-solving across a wide array of fields beyond computing.

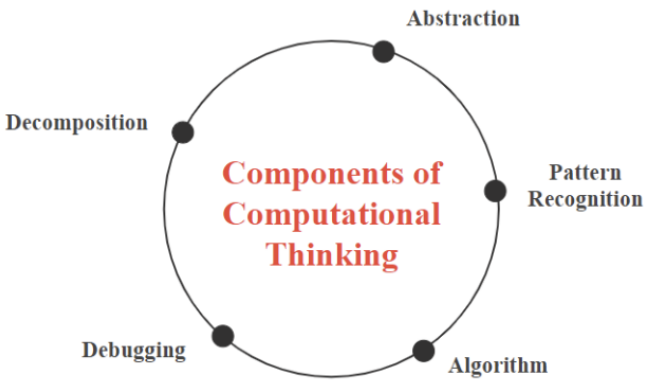


Figure 1 - Components of Computational Thinking according to Wing (2006).

2.1 Cognitive Aspects of Computational Thinking

Since the late 1970s, there has been a growing need for theoretical studies of the cognitive processes underlying programming and their relationship to established theories of problem solving. Brooks (1999) viewed programming as a process that involves understanding a task, analyzing its components, and identifying effective methods to solve it. Meta-analyses in the literature suggest that programming and computational thinking as being able to strengthen cognitive skills such as reasoning, logical thinking, planning and problem solving (Tsarava et al. 2019) and, as well as broader higher-order thinking skills (Rianti et al., 2024). In this context, computational thinking has also been found to have a significant impact on creative thinking and metacognition (Yadav, 2022).

Recent research has increasingly focused on the specific cognitive processes involved in CT, especially in young learners. Defining the cognitive foundations of CT is challenging due to the complex interactions among reasoning, spatial skills, executive functions, and visuospatial abilities (Montuori et al., 2023). Within this framework, "cognitive compiling" – the ability to mentally construct action plans – has been found to have a strong connection to CT (Tsarava et al., 2019). Additional correlational and intervention studies have highlighted links between CT and reasoning, spatial, and verbal abilities, as well as a strong association between CT and problem-solving skills (Roman-Gonzalez et al., 2018).

Additionally, CT involves analytical thinking, defined as the ability to analyze problems by breaking down their components and reorganizing them into a solution sequence—one of the core skills in problem-solving processes. Algorithmic thinking, in contrast, focuses on planning a structured sequence of actions and steps to solve a problem. This requires a complex organization of the envisioned solution, achieved through the manipulation of components. Depending on the task, this process may engage verbal or pictorial/visual reasoning.

Debugging skills elevate the processes of monitoring and updating by explicitly prompting these actions. Unlike tasks that are purely generative, with no feedback requiring systematic revision, CT tasks inherently encourage individuals to revisit, assess, and refine their work to correct errors.

The link between CT and executive functions is particularly significant: CT development, with its complex problem-solving aspects, overlaps with executive functions that are crucial for effectively managing cognitive tasks (Taylor et al., 2018). The complexity of CT processes highlights that it encompasses not just specific skills but also a synergy of broader cognitive abilities, aligning well with the skill demands of modern education. Despite these advancements, research remains limited, restricting both the assessment and deeper exploration of CT.

Despite the conceptual overlap in the literature, it is important to distinguish between CT and programming: while CT refers to a mental process, programming is one of the practical applications of CT. Cognitive science and psychology have only recently turned their focus to these phenomena, initially exploring programming before specifically addressing CT.

2.2 Differentiating Aided Education and Technology Education

A common misconception among researchers and teachers is that computer-mediated education is inherently inclusive. This perspective assumes that incorporating a computer or other device automatically ensures accessibility, overlooking that visual accessibility, while important, is only one aspect of making education truly inclusive. Aided education and technology education are related but distinct concepts: aided education refers to instruction supported by technology or analog tools, while technology education focuses on teaching technology and its applications to develop technical skills. Furthermore, aided education does not necessarily require technology; in fact, activities such as CS Unplugged illustrate that technology-focused education can effectively occur without digital devices.

3. Methods

This literature review aims to address two key research questions in the field of CT and CS education within compulsory education for students with special needs. The first question seeks to provide a comprehensive overview of the current landscape of CT and CS education for students with special needs, examining existing tools, practices, and approaches. The second question focuses more specifically on identifying the most effective interventions for CT and CS education for this group within compulsory education.

To explore these questions, we conducted a systematic review using the PRISMA framework (Page et al., 2021) and applied a set of inclusion criteria. Specifically, we included peer-reviewed interventional studies published between 2015 and 2024 in the context of compulsory education. The studies were required to address interventions specifically targeting CT and CS, excluding those involving technology without this explicit focus. The PRISMA flowchart detailing the study selection process is shown in Figure 2.

The selected studies were then analyzed to evaluate the effectiveness and focus of each intervention. For each study, we identified the type of intervention and its focus regarding the targeted skills, aiming to clarify the competencies each activity sought to develop. We also examined the specific special needs or populations targeted, and, where applicable, reviewed the theoretical framework underpinning each intervention to contextualize its academic and pedagogical foundations.

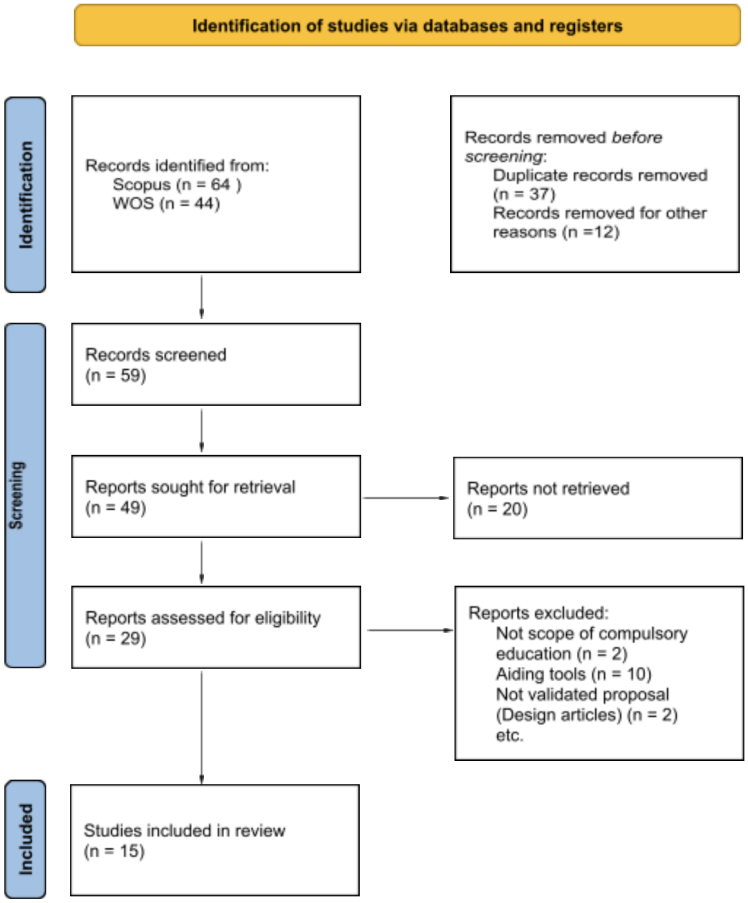


Figure 2 - Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA; Page et al., 2021).

4. Results

The selection process resulted in the inclusion of 15 studies, summarized in Table 1, which presents selected reports' main characteristics and findings. Overall, the selected studies focused on compulsory education for participants aged 6 to 15 years, with the majority (13 studies) targeting primary education and only 2 studies focusing on high school students. As shown in Table 1, six of the included studies involved Educational Robotics interventions, targeting seven different types of special needs and different types of skills, including coding, problem-solving, executive functions, and communication.

The outcomes spanned both hard and soft skills, unified by a holistic approach toward CT and CS. Notably, interventions designed to develop CT and CS were often adapted to support additional skill areas relevant to the target group. For example, in interventions for students with autism spectrum disorder (ASD), activities designed for CT were enhanced with tasks aimed at fostering social-emotional learning (Voon et al., 2022). The diversity of target populations, interventions, and outcomes is further reflected in the lack of a unified methodology across studies, which employ a mix of quantitative, qualitative, case study, and ethnographic approaches. The specifics of special needs, intervention types, targeted skills, and outcomes are discussed in greater detail in the following sections.

Recurring themes emerging from the analysis of these reports include the widespread use of Educational Robotics, the notable impact of CT and CS activities on problem-solving skills, and the effective stimulation of executive functions. Additionally, these interventions provide a supportive setting for the development of socio-cognitive skills. Practical considerations focus on embedded cognition and accessibility, all within a constructivist lens. More specifically, ER stands

out as a widely used and valuable tool for enhancing the CT learning experience for students with special needs. By integrating robotics into the educational process, ER promotes active engagement and stimulates autonomy through an interactive, hands-on activity (Kight et al, 2019 a-b). This approach supports cognitive development as well as skills such as problem-solving, logical reasoning, and sequence planning, particularly in the context of expressing instructions – skills of crucial importance for special needs education (Israel et al., 2015).

Embedded cognition is another prominent theme, aligning well with ER and serving as a common denominator across all selected studies. For special needs students, the connection between physical experience and the learning process helps achieve educational goals more effectively by bypassing abstract barriers (Oswald et al., 2023). This theme brings into focus the issue of accessibility. Accessibility in this context means creating inclusive, creative learning environments that overcome sensory impairments and difficulties in reading, comprehension, or numerical perception (Di Lieto et al., 2020). ER is especially adaptable, accommodating diverse modalities and learning styles. Combined with constructivist principles, ER enables a learner-centered approach, allowing students to build knowledge through personalized exploration (Cervera et al., 2020; Giannakulas et al., 2023).

Finally, Social Emotional Learning emerged as a key theme, particularly in interventions for students with behavioral challenges and neurodivergences. Integrating ER with activities that emphasize teamwork, communication, and emotional regulation supports students in navigating social situations more effectively (Oswald et al., 2023).

Table 1 - Analysis of the included studies according to *Targeted Skills, Special Needs* focused in the research, *Sample*, *Outcomes* and *Theoretical Framework.*

Author & Year	*Targeted Skills*	*Special Needs*	*Sample details*	*Outcomes*	*Theoretical Framework*
Liao et al., 2020	CT skills, problem-solving	Learning disabilities	3rd and 4th grade students, intervention group & control group	Improved CT skills, problem-solving, and engagement using Scratch	Constructivism
Salac et al., 2021	CT skills, social-emotional skills, inclusive learning	Diverse learn needs and learning disabilities	K-8 students with diverse learning needs	Validation of TIPP&SEE protocol with Scratch	Constructivism and Scaffolding
Giannakulas et al., 2023	CT skills, problem-solving	Neurotypical and intellectual disabilities	Neurotypical and intellectually disabled elementary school children	Review of practices with educational serious games for CT skills, problem-solving, and engagement in both groups	Constructivism, Game-Based Learning
Bouck, 2022	CT skills, math skills, academic engagement	Developmen tal disabilities	Students with disabilities in primary education	Practices (also with codable robots) for the integration of CT in CS and math education for students with disabilities	Not specified
Kert et al., 2022	CT skills, problem-solving, self-efficacy	Non-specific learning disabilities	Student with learning disabilities	Enhanced CT skills, problem-solving, and self-efficacy after a robot development process.	Constructivism, Self-Determination Theory
Di Lieto et al., 2020	Executive functions (attention, self-regulation)	Non specific special needs in education	Children with special needs from 1st and 2nd grade	Improved executive functions, attention, and self-regulation using ER-lab with BeeBot powered activities.	Constructivism

Author & Year	*Targeted Skills*	*Special Needs*	*Sample details*	*Outcomes*	*Theoretical Framework*
Elshahawy et al., 2020	CT skills, problem-solving, social-emotional skills	ASD	Students with ASD in elementary school	Improved CT skills, problem-solving, and social-emotional skills using a serious game with positive impact on multiple areas, including social skills	Constructivism, Game-Based Learning
Prado, 2021	Coding skills, problem-solving	ASD and severe behaviour problems	Students with ASD in inclusive classrooms in 4th grade.	Improved coding skills, problem-solving, and engagement. Validation of inclusive instructional practices for CT curricula	Constructivism, Behaviorism
Knight et al., 2019 a	Coding skills, problem-solving	ASD with severe behaviour problems	Single high school student with ASD	Improved coding skills, problem-solving, and engagement. Coding learning with robot calibration and tracks design.	Constructivism, Behaviorism
Knight et al., 2019 b	Coding skills, problem-solving, self-regulation	ASD and challenging behaviors	High school students with ASD	Enhanced coding skills, problem-solving, and self-regulation via ER lab.	Constructivism, Self-Determination Theory
Taylor, 2018	Programming skills, problem-solving, communication	Intellectual disabilities	Early elementary (PreK-1st grade) students with intellectual disabilities	Improved programming skills, problem-solving, and self-confidence	Constructivism, Self-Efficacy Theory
Taylor et al., 2017	Programming skills, problem-solving, communication	Down syndrome	Students with Down syndrome	Improved programming skills, problem-solving, and communication	Constructivism, Social Cognitive Theory
González-González, 2018	Coding skills, problem-solving, motivation	Down syndrome	Students with Down syndrome	Enhanced coding skills, problem-solving, and motivation using KIBO robot	Constructivism, Game-Based Learning
Assainova et al., 2018	CT skills, problem-solving	Mental disabilities	Students with mental disabilities	Improved CT skills, problem-solving and validation of inclusive pedagogy for CT via web technologies.	Errorless learning

4.1 Defining Educational Special Needs and the Concept of Tailoring

An initial review of the selected literature reveals the broad spectrum of conditions encompassed under educational special needs, each requiring uniquely tailored approaches to address various developmental, physical, or emotional challenges. In at least three reports, however, the special needs were not fully detailed, instead categorized under broad terms like “non-specific learning disorder,” which covers a complex array of challenges.

In addition to the diversity of special needs, there is also an issue of unequal representation in scientific literature and, consequently, in the selected studies. Educational research tends to concentrate on cognitive and learning disorders, likely because these are the most prevalent and have a significant impact in school settings.

However, a review of the literature on special needs in education reveals the following typologies: (Syarif et al., 2024):

- *Physical and sensory impairments* are disabilities within the perceptual domain, with visual impairments being the most represented. The specificity and variability of these

conditions make it challenging to identify generalizable interventions, as the limited literature often necessitates highly tailored approaches.

- *Learning and Cognitive disabilities*, which receive significant attention from the scientific community, include conditions such as dyslexia, dyscalculia, and dysgraphia. These conditions impact information processing and require targeted interventions and support systems.
- *Emotional and Behavioral disabilities*, such as autism spectrum disorder, can hinder a child's ability to integrate into the classroom and more broadly engage in traditional learning environments, affecting interactions with educators and peers (Bidică, 2022).
- *Intellectual Disabilities* differ from cognitive disabilities as they involve developmental delays with substantial impacts on overall functioning. These conditions demand a high level of tailoring in educational settings, resulting in limited generalizability of interventions.

A common theme across all types of special needs in education is the distinction between "tailored" and "inclusive", which do not always overlap. Effective tailored education for students with special needs involves individualized, goal-oriented instruction customized to each child's unique needs. However, such specialized accommodations can sometimes impact social integration and self-esteem, as students may feel isolated or unable to participate alongside their peers, often completing tasks separately from the class.

A core challenge in special needs education, therefore, is not only tailoring activities but also developing approaches that promote inclusion—balancing individualized recognition with a holistic view of classroom dynamics. Many interventions in the selected studies address this by engaging all students together in activities that allow each to reach their individual learning goals: students with special needs work toward foundational objectives, while more advanced learners can pursue further challenges and independence.

4.2 Computational Thinking Activities for Students with Educational Special Needs

CT activities demonstrate a twofold potential to significantly benefit students with special educational needs: they support cognitive aspects by enhancing problem-solving skills and cognitive development, while also promoting integration, accessibility, and the development of social skills.

The main types of interventions include CS unplugged activities, tools such as Educational Robotics (ER), educational digital games based on web technologies. CS unplugged activities offer high potential for implementation, as they do not require specific tools and can be easily conducted with standard classroom materials. Web technologies and educational digital games, however, depend on devices that may not be universally available, leading to potential disparities among students. Research indicates that web technologies can effectively support CT skill development in students with intellectual disabilities; for example, a study involving an eight-week program demonstrated significant improvements in CT skills, showcasing the effectiveness of online learning tools in CT education (Assainova et al., 2023).

Another validated approach is the use of Scratch (Assainova et al., 2023; Tsarava et al., 2019). With its block-based, drag-and-drop programming interface, immediate feedback, and visual interactions, Scratch can effectively introduce programming basics to special needs students, fostering logical reasoning in a playful environment. However, its complexity and reading requirements may limit its accessibility for students with certain types of needs or at lower skill levels.

4.3 Theoretical Frameworks for Activities Design

The selected papers primarily referenced the following theoretical frameworks: *Constructivism, Game Based Learning, Self-Determination theory* and *Social Emotional Theory*.

Constructivism emphasizes active learning, where students construct knowledge through hands-on experiences and exploratory approaches, aligning well with the rationale behind Educational

Robotics (ER) and coding activities (Assainova et al., 2023; Di Lieto et al., 2020). Game-Based Learning promotes engagement and motivation through goal-driven tasks, reinforcing the application of knowledge and concepts critical to CS and CT (Giannakoulas & Xinogalos, 2023; Elshahawy et al., 2020). In terms of fostering self-regulation and interpersonal skills, Self-Determination Theory and Social Emotional Learning provide foundational support. These frameworks emphasize motivation, autonomy, emotional regulation, and social skills, particularly valuable for students with ASD, ADHD, or other behavioral challenges (Oswald et al., 2023; Knight et al., 2019).

4.4 Educational Robotics and Special Needs

Educational Robotics, also referred to as *Robotics in Education* (RiE) or *pedagogical robotics*, involves using robots as learning tools across various educational levels, from preschool to high school (Cervera et al., 2020).

Robots with diverse types and functionalities can be integrated into teaching to enrich and enhance the learning experience. These tools may come fully assembled and ready to use or as kits requiring assembly. An example of the first type is *Bee-bot* (Fig. 3, Cervera et al., 2020), popular in preschool and primary education, while an example of the second type includes kits like *LEGO® Education SPIKE™* (Fig. 4), designed for older students in late primary through secondary education.



Figure 3 - Bee-bot robot (from Cervera et al., 2020)



Figure 4 - Set LEGO® Education SPIKE™ Prime 45678

4.5 Skills Development

The interventions in the selected studies were not limited to CT and CS-related skills, but spanned a range of domains and levels of specificity, covering both technical and personal competencies. Given the nature of the activities using CS unplugged, ER and Scratch or other digital tools (Assainova et al, 2023), seven studies targeted the skills dyad of CT and programming, while the others did not directly involve coding. While CT skills and problem solving were the priority for the more technical learning objectives, many studies, especially those referring to special needs such as behavioural disorders, embedded in the activities goals for socio-emotional skills (Oswald et al, 2023; Knight et al 2019a, 2019b).

5. Discussion

As noted by Nicolajsen et al. (2021), CT can be approached from three key perspectives: reasoning, simplification, and empowerment. For effective CT education, these elements should interact constructively within each intervention. The literature analysis highlights a critical discussion point: the primary challenge in CT education for students with special needs extends beyond identifying appropriate tools and aids. It lies in leveraging these tools to integrate these three perspectives, creating activities and environments where all students can engage in meaningful learning experiences (Prado et al., 2022).

In this light, ER stands out as an effective tool for addressing these challenges due to its ability to integrate reasoning, simplification, and empowerment. Like Scratch, ER supports reasoning by

presenting problem-solving tasks within a playful, game-based context, where gamification enhances motivation and accessibility is supported through specific features. ER also addresses simplification by breaking down complex, abstract concepts into tangible, embodied experiences.

Regarding empowerment, ER offers immediate feedback and simplified interfaces, enabling autonomous exploration and rewarding activities that build confidence and encourage a positive attitude toward STEM disciplines (Di Lieto et al., 2020). The strategic combination of reasoning, simplification, and empowerment not only supports skill development and cognitive growth but also nurtures self-efficacy, helping learners feel capable and motivated as they engage with CT.

From a practical standpoint, integrating ER into educational settings not only fosters active and personalized engagement, enhancing motivation, but also facilitates the development of essential cognitive and social skills tailored to individual learning needs.

Even in the case of CS unplugged activities, the role of embedded cognition and personalized learning approaches—whether through collaborative design or robotics—enables students to engage in effective educational experiences. Additionally, a key advantage of ER lies in its support for developing transversal skills that enhance learning for typically developing students and provide compensatory skills for students with special needs. Its value in cognitive training, facilitating transferable competencies for technical domains, and fostering positive attitudes and empowerment is highly significant for future career readiness.

The unique approach and structure of ER offer students a rich, immersive experience within a collaborative and inclusive environment. Key benefits include:

- *Enhanced engagement:* ER promotes high levels of engagement among students, enabling them to work in parallel within tailored and inclusive learning environments. This not only improves learning outcomes but also promotes socialization and motivation (Knight et al., 2019a, 2019b; Montuori et al., 2023). These aspects are particularly impactful for students with ADHD or ASD, where increased motivation and social interaction are especially valuable (Knight et al., 2019a, 2019b).
- *Skill Development:* As discussed in Section 4.5, ER supports the development of key cognitive skills, including Higher Order Thinking Skills (Rianti et al., 2024) such as problem-solving, logical reasoning, executive functioning, as well as verbal expression and planning (Di Lieto et al., 2020; Cervera et al., 2020; Kert et al., 2021).
- *Personalized Learning and Inclusion*: In balancing tailored learning experiences for students with special needs and inclusive activities for the entire class, ER serves as a valuable tool, offering a middle ground that accommodates individual needs within a collective setting (Prado et al., 2022; Salac et al., 2021).

ER can be applied beyond introductory programming and coding to include simulation and modeling, thereby supporting executive functions, problem-solving skills, and social-emotional learning. While several studies underscore the effectiveness of ER and web tools in teaching programming to students with special needs (Liao et al., 2020), ER is particularly powerful for simulation and modeling activities, helping students visualize and engage with abstract concepts (Kert et al., 2022).

Another valuable application of ER involves tasks centered on planning and sequencing, which can significantly support the development of executive functions critical for students with learning disabilities. Empirical studies demonstrate the effectiveness of ER in enhancing cognitive planning and task execution through interactive, hands-on activities, suggesting its potential use as a form of cognitive training (Di Lieto et al., 2020).

Additionally, ER can be structured to create interaction settings that support social-emotional learning for students with neurodevelopmental challenges. For example, Knight and colleagues (2019) used ER to teach coding to students with ASD, which led to improvements in both classroom behavior and communication skills.

Overall, the strength of ER lies in its capacity to support a wide range of skills and abilities—from cognitive foundations and executive functions to social and emotional competencies—within the dynamic classroom setting. ER activities enable students with special needs to develop

transversal skills that are both compensatory and valuable for future careers, fostering growth within a more inclusive environment.

6. Limitations

The complexity of the subject and the numerous variables involved limit the generalizability of findings. Furthermore, the kaleidoscopic definition of *educational special needs* results in a diversity of methodologies, from case studies to quantitative research, making it difficult to conduct meta-analyses or rigorous literature reviews. Ethical concerns around data collection in such a sensitive educational context also arise, leading to limited sample sizes and a prevalence of single-case studies and qualitative approaches.

Beyond research challenges, implementation barriers include inadequate school resources, insufficient teacher training, and limited curriculum integration (Tiwari, 2023). Nonetheless, these limitations – particularly the shortage of resources and teacher preparation – highlight the need for further research and increased institutional support to fully harness the potential of CS and CT interventions for students with special needs.

7. Conclusions

Recalling the first research questions, the current landscape of CT and CS education for students with special needs appears to be still in its early stages. However, the increasing focus on intervention design that leverages established approaches is promising. The wide range of conditions covered under "special needs" and the methodological inconsistency across studies make it challenging to derive generalizable findings.

Addressing the second research question, ER stands out as a prevalent type of CT educational intervention that fosters inclusion, engagement, and learning for special needs students. Compared to other types of activities, ER uniquely combines various tasks and theoretical frameworks. Its hands-on approach aligns with constructivist principles, allowing students to explore computational concepts and develop skills through embodied cognition. The tangible nature of ER helps students visualize and manipulate concepts, fostering engagement and autonomy in line with both constructivist and self-determination theories, without necessarily creating a perception of “being aided”. Additionally, integrating ER with activities such as CS unplugged enhances embodied cognition by encouraging students to translate physical interactions into computational processes (Montuori et al., 2023).

The holistic approach in the selected studies fosters essential skills like problem-solving, executive functions, and communication. ER activities, through tasks like decomposition, planning, and troubleshooting, build competencies useful in daily life and future careers (Di Lieto, 2020). A key feature is the high accessibility of these approaches, enabling inclusive, meaningful learning experiences within the classroom.

As shown in reports with ASD children, activities with ER can support interventions also targeted at social-emotional skills and communication in students with behavioral disorders by offering a structured environment which allows the safe practice of these skills (Knight, 2019).

As discussed, the value of ER lies in organically merging the three perspectives on CT by Nicolajsen and colleagues (2021) by providing a simplified setting able to stimulate reasoning on computational concepts through embodiment and fostering empowerment in students whom often feel not enough competent.

In conclusion, the selected literature underscores the potential and effectiveness of tools such as ER as a powerful intervention to promote inclusive CT/CS education for students with special needs by supporting the development of key skills not only transversal to other disciplines but highly relevant for their future careers. Envisioning a future with increasing demand for technology-related jobs, emphasizing CS/CT education along with digital education for all

students could effectively bolster their future opportunities and enable them to fulfill their potential despite individual weaknesses.

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Promoting accessibility and inclusion in e-Learning: the University of Turin's experience

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Abstract

The Staff E-learning, Online collaboration, Architectures - Information Systems Management, Portal, E-learning of the University of Turin, among other services, deals with technical and methodological support for the E-learning' universe. Based on general indications from the university's strategic plan, the Staff has implemented actions aimed at promoting greater accessibility and inclusion of web resources against any form of discrimination. In this context, a Moodle E-learning platform and a video registration and management system have been made available to all academic teaching structures, along with technical and methodological training interventions for teachers. Currently, the goal is to keep on improving the accessibility of digital resources. Several initiatives have been implemented: documentation for creating accessible teaching materials, tools for subtitling videos and vocalizing texts, software for producing accessible multimedia content, and so on. Furthermore, the Staff has participated in the development of an online course for disabled students' tutors, based on materials made accessible since its design phase. From this experience and participation, along with expert teachers in the field, in a call from the University's Teaching and Learning Center, the idea of a course for professors dedicated to the creation of accessible teaching materials has emerged, with delivery methods that respect the recommendations contained within the course itself. A multi-channel, interactive course to support the creation of inclusive teaching materials based on Universal Design for Learning, where the user can autonomously decide the order in which she/he will access the content.

Keywords: Universal Design for Learning, E-learning, Accessibility, Diversity and inclusion, Digital resources.

1. Introduction

For several years, the University of Turin has been on a path toward inclusion based on the principles expressed in the United Nations Convention on the Rights of Persons with Disabilities. Over time, the university has implemented numerous initiatives to better align with the principles set forth in the Convention, such as the right to full and effective participation in society and accessibility (Article 3), access to quality education on an equal basis with others (Article 24), and the elimination of obstacles and barriers to accessibility (Article 9). Despite the results achieved, there are still many challenges to face. One of the main challenges is to ensure the accessibility of educational materials in order to adapt teaching methodologies to the diverse needs of students. In fact, in recent years, the University has observed a considerable increase in students with Specific Learning Disabilities (SLD) and disabilities. There has also been a growing demand from students for accessible educational materials and a desire to study at a University that is generally attentive to inclusion (Figure 1).

In this scenario, it is therefore necessary to invest in the training of teaching staff and specific support roles, as well as in the ongoing search for innovative technological solutions. In recent years, the University has introduced new tools that facilitate the accessible delivery of educational materials, including through pilot projects. However, for these tools to be truly effective, they need an added value: targeted and conscious use. Having technological tools available is a first step, but it is not enough. To make the best use of these resources, teachers need practical and

ongoing support. Theoretical training and research on accessibility, while essential, are not sufficient to bridge the gap between knowing and doing. Teachers need practical answers, concrete examples, and operational tools to integrate technologies into their daily practice.

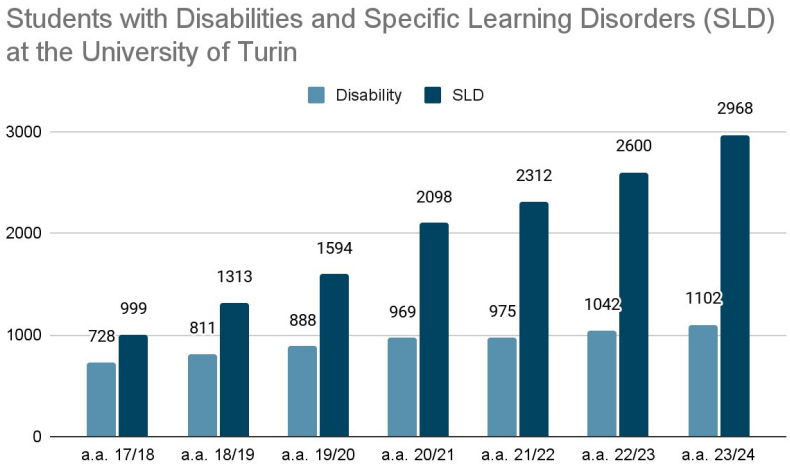


Figure 1 - Students with Disabilities and Specific Learning Disorders (SLD) at the University of Turin from the Academic Year 2017/18 to the Academic Year 2023/24. Data collected by the Office for Students with Disabilities and SLD at the University of Turin and published on the University Portal.

How to adapt existing materials and create new accessible content are issues that require long-term and ongoing support from trained personnel. University teaching and research staff often face a gap between theoretical knowledge and practical application. The question that those involved in accessibility are most frequently asked by teachers is: “How can we adapt existing materials and create new ones that are truly accessible?” However, before trying to formulate an answer, it is necessary to address another question first: “What is the current situation of educational materials within the online learning environment?”.

2. The University of Turin: A Journey Towards Inclusive E-Learning

The Strategic Plan of the University of Turin (Objective 1.2) aims to promote inclusion and accessibility for all students, with particular attention to those with disabilities or specific learning disorders (SLD). Based on these directives, the E-learning Staff of the University of Turin has implemented over the years a series of initiatives to realize the ideal of an accessible web (Mangiatordi, 2019; Repetto et al., 2022).

Since 2007, all educational structures of the University have been equipped with the open-source Moodle e-learning platform to provide online access to materials and activities for all students, thereby facilitating their academic journey. To encourage more conscious and effective use of the tool, training sessions were organized for faculty members. Once the faculty had become accustomed to using Moodle for course management, the E-learning Staff deemed it appropriate to expand their approach from a primarily technical one to a more pedagogical-theoretical one. In this perspective, training courses have been launched to provide teachers with methodological guidance as well: Moodle, in fact, allows them to rethink their teaching materials, overcoming the idea of the platform as a mere repository and making the most of the potential offered by e-learning. For instance, the use of collaborative activities, customizable learning paths, self-assessment systems, and interaction spaces between faculty and students and among students themselves can enhance inclusivity by catering to different learning styles. In the ensuing years, additional services were introduced, including the capability to record lectures – both live and on-demand – and the use of plugins for creating interactive and accessible multimedia content.

During the pandemic, there was a substantial, if not exclusive, reliance on Moodle e-learning platforms for managing educational activities, which confirmed the utility of this technological solution. Currently, every course instructor at the University has their own Moodle course for each in-person class they teach, and faculty members have become adept at using the platform autonomously. Therefore, the time appears opportune for a further qualitative leap towards maximum inclusion in educational design. Today, each teacher at the University has their own Moodle course for each in-person class, and the use of the platform by professors and teachers is now stable. They use its functionalities with a certain degree of autonomy. The time therefore seems ripe for a further leap in terms of quality in the direction of maximum inclusion in educational design. With the ideal of an accessible web in mind, the E-learning Staff has undertaken various initiatives. Guidelines for creating accessible educational materials have been drafted for faculty and made available on the University's Intranet.

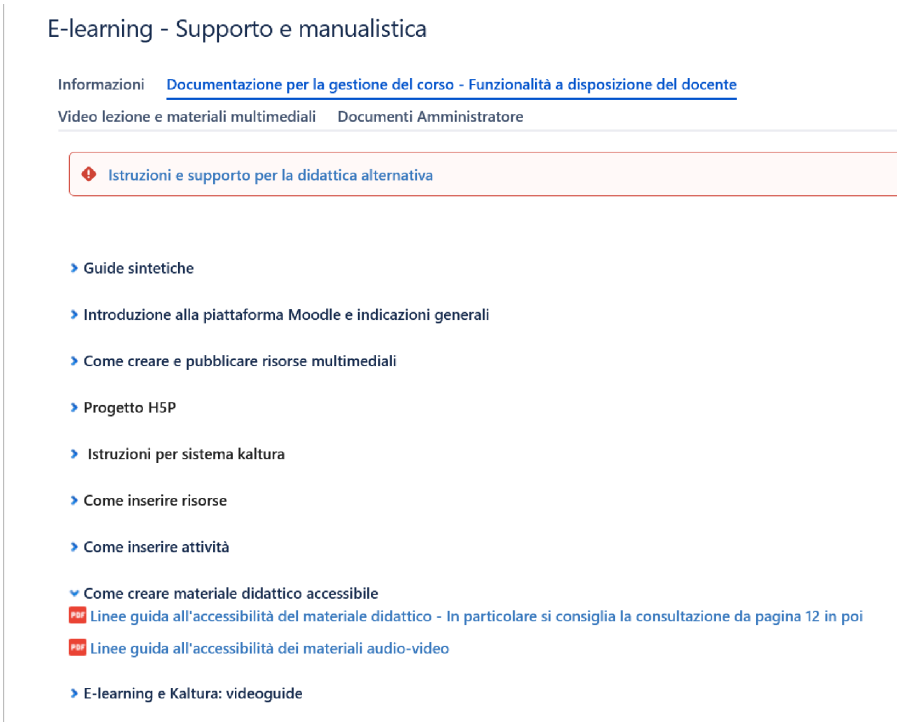


Figure 2 - Guidelines on the University Intranet for Creating Accessible Material.

A feature has been implemented in the Moodle theme that allows users to customize the platform's font; the available choices include fonts specifically designed for accessibility, such as Easy Reading or Open Dyslexic. Text-to-speech software has been introduced, which is also available for the University portal and departmental websites. Applications for subtitling video content, both live and on-demand, have been made available to make this type of material accessible (see Armano et al., 2021). To facilitate the production of accessible content, the H5P framework has been adopted, allowing for the creation of educational objects that activate learning using multimedia, multichannel and multimodal communication strategies, and targeted interactivity.

A particularly noteworthy initiative by the Staff was participating in the design of an online course for tutors of disabled students in 2020 (see Baratto et al., 2021; Vindigni et al., 2023). In this context, accessible resources and activities were created from the ground up, using the tools available at the University.

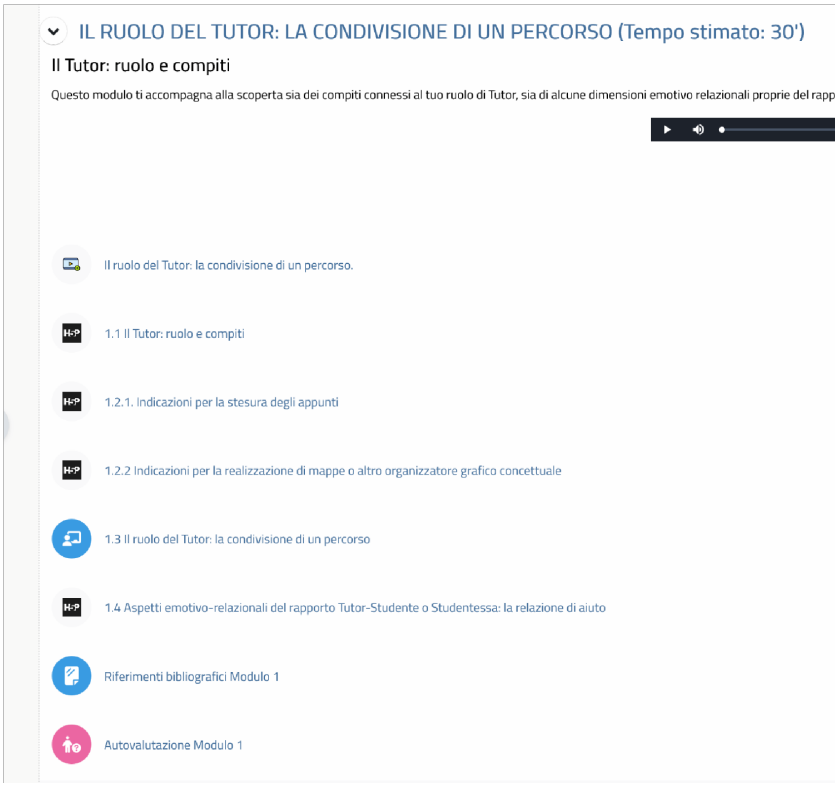


Figure 3 - Module 1 of the Course for Tutors of Students with Disabilities on Moodle.

Even after the pandemic, the university education has continued to use audiovisual tools for teaching to a much greater extent than in the pre-pandemic period. This happens both through the uploading of video lectures or on-demand audiovisual teaching materials to the university's e-learning courses, and more frequently through the streaming of lectures or other educational events via online videoconferencing platforms. This transformation highlighted the growing need to make educational content accessible, particularly through subtitling, a crucial tool for supporting students with hearing impairments or language barriers, as well as improving accessibility overall. To raise awareness among faculty and provide them with technical and linguistic guidelines applicable to daily teaching activities, guidelines have been developed to more effectively use the available technological tools and thus obtain higher-quality automatically generated subtitles.

This activity laid the groundwork for a further initiative presented in November 2023 as part of the call "Embrace the Future: Unleash Innovation in the Classroom" proposed by the University's Teaching and Learning Center to encourage the entire University Community to promote educational innovation at various levels.

The project presented involved the creation of an e-learning course for University faculty, aiming to raise awareness of inclusion and foster a shared culture of producing accessible educational materials. The aspiring purpose is to create a guide-course which provides instructions for designing and producing accessible materials in the most straightforward and simple way possible. In other words, it would be a kind of meta-course, where the delivery methods themselves follow the recommendations outlined in the course. Often, the set of guidelines for creating accessible materials is contained in lengthy documents that require time and careful analysis to fully understand, and even more time to try to implement the suggested practices. Instead, this e-learning course aims to create flexible modules that allow users to quickly acquire easily digestible and applicable information through short readings, which can also be easily retrieved for future reference and consultations.

3. The Challenges of Digital Accessibility in Teaching Practice: A Sample of the Current Scenario

In 2024, an experimental initiative was conducted to provide a snapshot of the current situation of courses (and the educational materials contained within them) on the University's Moodle platform. The pilot project, in fact, foreseen the use of a technological solution which allows the accessibility level of a Moodle course to be checked and provides guidance on how to address any issues. Around twenty faculty members volunteered to participate, agreeing to assess the teaching content in their online courses based on specific accessibility standards. A detailed technical analysis of this experience will be covered elsewhere; however, in this contribution, we will present some insights derived from the reflections of the faculty members who participated in the initiative. At the end of the trial, several focus groups were planned to discuss the experience and gather broader feedback from teachers on such an important topic. The initiative highlighted a widespread concern among teachers regarding the accessible delivery of their materials, but also a lack of basic knowledge about how to create accessible materials in accordance with international standards. Several teachers realized that they had implemented incorrect actions precisely in the parts of the course where they believed they had facilitated content access for all students. Another common element that emerged from the feedback of teachers from different disciplines and participating in separate focus groups was the recurring request for practical and operational support to make educational materials accessible, in order to translate the theoretical principles of accessibility into actions within daily teaching practice.

4. Conclusions

Digital accessibility represents a complex challenge that requires a multidisciplinary approach. Continuous training for teaching staff and technical-administrative personnel is essential to promote the conscious use of technological tools and to ensure that educational materials are as accessible as possible to all students. This crucial challenge will require the development of specific training models which combine a solid theoretical foundation on the principles of accessibility with practical activities aimed at developing concrete digital skills. Such training programs will need to be continuously updated in light of technological innovations and emerging needs, particularly regarding special educational needs.

The growing demand from teachers for the implementation of inclusive teaching practices opens the door to numerous future developments. To prepare for these new scenarios, it will be crucial to delve deeper into the specific needs of teachers through further qualitative analyses of data collected from various initiatives related to content accessibility. Such analysis will allow for a more precise identification of key issues and expectations regarding technological tools and training needs, contributing to guiding the adoption of ad hoc solutions within an integrated framework. It will also be necessary to systematically evaluate the technological tools available on the market, comparing their advantages, limitations, and potential uses in the university context together with teachers and students. This comparative analysis will enable the selection of the most suitable tools to support teachers in creating accessible educational materials and in making current materials accessible.

Another distinctive element of any accessibility initiative should be the co-design of certain solutions with students with disabilities or Specific Learning Disorders (SLD) and interest advocacy organizations. Directly involving end users in the design and development phases of solutions will be essential to ensure that these effectively meet their real needs. Through workshops, focus groups, and pilot projects, it will be possible to gather valuable feedback and co-create innovative solutions. Additionally, it will be crucial to monitor the impact of accessibility initiatives both in terms of effectiveness – measuring, for example, the increase in the use of educational materials by students with disabilities – and user satisfaction through the collection of qualitative feedback. Furthermore, it will be essential to define quality indicators that allow for evaluating the actual accessibility of educational materials and learning environments. These

indicators can be used both to monitor progress made and to compare different solutions adopted.

In conclusion, the development of inclusive teaching practices represents a complex yet fascinating challenge. A multidisciplinary approach involving teachers, technologists, students, and representatives from disability organizations is fundamental to ensuring the success of these initiatives. Only through continuous collaboration and constant updating of knowledge will it be possible to create truly inclusive learning environments for all.

The University's vision for the future is that of an inclusive university where every student, regardless of their abilities, can access all resources and opportunities offered. To realize this vision, as previously mentioned, it will be necessary to undertake actions related to:

- Continuous training, offering teachers updated and personalized training pathways focused on developing digital and pedagogical skills for inclusive teaching;
- Technological tools, adopting innovative and accessible technological tools that facilitate the creation and distribution of inclusive educational materials;
- Strategic collaborations, establishing partnerships with other institutions, companies, and associations to share experiences, resources, and expertise;
- Monitoring and evaluation, implementing monitoring and evaluation systems to measure progress made and identify new areas for improvement.

In line with this vision, the Staff E-learning, Online collaboration, Architectures of the University of Turin aims to continue focusing on technological tools that can effectively ensure access to the resources and materials necessary for acquiring knowledge and skills; these tools must be easy for faculty to use and widely applicable in educational activities.

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Teachers' perspectives and challenges in Inclusive Education: insights from IA-ME Project Focus Groups

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Abstract

The European Project IA-ME (Innovative methods and Artificial Intelligence in MOOC for special needs teacher Education) aims to enhance inclusive education by providing teachers with a technological tool to guide them in creating and monitoring individualized educational plans (IEPs) for Special Educational Needs (SEN) students. The project consists of five work packages, and initial findings are based on focus groups conducted in Italy, Hungary, Spain, Greece, and Turkey. A total of fifty-two teachers (43 female; age range 24-62 yrs) from primary and middle schools participated, including general and SEN teachers. Teachers completed the MyDigiSkills questionnaire to evaluate their digital competencies and discussed their experiences with technology in inclusive education. The thematic analysis of the focus groups highlighted several key areas: the concept of inclusive teaching, the role of technology, flexibility in integrating technology, obstacles faced, and the types of educational technology used. Teachers emphasized the importance of adapting teaching to meet student needs and acknowledged that technology can enhance student motivation and support lesson preparation. However, they identified significant barriers, such as insufficient training and inadequate infrastructure. Commonly used educational technologies included evaluation and feedback systems (e.g., Kahoot, Quizizz), learning platforms (e.g., Wordwall, YouTube), and content creation tools (e.g., Canva). While all partner countries except Italy reported using technology for IEPs, there was a strong interest in employing these tools. Overall, teachers view technology as a valuable supplement to traditional methods, with a need for continued support to overcome barriers and foster an inclusive educational environment across Europe.

Keywords: Inclusion, Focus Group, Educational technology, Individualized Educational Plans (IEP), Teacher Training.

1. Introduction

In recent years, educational inclusion has become a priority in many nations with the aim of ensuring that all students, regardless of their abilities or disabilities, have access to quality education (UNESCO, 2020). Inclusion is a fundamental element for building sustainable and democratic societies, based on the principles of equity and justice. It provides a systematic framework that aims to remove educational barriers, ensuring that every student is valued and has an equal opportunity to succeed (UNESCO, 2020).

Inclusion is also conceived as a never-ending process of improving learning and participation for all children, reducing exclusion pressures and making educational environments more responsive to students' diversity of backgrounds, interests, experiences, knowledge and skills (Armstrong, Armstrong, & Spandagou, 2009). In this context, inclusive education not only promotes human rights, but also acts as a means to achieve other development rights (Minello, 2013). However, despite general consensus on the importance of inclusion, little attention has been paid to initial teacher training and continuing professional development. As the main actors in reducing inequalities, teachers must be adequately prepared to favor inclusive education (Minello, 2013).

The growing diffusion of educational technologies has opened up new opportunities to make school inclusion more effective and accessible. In this context, a recent study (Pérez-Jorge et al.,

2024) explored the opportunities and challenges of using digital technologies for inclusive education, highlighting the crucial role of teachers in supporting students with special educational needs. The findings indicated the need for continuous training in Information and Communication Technologies (ICT) to enable teachers to effectively address diversity in the classroom and improve the accessibility of teaching (Pérez-Jorge et al., 2024). The digital skills of educators, especially future teachers, are crucial for promoting inclusion through technological tools (Mendez, 2023).

The European project Innovative methods and Artificial Intelligence in MOOC for special needs teacher Education (IA-ME, project code: 2022-1-IT02-KA220-SCH-000087877, www.ia-me.eu) was drafted to respond to these challenges. IA-ME is an Erasmus+ project that aims to develop innovative technological tools to support teachers in inclusive education. IAME combines Artificial Intelligence (AI) and a Massive Open Online Course (MOOC) to provide training resources to teachers, helping them improve their technological proficiency and apply inclusive teaching methodologies more efficiently.

A fundamental component of the IA-ME project is the creation of resources for teachers in the management of students with Special Educational Needs, with particular attention to the integration of advanced technologies that can facilitate this process. The need to develop digital skills among teachers has been recognized as crucial for the full adoption of technologies in educational contexts (Redecker, 2017). The IA-ME project aims to fill this gap.

This study focuses on the preliminary data to craft the pedagogical framework of the IA-ME project, which stemmed from a series of focus groups conducted in five partner countries (Italy, Hungary, Spain, Greece and Turkey). These focus groups were designed to collect teachers' opinions and practices regarding the use of technology to improve school inclusion, with particular reference to the integration of technologies in the process of creating personalized paths for SEN students.

2. Materials and Methods

For the study, the focus group methodology was used. The focus group method was chosen for its ability to encourage discussion and sharing of experiences among participants, allowing different ideas and perspectives to emerge (Casey & Crueger, 2000). Each Partner of the project conducted two focus groups in primary schools in its own country including Italy, Spain, Hungary, Greece, and Turkey. The focus group aimed to obtain a comprehensive assessment of teachers' perceptions of technology within the school context.

A total of fifty-two teachers (Female: 43; Male: 9) from five European countries participated in the focus groups. The sample included 16 general teachers and 16 SEN teachers, while 20 teachers fell into both categories. The age range of the teachers participating in the focus groups was 24-62 years, with teaching experience ranging from 2 to 37 years. Table 1 summarizes the demographic characteristics of the sample. Teachers participating to the focus group belonged to three different types of schools: public, charter, and private.

All teachers completed an informed consent form before participating in the focus groups. Participation was voluntary.

The focus groups in the five European countries were conducted over a period from late August to late October 2023. Each focus group involved the participation of teachers (both general and SEN), 1 moderator, and 2 observers.

Participants were asked to fill in two questionnaires:

- the MyDigiSkills questionnaire (https://mydigiskills.eu/test/), administered before the focus group, to assess teachers' digital skills.
- a satisfaction evaluation of the event, an online survey that participants were asked to fill in after the event. An anonymous Google Form was used for this survey.

An expert moderator sequentially presented the 14 pre-selected questions chosen by the entire Partnership. This approach ensured consistency and uniformity in the discussions across different

countries, allowing for more accurate comparisons of the responses emerging in the various national contexts. Table 2 shows the guiding questions proposed during the focus groups.

Table 1 - Demographic characteristics of teachers participating in the focus groups.

Participants	*Number*	*Type*	*Gender*	*Age range*	*Experience*
Italian teachers	15	- 8 general teachers - 7 SEN teachers	Female: 13 Male: 2	26-62 years	2-37 years
Spanish teacher	10	- 10 general teachers and SEN teachers	Female: 8 Male: 2	30-53 years	8-28 years
Hungarian teachers	10	- 10 general teachers and SEN teachers	Female: 10	24-58 years	2-20 years
Greek teachers	6	- 3 general teachers - 3 SEN teachers	Female: 4 Male: 2	26-55 years	4-26 years
Turkish teachers	11	- 5 general teachers - 6 SEN teachers	Female: 8 Male: 3	31-53 years	9-25 years
Total	52	- 16 general teachers - 16 SEN teachers - 20 general and SEN teachers	Female: 43 Male: 9	24-62 years	2-37 years

Table 2 - Questions asked during the focus group.

N.	*Discussion Guide Questions*
1	What is and what is not inclusive teaching?
2	Which kind of obstacles and/or facilitators have you met in your daily work?
3	Have you ever used technology in education? If so, tell us about your experiences in terms of usability, student's reactions and learning outcomes.
4	What would you like educational technology to offer you?
5	Is there an appropriate infrastructure to implement it?
6	How flexible is your teaching schedule to include new technologies?
7	List 5 EdTech applications you could use effectively in inclusive education
8	Have you ever drawn up an individualized educational plan? / How do you currency track and analyze student progress and identify areas where they need extra support?
9	How do you choose educational goals within the individualized educational plans?
10	What barriers/challenges and facilitators do you encounter in your school context?
11	Have you ever used a technology that helped you draw up an individualized learning programme? What should technology do for you?
12	Do you involve parents or guardians in the creation and implementation of individualized learning plans for their children?
13	How do you collaborate with other educators or specialists when creating a learning plan for a student with special needs?
14	What are the various areas of the individualized educational plan? Would it be helpful to add other areas to explore?

Each focus group lasted approximately two hours, with a mid-session break to allow for active participation and prevent loss of attention from the participants. All focus group sessions were recorded and later transcribed by each partner country.

For each focus group, a thematic analysis was conducted, and the results were summarized in a report produced by each country. Specifically, the report includes the methodology, participants, results, and emerging themes. Here, we focused on 7 of the 14 initial questions, selecting those that sparked the most interest and gathered significant responses from all partner countries. This decision allowed us to gain a more comprehensive and global view of the results. Table 3 shows the questions selected for analysis.

Table 3 - Key questions used for the study.

Questions used for the study
1. What is and what is not inclusive teaching?
2. Which kind of obstacles and/or facilitators have you met in your daily work?
3. Have you ever used technology in education? If so, tell us about your experiences in terms of usability, student's reactions and learning outcomes.
4. What would you like educational technology to offer you?
5. How flexible is your teaching schedule to include new technologies?
6. List 5 EdTech applications you could use effectively in inclusive education
7. Have you ever used a technology that helped you draw up an individualized learning programme? What should technology do for you?

These questions formed the foundation for the development of our work. Specifically, after carefully examining the responses provided by each partner country to the focus group questions, we identified the key themes that emerged in each national context.

3. Results

The analysis of the focus group transcripts revealed interesting themes and reflections, gathered from the 7 questions presented in Table 3. In the following sections, we highlight the themes that emerged for each of the 7 questions analyzed.

Question 1: What is and what is not inclusive teaching?

The results from this question reflect a broad consensus among all partner countries of the IAME project. The first theme that emerged is "involvement of the entire class group": inclusive teaching is defined by its ability to integrate and include all students within the classroom learning environment. This theme was unanimously highlighted by all teachers participating in the focus groups from the various partner countries.

The second theme that emerged is "adaptation and personalization": specifically, teachers from Spain, Hungary, and Italy emphasized the importance of paying attention to the individual needs of each student. This requires the use of teaching strategies that take into account the diversity of needs and profiles within the class group.

Question 2: What kind of obstacles and/or facilitators have you encountered in your daily work?

Despite the question's focus, which addressed both obstacles and facilitators, the discussions predominantly centred on obstacles.

The analysis reveals various obstacles that teachers encounter in their daily work. Table 4 shows the obstacles gathered from the sample of teachers belonging to the various partner countries of the project.

Table 4 clearly shows that the main obstacle identified is the “lack of training and technological teaching methods”, reported by Italian, Spanish, Hungarian, and Turkish teachers.

Another theme that emerged is “infrastructure”, reported by teachers from Italy, Greece, and Turkey. This theme highlights the lack of adequate facilities to effectively carry out teaching.

Additionally, other emerging themes were:

- “inadequate teaching materials”, reported by Hungarian and Greek teachers;
- “lack of collaboration with families” and “prejudices about disabilities”, reported by Italian and Turkish teachers involved;
- “staff turn over”, reported by Spanish teachers;
- “lack of communication between colleagues”, reported by Italian participants.

Table 4 - Obstacles highlighted in the focus group.

Themes emerged	Italian teachers	Spanish teachers	Hungarian teachers	Greek teachers	Turkish teachers
Infrastructure	x			x	x
Inadequate teaching material			x	x	
Staff turn over		x			
Lack of training and technological teaching methods	x	x	x		x
Lack of collaboration with families	x				x
Lack of communication between colleagues	x				
Prejudices about disabilities	x				x

Question 3: Have you ever used technology in education? If so, tell us about your experiences in terms of usability, student's reactions, and learning outcomes.

The analysis of this question reveals that all participants in the focus groups across the partner countries have used technology in their educational practice.

Several themes were identified regarding both the teachers' experiences with technology use and the students' reactions during its use.

As for the teachers' experience in using technology in teaching, Greek and Italian teachers emphasized the theme of "increased student motivation". This is because they found that students were more motivated and engaged in educational activities when technology was integrated.

Another relevant theme emerged was "support for learning and teaching", reported by Greek, Spanish, and Italian teachers. This theme highlights the importance of technology not only for students, who learn with greater interest, but also for teachers, who benefit from a valuable tool to enhance their lessons.

A significant theme was "support and facilitation of inclusion", reported by Spanish, Hungarian, and Italian teachers. This theme emphasizes the added value that technology offers in increasing the inclusion of children with disabilities, allowing them to learn alongside other students and promoting cooperation during educational activities.

Regarding the students' reactions, teachers from Greece, Hungary, Italy, and Turkey agreed that the main reaction observed was "increased concentration, engagement, and interest" during the use of technology.

Finally, it is important to note the feedback from Hungarian teachers, who emphasized that one of the students' reactions was the perception of a more varied lesson.

From these results, we can confirm the significant role of technology in education, highlighting the multiple benefits for both teachers and students, including increased motivation, participation, and inclusion.

Question 4: What would you like educational technology to offer you?

The analysis of this question reveals several themes that allow us to understand what teachers would like technology to do for them. Table 5 shows the results that emerged for question number 4.

As shown in Table 5, "personalized teaching" was the predominant theme in response to the question "What would you like educational technology to offer you?" reported by Italian, Spanish, Hungarian, and Turkish teachers. This result highlights that despite progress in educational technology, schools across Europe still face significant challenges in offering adequate

personalized teaching to meet the diverse needs within the classroom. Another emerging theme was “inclusion”, reported by teachers from Italy, Hungary, and Greece. This result underscores the importance of using technology to foster an inclusive educational environment that takes into account the diversity among students.

Table 5 - Added value of technology reported by teachers.

Themes emerged	Italian teachers	Spanish teachers	Hungarian teachers	Greek teachers	Turkish teachers
Inclusion	x		x	x	
Stimulating, motivating and engaging learning environment	x	x		x	
Educational customization	x	x	x		x
Teacher support	x	x			x

Another notable theme reported by Italian, Spanish, and Greek teachers was “a stimulating, motivating, and engaging learning environment”. This shows that teachers view technology as a potential tool to boost students’ motivation and engagement, a point that was already raised in the previous question (Question number 3).

Lastly, the final emerging theme was "teacher support," reported by Italian, Spanish, and Turkish teachers. Specifically, teachers have asked for more assistance from technology in preparing educational materials, improving teaching and learning processes, and reducing bureaucratic workload.

Question 5: How flexible is your teaching schedule to include new technologies?

The analysis of this question reveals a common viewpoint across all partner countries: there is a general consensus that their teaching activities were considered very flexible in integrating new technologies. This result highlighted a widespread openness to introducing and incorporating technological tools in the educational environment.

However, an important point emerges from the focus groups conducted in Spain and Hungary: teachers pinpointed the lack of sufficient time to acquire the knowledge and skills needed to use new technologies effectively.

Question 6: List 5 EdTech applications you could use effectively in inclusive education All participants from the different partner countries listed various technologies they use in their educational practice.

Specifically, the most commonly reported EdTech applications across participants belonging to the five European countries were the following:

- Assessment and feedback systems: Kahoot, Quizizz, and Mentimeter
- Learning platforms: Wordwall, and Youtube
- Educational content creation software: Canva, and Mindomo.

Question 7: Have you ever used a technology that helped you draw up an individualized learning programme? What should technology do for you?

The analysis of this question revealed that participants from all partner countries used some kind of technological tools to draw up individualized programmes for SEN students, except for Italy.

Nevertheless, a strong interest emerged from all teachers in the focus groups in using technology for drafting Individualized Educational Plans, although this was accompanied by ethical concerns.

The ethical concerns mainly revolve around the fear that technology could replace the teacher's role, even in crucial aspects such as empathy and direct contact with students and their families.

Finally, teachers believed that technology could be a valuable aid in the process of personalizing the Individualized Educational Plan based on the student's specific needs. Also, technology could offer them a more complete and holistic view of the student.

4. Conclusions

The results from the IA-ME project focus groups provide a clear and detailed overview of the challenges and opportunities of inclusive teaching, with particular reference to the integration of technology into teaching practices. From the very definition of inclusive teaching, to the use of EdTech applications and the creation of Individualized Education Plans, it is clear how technology plays an increasingly central role in offering an adaptive and accessible educational environment to all students.

A key theme that emerged from the focus groups was the shared vision of inclusive teaching, which is realized through the active involvement of the entire class group and the adaptation of teaching strategies to the specific needs of each student. Teachers agreed that inclusion should not be limited to ensuring the physical presence of all students within the classroom, but should be conceived as a dynamic process that requires constant customization of the teaching plan. As highlighted by Tomlinson (2014), a differentiated learning environment allows teachers to respond to the different needs of students, promoting inclusion and active involvement of all in the educational experience.

The focus group findings, however, also highlight several obstacles that limit the effectiveness of inclusive teaching, with particular attention to the "lack of training" and the absence of "technological teaching methods". This point was unanimously highlighted by teachers from Italy, Spain, Hungary and Turkey, who reported a significant shortage of specific technological skills for teaching. This gap confirms the conclusions of the European Commission Report (2019) pinpointing that many European teachers feel unprepared to effectively integrate technology into their teaching practices. Furthermore, the need for more adequate infrastructure, reported by teachers from Italy, Greece and Turkey, represents a further obstacle that limits the use of technology to support inclusive education.

A central theme that emerged was the role of technology as a tool to improve student motivation and engagement as reported by teachers from Greece and Italy. This not only has positive effects on student motivation but also facilitates teachers' daily work, allowing them to personalize activities and better respond to students' individual needs. As highlighted by Selwyn (2016), integrating technology into education allows for the transformation of the learning process, providing tools that enhance student interest and engagement, as well as facilitating teachers' tasks in managing diversity in the classroom.

Despite these advantages, a shared feeling emerged among teachers regarding the risks that the use of technologies could entail. Some fears rely on the idea that technology could be perceived as a substitute for teachers rather than a tool at their service, capable of supporting their educational role. In line with Wang et al. (2021), technology must be considered an ally in teaching, capable of facilitating the educational process, but not replacing the human interaction and connection that are fundamental for meaningful learning. Nonetheless, technophobia remains a prevalent issue (Azarfam & Jabbari, 2012; Bardakci & Ünver, 2020), often causing educators to shy away from integrating new technologies into their teaching practices. To address this issue, technology integration must be accompanied by comprehensive training, aimed at enhancing teachers' self-efficacy and fostering a more positive attitude toward the use of digital tools (Saal, Mdlulwa & Hannan, 2024).

Furthermore, the experiences shared by teachers from various countries provided a strong foundation for understanding specific local needs with the aim of developing a technological tool that is both practical and adaptable. In particular, the feedback collected through the focus groups was instrumental in advancing the IA-ME project's mission in creating a tool that not only

meets the practical needs of teachers but is also flexible enough to be implemented across different European educational contexts. This aligns with Scherer et al. (2019), who emphasize the importance of tailoring educational technologies to the unique needs of each school environment.

There are some limitations in this study that deserve attention. First, the sample size of the focus groups may not fully represent the diversity of teachers' experiences and opinions across Europe. Furthermore, the results may be influenced by the subjectivity of the participants. Finally, the implementation of educational technologies may vary significantly depending on the local context, limiting the universal interpretation of teachers' perspective.

In conclusion, data gathered from focus groups in each country provide invaluable insights into the practical aspects of teaching with SEN students and a glimpse into teachers' perceptions of technology integration in the classroom. Results of our study clearly show that, despite the challenges, teachers recognize the potential of technology to facilitate inclusive teaching and improve the educational experience for all students. However, to fully exploit this potential, it is essential to provide teachers with the necessary skills and resources, as well as to develop tools that respond to specific local and cultural needs. Training and ongoing support will be essential to ensure the effective use of technologies, always keeping the irreplaceable role of the teacher at the center of the educational relationship. In this regard, the IA-ME project was crafted to provide useful technological resources to support teachers' role.

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· Section 7 ·
AI in Education

Learning Physics by playing: an AI-guided escape room adventure in Unreal Engine

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Abstract

This project integrates game design and problem-solving education via an escape room game in Unreal Engine (Epic Games, n.d.). Beyond just gamifying problem solving, it establishes an immersive realm where players intuitively absorb principles and laws of Physics by using machine learning to identify learning patterns and enhance the game.

The objective is to gauge the game's impact on problem-solving understanding, contrasting in-game metrics with traditional exam scores, advocating for hands-on, immersive learning. "Serious Games" have risen from simple diversions to potent educational tools. Emphasized by research, particularly Menon & Romero's 2019 insights, Game-based Learning (GBL) significantly bolsters retention and engagement. Building on this foundation, this project blends the realms of virtual laboratories and gaming. Gunawan et al. (2018) elucidated the positive impacts of virtual laboratories on the students' conceptual understanding in Physics, highlighting that students engaged with virtual labs demonstrated superior learning outcomes.

We will develop a distinctive escape-room game, where puzzles symbolize distinct problem solving games, urging students to transition from passive lectures to active exploration of physical systems. Within this environment, every action, choice, and interaction is meticulously recorded, then analyzed through machine learning to ascertain learning trends and obstacles. Our core mission is to unify digital laboratories with the escape room model to improve student learning.

Keywords: Serious Game, Tutoring AI, Game Based Learning, Physics, Escape Room.

1. Introduction

The project aims to enhance the quality, flexibility, and effectiveness of teaching in the scientific degree programs at the University of Camerino (Italy) by offering to the students innovative online learning activities. In this context, we are designing a Serious Game based on Physics experiments to support theoretical classroom lessons.
This educational game provides a learning environment where students immerse themselves in a virtual journey that combines a virtual laboratory and Game-Based Learning (Plass, Homer & Kinzer, 2015). The escape room-style video game simulates a series of virtual physics laboratories where students engage by solving problems. In addition we created a Metahuman tutor (Epic Games, n.d.) that follows the player inside the rooms giving some hints if the player needs help. The goal is to offer an integrated learning system that connects theoretical lessons and practical activities typically conducted in a laboratory (Amendola & Miceli, 2016).
Several factors are behind this chosen direction. Firstly, scientific degree programs often lack practical laboratory activities or include very few hours of such activities.
Secondly, there is a growing gap between traditional teaching methods and the learning and communication tools which are typical of the new generations (Oblinger & Oblinger, 2005).
The choice to create a Serious Game originates from evidence that game-based learning (GBL) improves both student learning and understanding, interest, and motivation for the subject matter (Menon & Romero, 2019). GBL, when integrated with digital tools, constitutes a teaching strategy that uses games to teach specific content or achieve a particular learning outcome.
Infact, the game itself facilitates the acquisition of knowledge. While playing, students learn the knowledge targeted by the game. Game-based learning uses disciplinary content and makes it

challenging and enjoyable, resulting in immediate and meaningful learning (Camacho-Sánchez et al., 2022).
This aligns also with findings by Psyllou (2024), who reported improvements in student performance and motivation using educational escape rooms. Papadakis (2024) also found that gamified learning environments yield better outcomes than traditional methods in various academic metrics.
We also expect that students deeply engaged with the game will show improved comprehension and problem-solving skills.
To personalize and improve learning outcomes we need to record the students' interactions and behaviors inside the game, this will give us the opportunity to gather information about how they play and how they learn Physics throughout the escape room.
This data-driven approach allows us to identify areas where students struggle and adjust the game accordingly, enhancing its effectiveness as a learning tool personalizing the game.
In the game, we have incorporated the principles of Universal Design for Learning (CAST, 2018) to enhance accessibility and inclusivity. As Flynn (2024) stated, aligning the escape room with UDL principles increases student engagement and collaboration.
As a result of our new game's design, we expect it to enhance engagement, accessibility, and understanding of Physics concepts of the students.

2. Materials and Methods

The project is divided into two phases:
1. The realization of the game;
2. The implementation of the game with academic students.

First phase
Building upon strategies employed by Psyllou (2024) we designed a game featuring a captivating narrative and integrated hints to facilitate an interactive and inclusive learning environment.

Rooms Design: The rooms represent distinct physics problems inside using a virtual integrated laboratory that require students to apply theoretical knowledge in practical scenarios, reinforcing key concepts in an engaging way. Each time a player enters the game, the solutions to the quizzes are generated randomly, ensuring that they must perform the necessary calculations anew every time. This prevents rote memorization and encourages continuous critical thinking, making each gameplay experience unique and challenging. The map is made up of a series of closed rooms as shown in Figure 1.

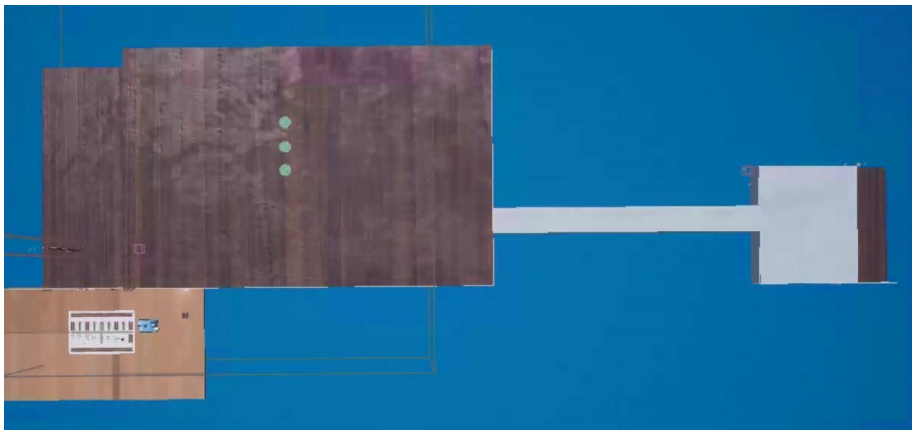


Figure 1 - Map seen from above, version 1.0 (not final).

AI-Powered Tutor: An AI tutor is integrated into each room to provide hints and assistance, enhancing the learning experience and maintaining engagement (Figures 2 and 3).



Figure 2 - Tutor Face.



Figure 3 - Tutor interaction.

Tutor Architecture

To facilitate problem-solving, each room contains an AI-powered tutor that provides students with assistance through hints and help, always referring back to the examined physics topic. The tutor simulates human behavior with realistic movements and dialogues, making the experience more immersive. By syncing its mouth with received audio, the tutor creates natural interactions, enhancing user engagement. Research by Johnson et al. (2000) shows that animated pedagogical agents can significantly improve learning by offering immediate assistance, while Baylor and Kim (2005) found that interactive tutors positively impact engagement and learning outcomes.

In this system, the tutor is a MetaHuman, a highly realistic 3D digital character developed by Epic Games through the MetaHuman Creator tool (Epic Games, n.d.). MetaHumans offer detailed facial expressions, realistic body movements, and customizable features, ideal for interactive environments. The tutor communicates using ChatGPT-4.0 (OpenAI, 2023) with an internal prompt guiding it to act as the 'physics professor', providing hints but not full solutions.

Once the tutor generates a response, it is sent to ElevenLabs, an AI that converts text into audio (ElevenLabs, 2023). The audio is then processed in Unreal Engine, with the tutor's lip movements synchronized in real time using Audio2Face, an AI tool from NVIDIA designed for lip sync based on audio input (NVIDIA, 2023).

Universal Design for Learning (UDL) Principles

In line with Flynn's (2024) approach, our game incorporates UDL guidelines by providing multiple means of engagement, representation, action and expression.

1. Interactive Tutor: The tutor interacts through both audio and text, responding verbally and in writing. This multimodal interaction ensures accessibility for auditory and visual learners (Figure 3).
2. Physics Video Tutorials: During gameplay, students access video tutorials offering alternative explanations of concepts, supporting varied learning styles.
3. Supportive Feedback Mechanisms: The tutor provides assistance when students face difficulties, preventing frustration and maintaining motivation.

<u>*Second phase*</u>

Once the game is finalized we start with the second phase that consists in the implementation involving students from various scientific degree programs at the University of Camerino. The game features variable difficulty levels, which means even more advanced physics students can challenge themselves by testing the game. Pilot groups will include undergraduate students enrolled in introductory Physics courses to validate the game's effectiveness across different levels of prior knowledge, ensuring it caters to both beginners and those with a stronger background in Physics.

Data Analysis

1. Machine Learning Analysis: We analyze collected data using machine learning techniques to identify learning patterns and obstacles, and to personalize the learning experience.
2. Students perception.

3. Comparative Analysis:
   a) In-game performance data is compared with traditional exam scores to evaluate the correlation between gameplay engagement and academic achievement.
   b) The effect of the intervention on the students' academic performance is compared between the experimental and the control group.

Data Analysis Tools

1. Machine Learning Algorithms: Used to analyze interactions and identify trends.
2. Unreal Engine Analytics: Provides real-time data collection and preliminary analysis.
3. JSON Files: Used to capture and store detailed student data in a structured format for analysis.
4. Disciplinary Test: Closed and open questions.
5. Students perception questionnaire: Closed and open questions.

3. Results

We are in the first phase of the project, that consist in the realization of the serious game using Unreal Engine 5, the game is divided into rooms, in each room there is a particular physics chapter, at the moment there are 3 rooms.
The first room is based on the "inclined plane" topic, where the student needs to position 3 balls inside three inclined planes where in every one of these is applied some friction.
Once the balls are placed there the student needs to understand which sphere will slip faster to the end of the plane. There the student needs to calculate the time it takes for each sphere to reach the bottom of the inclined plane using the correct physical law and its associated equation.
In the second room, the main topic is the "parabolic motion", where students must hit a target at the end of the map by throwing a ball. To do so, they need to calculate the necessary force to throw the ball correctly. The challenge is to hit the target three times. In each session, the target's distance from the ball changes randomly, making the task more difficult, as precise calculations are required each time.
The third room's main topic is electromagnetism. Here the students have to move and connect several wires to obtain a certain value of electricity to open some doors.
When the player solves all the quizzes inside a room, they receive a key or a code to open a door and gain access to the next room.
Thanks to our game design, it's possible to collect as much relevant data as possible to analyze how effective the game is in an educational setting, specifically in determining whether it helps students better understand physics concepts. The data gathered is important to assess the game's impact on student learning, engagement, and overall comprehension of the subject matter, providing insights into how well the game functions as a teaching tool.
This will be the gathered data:

1. Completion Time: Recording the time taken to complete challenges across attempts assesses learning progression.
2. Attempts to Solve Challenges: Tracking the number of attempts needed evaluates comprehension improvement over time.
3. Help Requests: Monitoring help requests helps us to understand the students' interactions with the AI tutor.
4. Action Sequences: Analyzing action sequences identifies common strategies and effective problem-solving approaches.

4. Conclusion

We have developed an educational game that integrates the use of MetaHuman and follows the principles of Universal Design for Learning (Flynn 2024), combining virtual laboratories to ensure an immersive experience in learning Physics. These design precautions aim to create an inclusive

and engaging environment, capable of adapting to the different needs of the students and stimulating their active participation.
Our next step is to move on to the second phase of the project, during which we will evaluate whether this innovative tool improves the students' engagement and understanding of Physics concepts. Through an in-depth analysis of the data collected and a comparison with traditional teaching methods, we aim to verify the effectiveness of the game in enhancing student learning and motivation. Our expectation is that the implementation of this approach will contribute to better learning results and a greater interest in the subject.
The success of similar implementations, such as those by Psyllou (2024), Papadakis (2024), and the conclusions of Achour et al. (2023), reinforces the potential of escape room games and gamified learning to improve learning outcomes and student engagement in several different academic contexts.

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Implementation of a virtual tutor based on generative AI to enrich the training experience

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Abstract

Continuous training for company employees is evolving in an increasingly important and continuous way. There are many reasons and they have to do both with the rapid obsolescence of knowledge and with the need for transversal skills that cross specialist knowledge. All this must happen compatibly with work activities, deadlines, organizational constraints of space and time. In this sense, continuous training for employees represents fertile ground for experimentation and innovation of forms and tools. The paper describes the implementation of a generative AI-based virtual tutor within the Moodle platform to enhance the educational experience. The ongoing experimentation at a company that carries out online training for sales staff is structured in three phases: 1) integration of AI into the Learning Management System; 2) training on specific course content; 3) integration of a virtual avatar for voice interactions. The virtual tutor uses GPT-4 to provide: (a) personalized support 24/7, reinforcing learning through immediate feedback, (b) insights on specific topics, (c) interactive quizzes, (d) multilingual support and potential integration of external resources into course content. The effectiveness of the assistant will be assessed based on the collection and analysis of student feedback, with ongoing adjustments and improvements. Finally, the document emphasizes the importance of privacy and suggests the evaluation of open source LLMs for enhanced data protection. Moreover, the importance of training through Retrieval Augmented Generation (RAG) is highlighted, and some tips are provided to ensure targeted and personalized responses.

Keywords: LLM, RAG, Generative AI, Digital Tutor, Conversational Interaction, Moodle, LMS.

1. Introduction

In the rapidly evolving context of corporate training, adaptive and personalized learning has become essential for ensuring organizational competitiveness and innovation. As organizations face evergrowing demands for efficiency and efficacy in their training programs, the need for solutions that provide flexibility, scalability, and tailored support becomes increasingly evident. The implementation of an AI-based virtual tutor represents a significant advancement in this domain, providing an interactive learning environment specifically tailored to meet the individual needs of employees. This technology addresses key challenges such as limited access to training services, resistance to adopting new methods, and the need for continuous learning in dynamic work environments.

AI-driven virtual tutors can mitigate traditional learning barriers by offering personalized, on-demand guidance, which is crucial for employees balancing training with their day-to-day work responsibilities. The dynamic nature of this technology allows organizations to foster a culture of learning and development, wherein employees are empowered to take control of their growth while leveraging tools that are responsive to their unique needs. Furthermore, such a system enhances the ability of companies to remain agile and innovative, adapting to changes in technology and industry requirements. The implementation of a virtual tutor presents numerous advantages that fundamentally transform the learning experience. By leveraging the capabilities of artificial intelligence, the tutor can create a more responsive and supportive educational environment that meets the evolving needs of modern learners.

Personalized 24/7 Support

The virtual tutor is available 24/7, offering immediate support to users regardless of their geographical location or time zone. This continuous availability is essential for ensuring that learning opportunities are not limited by time constraints. It provides a solution for employees who may need to access training resources outside of conventional working hours, whether due to their roles or personal commitments. This flexibility enhances the accessibility of learning and ensures that support is always at hand, thereby fostering a more inclusive learning culture. Such accessibility not only increases engagement but also reduces the frustration that can arise from delayed assistance, contributing to a seamless learning experience.

In-Depth Explanations

The virtual tutor provides detailed and personalized explanations specifically designed to address the unique needs and learning preferences of each user. For complex concepts that might pose challenges, the tutor offers targeted examples, step-by-step analyses, and alternative explanations to help bridge knowledge gaps. This form of tailored instruction facilitates a deeper understanding of the subject matter and aids in the retention of critical information. By aligning new content with existing knowledge frameworks, the virtual tutor also supports knowledge scaffolding, enhancing the learner's ability to integrate and apply new insights effectively. This adaptive approach ensures that learners receive the right level of support at the right time, ultimately leading to improved outcomes.

Adaptive Interactive Quizzes

The virtual tutor's interactive quizzes are designed to adapt dynamically to the learner's performance in real-time. These quizzes utilize sophisticated algorithms to assess the learner's strengths and weaknesses, adjusting the level of difficulty accordingly. For proficient learners, the system escalates the complexity of questions to keep them challenged and engaged. Conversely, for learners who may struggle with foundational concepts, the tutor reinforces essential topics to solidify their understanding. This adaptive methodology not only makes learning more engaging and interactive but also serves as an effective self-assessment tool, allowing learners to gauge their progress, identify areas for improvement, and take ownership of their educational journey. By incorporating these self-regulating elements, the virtual tutor helps cultivate a growth mindset among learners, encouraging continuous improvement and resilience.

Multilingual Support

In today's globalized corporate environment, the presence of a multilingual virtual tutor is critical for ensuring that language differences do not pose barriers to effective learning. The tutor's ability to communicate in multiple languages promotes inclusivity by catering to a diverse workforce, thereby enhancing accessibility to learning content across geographical and cultural boundaries. The option for employees to interact with the tutor in their native language reduces cognitive load and increases comfort levels, which can significantly improve both engagement and comprehension. By providing linguistic support, the virtual tutor ensures that all employees, regardless of their background, can fully participate in training initiatives, thereby fostering an equitable learning environment that values diversity and inclusion.

Integration of External Resources

The virtual tutor is designed to seamlessly integrate a wide range of external resources, such as videos, case studies, research articles, and real-world examples, into the learning experience. By incorporating multimedia and varied types of content, the tutor enriches the learning material, making abstract concepts more relatable and easier to understand. This contextualized approach provides learners with practical insights that can be directly applied to their professional roles, bridging the gap between theory and practice. Moreover, the integration of external resources keeps the learning experience fresh and relevant, encouraging learners to explore topics in

greater depth and fostering a culture of lifelong learning. The use of diverse learning materials also accommodates different learning styles, ensuring that content resonates with all users.

2. Materials and Methods

Evaluating the effectiveness of the virtual tutor requires a comprehensive approach that incorporates both quantitative and qualitative metrics. This multi-faceted evaluation ensures a holistic understanding of how the tutor impacts the learning experience and its contribution to overall organizational goals. Quantitative metrics such as user engagement, frequency of use, and course completion rates provide objective data regarding the tutor's usage and effectiveness. Meanwhile, qualitative methods, including satisfaction surveys, focus groups, and interviews, offer valuable insights into the learner's perspective, highlighting areas of success and opportunities for enhancement.

User Engagement

1) Course completion rate: A 10-20% increase compared to pre-intervention rates, indicative of greater training effectiveness. Higher completion rates suggest that learners find the content accessible, relevant, and supportive of their professional development.
2) Average usage time: A 10-30% increase in time spent on the platform, indicating deeper engagement and sustained interest in the learning materials. Increased usage times reflect the tutor's ability to maintain learner motivation and focus throughout their training sessions.
3) Interactions with the tutor: A significant number of daily interactions per user (e.g., 3-5 per session) serves as a positive indicator of system acceptance and user engagement. Frequent interactions suggest that learners view the tutor as a valuable resource for clarification and guidance.

Learning Performance

1) Test scores: A 5-15% improvement in test results following the introduction of the tutor. Such gains demonstrate the tutor's impact on learner comprehension and the effective reinforcement of key concepts.
2) Learning pace: A reduction of at least 10% in the time needed to complete course modules, demonstrating greater process efficiency. Improved learning pace is indicative of the tutor's role in streamlining the learning process, allowing learners to achieve their objectives more quickly.

User Satisfaction

1) Satisfaction index: An average rating of at least 4 out of 5 in post-intervention surveys, indicating a positive user experience. High satisfaction scores reflect the tutor's ability to meet learner needs and enhance the overall training experience.
2) Net Promoter Score (NPS): An NPS of at least 30, suggesting a willingness among users to recommend the system to others. A strong NPS highlights the perceived value of the tutor and its impact on learner engagement.

Personalization and AI Responsiveness

1) Relevant response rate: At least 75% of AI responses must be deemed useful by users, highlighting the effectiveness of personalization. A high relevant response rate demonstrates the tutor's capability to provide contextually appropriate and valuable guidance to learners.

2) Response speed: An average response time of less than 5 seconds, ensuring continuity in the learning flow. Rapid response times are crucial for maintaining learner engagement and preventing disruptions in the learning process.

Operational Efficiency

1) Reduction in instructor workload: A 20% reduction in time spent on frequently asked questions, freeing resources for higher-value activities such as personalized coaching and curriculum development. The tutor's support allows instructors to focus on more strategic tasks, thereby optimizing the efficiency of the training program.
2) Cost per user: Maintaining or reducing the cost per user compared to traditional training systems, optimizing economic efficiency. The implementation of an AI tutor can lead to significant cost savings, particularly when scaled across large organizations.

Technical Integration and Scalability

1) Error rate: Less than 1% of sessions should be affected by technical errors, ensuring operational stability. A low error rate is essential for maintaining user trust and ensuring a smooth learning experience.
2) System scalability: The ability to handle a 50% increase in users without performance degradation, ensuring infrastructure sustainability. Scalability is a key consideration for organizations looking to expand their training initiatives while maintaining consistent quality.

Data Privacy and Security:

1) Security breaches: No data breaches during the trial period, adhering to high security standards. Robust data security measures are crucial for protecting sensitive user information and ensuring compliance with regulatory requirements.
2) Privacy compliance: Full compliance with applicable regulations, ensuring user data protection. Privacy compliance builds trust among users, encouraging greater participation in training activities.

The study originally aimed to involve a group of 50 employees from the sales department of a multinational corporation. These participants were selected based on their varying levels of experience with eLearning platforms, ensuring a diverse sample for the evaluation of the AI tutor's effectiveness.

The research method was designed as a mixed-method approach, combining both quantitative and qualitative data collection. Participants were divided into two groups: one using the AI-powered virtual tutor integrated into the Moodle platform, and the other using traditional eLearning methods without AI support.

The research process consisted of the following key stages.

Phase 1 - Training on Specific Course Content

This phase focuses on the specialization of the AI-based virtual tutor to handle specific course content effectively. This phase is crucial for ensuring that the AI can deliver highly relevant and context-aware assistance tailored to the particular needs of the sales training courses offered by the company. RAG and prompt engeenering are primary processes for this activity. Here’s breakdown list of the activities in this phase: Analysis of the existing course materials, Dataset creation, Tutor customization, Validation;

Details: Training a Retriever-Augmented Generation (RAG) model on specific course content can offer an effective way to create a virtual assistant that provides relevant, personalized responses to students. Here are some tips for implementation and training:

1) Selecting Training Data: Collect a complete dataset of the course's learning materials, including textbooks, lecture slides, notes, exercises, and any other relevant resources. Ensure data is well organized and categorized by topic or module, to facilitate targeted training and indexing.
2) Preprocessing Data: Before training, it is important to clean and preprocess the data. This can include removing unnecessary formatting, fixing typographical errors, and standardizing text formats to improve the effectiveness of model training.
3) Targeted Training: Consider model-specific training on frequently asked or typical student questions related to the course. This may include using past exam questions, questions from course discussion forums, or any other source that reflects students' actual information needs.
4) Evaluation and Optimization: After initial training, evaluate the model's performance using a test set of questions and answers not seen during training. Use the collected feedback to further optimize the model, for example, refining the retriever or refining the generated responses.
5) Continuous Update and Maintenance: Course content may evolve over time, so it is important to keep the model updated with new materials and student feedback. This may require periodic cycles of data reacquisition, retraining, and evaluation.

It is also important to take into consideration the "character" and the type of communication you want to give to the assistant. To do this it is essential to design the "prompt" very well, the instructions that are given to the assistant in addition to the knowledge base documents.

In our experimentation the first stream was to identify the course and target audience for which to build the virtual tutor. In particular, the empathic communication course already present on the platform and aimed at sales staff was chosen.

Once the course was identified, the search began for the material to train the tutor. As it was an existing course on the platform, priority was given to the course content, but the tutor's knowledge was expanded with the source material from which the course was originally created and the transcript of the video produced by the instructor. An additional step was to have the instructor create a set of 20 questions and answers to provide more targeted guidance. The trained tutor was thoroughly tested along with the instructor, and after the initial tests, it became clear that the content initially provided without any elaboration needed to be reworked further. The responses often appeared repetitive, and the hallucination phenomenon sometimes occurred, failing to find all the information needed in the material. This was greatly mitigated by better organizing the materials and through the prompt created to provide additional information to the virtual tutor. For example, it was told that if it could not find the answers within the documentation, and only in that case could it search in its knowledge base (that of the LLM), but in that case, it would have to cite the sources. Through the prompt, it was also defined how to communicate and that it should respond in the language in which the question was asked. In this way, after a few weeks, the training was completed with satisfactory results.

Phase 2 - Integration of AI into the Learning Management System (LMS) accessible by Intranet

This phase involves several critical steps designed to lay a robust foundation for AI-enhanced learning. This phase is fundamental because it ensures that the AI functionalities are deeply embedded into the existing learning management system and intranet, allowing for seamless interactions between the AI and the learners. Here is a breakdown list of the activities in this phase: System Assessment and Requirements Gathering, AI integration planning, API development and integration, implementation and testing.

Using a Large Language Model (LLM) like GPT-4 or an open source alternative to integrate a virtual assistant into an educational platform like Moodle poses important considerations from a technology and privacy perspective. Here are some important aspects:

1) Data Privacy and Security: One of the main advantages of using an open source LLM is the ability to host it on your own servers, offering greater control over the privacy and security of both user data and content used for training.

2) Customization and Control: An open source LLM could offer greater flexibility in terms of customization and adaptation to specific course content. You would have the ability to modify the model to optimize performance.
3) Costs and Resources: The costs associated with using a commercial service versus implementing an open source solution must be considered. While commercial services may offer greater ease of use and support, using an open source LLM may require more upfront resources for installation, configuration, and maintenance, as well as specific technical expertise.
4) Scalability and Performance: The scalability and performance of the chosen solution must be evaluated in relation to the expected number of users. Open source solutions may require careful planning of hardware resources to handle high user loads and requests, while commercial services often offer flexible scaling as part of the service.
5) Community and Support: The use of open source solutions can benefit from the support of a community of developers and users. Explore the availability of documentation, support forums, and frequency of software updates to ensure your chosen solution is well supported.
6) Compliance and Future Updates: Any solution you choose must be able to be easily updated to remain compliant with changing privacy laws and to integrate improvements or new features over time.

In summary, choosing between a commercial LLM like OpenAI's GPT-4 and an open source alternative should be based on a thorough evaluation of your specific needs, considering privacy, cost, resources, scalability, and the level of community support available. It may also be useful to evaluate hybrid solutions, where both commercial and open source elements are used to balance the benefits of both approaches.

For our experimentation we opted to use OPENAI's LLM GPT-4-turbo-preview which however offers various configuration options to safeguard privacy and allows the effectiveness of these AI solutions for learning to be tested more quickly.

We started from an open source Moodle plugin and customized it using the assistant API to track interactions between users and the virtual tutor so we could measure the defined metrics.

A further objective was to simplify the user's interaction with the tutor by enabling voice interaction. Work is still ongoing on this point, but to begin testing the potential of this approach, a third-party service (D-ID company) was used, which allowed us to experiment with the potential of this approach, especially from a smartphone. Furthermore, on this aspect, the upcoming releases of the GPT-4o model will surely help us build a robust and effective solution.

Phase 3: Data Analysis

Quantitative data was analyzed using statistical methods, comparing engagement and performance metrics before and after AI tutor implementation.

Qualitative data, such as user satisfaction and feedback, was analyzed using thematic analysis to identify key trends and areas for improvement.

Tools used:

1) Statistical software for analyzing engagement metrics (time spent on the platform, number of interactions with the tutor, etc.).
2) Sentiment analysis on open-ended feedback collected through surveys and interviews to understand qualitative insights on user satisfaction.

3. Results

While the full experimental deployment was not realized due to unforeseen circumstances, a preliminary analysis based on a small-scale pilot indicated promising trends. Early feedback from a test group of four employees suggested that the AI tutor significantly enhanced engagement by

providing instant feedback and personalized learning paths. Participants reported higher levels of satisfaction with the AIbased interactions compared to their previous experiences with standard eLearning modules.

The AI tutor's detailed explanations and ability to offer instant feedback were frequently cited as key contributors to the improved learning experience. The interactive quizzes, which adapted based on learner performance, were especially well-received, helping users to stay motivated and engaged. Multilingual support also played a crucial role, making the learning material accessible to non-native speakers and fostering inclusivity within the company.

Although the pilot was limited, data gathered from this small-scale experiment indicated a noticeable improvement in both engagement and learning outcomes. Key quantitative metrics, including a 15% increase in course completion rates and a 10% improvement in test scores, demonstrated the tutor's effectiveness. User satisfaction also increased, with an average score of 4.5 out of 5 in post-intervention surveys.

These initial results align with the findings in recent literature, which highlights the positive impact of AI tutors in increasing user engagement and retention.

4. Conclusions

Despite the project not being able to have the expected number of participants, the preliminary pilot study demonstrated the potential of AI-powered virtual tutors in enhancing the learning experience, particularly in the context of corporate training. In comparison to existing studies in the literature, our findings – although limited – support the idea that AI tutors can significantly contribute to better learning outcomes, especially in environments where employees have varying levels of proficiency and require flexible learning schedules.

Future phases of this project will include the full deployment of the virtual tutor in the company's production environment and extended testing with real users. Feedback gathered during this phase will be crucial for refining the AI's responses and improving its usability.

Next Steps

1) Deployment of the Virtual Tutor: Implementation of the virtual tutor in the production environment, integrated into the corporate intranet for the selected pilot course. This step involves a phased rollout to ensure stability and allow for iterative improvements based on initial user feedback.
2) Testing with a substantial number of Users: Collecting feedback from users to further optimize the learning experience. User feedback is invaluable for identifying pain points, understanding learner preferences, and making necessary adjustments to enhance the tutor's effectiveness.
3) Analysis of Results: Evaluation of defined effectiveness metrics to identify new opportunities and areas for improvement. Data-driven analysis will guide future enhancements, ensuring that the tutor continues to meet the evolving needs of learners.
4) Development of Additional Features: Expanding tutor capabilities, including voice interaction and more advanced personalization to further enhance learning effectiveness. Voice interaction, in particular, represents a promising avenue for making the tutor even more accessible and userfriendly, enabling hands-free learning and catering to diverse user preferences.

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did not fully come to fruition, the insights gathered have paved the way for future advancements in this field.

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Is ChatGPT like Facebook 20 years ago? A diachronic reflection on its use in schools

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Abstract

The contradictory and doubtful positions regarding the use of educational technology, however, concern not only the teaching component, as a common bias might lead us to think, but also the students themselves (Zaimakis & Papadaki, 2022). After all, the younger generation's relationship with social networks, mostly associated with Generation Z and later, is problematic and complex. In an article published by Meta (Facebook's actual name) three years ago, the vice president of corporate research addressed a survey in The Wall Street Journal (Wells, Horwitz, & Seetharaman, 2021) that highlighted the negative effects social networks can have on teenagers' psychological well-being (Raychoudhury, 2021). Without resorting to extreme views, it is important to recognize that teenagers may have both negative and positive experiences with social networking tools. This, of course, also leads us to question other digital tools that are making a significant impact today, in addition to social media. This paper endeavors to offer a retrospective and critical examination of the use of digital tools in education, while also taking into account the evolving discourse surrounding the topic in recent years. The essay's aim is to provide readers with insightful perspectives and concrete references to comprehensively frame the discourse on Artificial Intelligence (AI) utilization within educational settings, with a particular focus on the ChatGPT tool (Rahman & Watanobe, 2023). The paper concludes with the presentation of a practical example of AI application in the educational field, developed by the authors and currently in its implementation phase.

Keywords: Education, Social Networks, ChatGPT, Artificial Intelligence, Media Education.

1. Introduction

At the dawn of the new millennium, during the apex of the social networking boom (Alexander, 2008), there was a concerted effort by educational institutions and other stakeholders to forge innovative paths in education by harnessing the capabilities of platforms like Facebook and its counterparts.

In Italy, national conferences on applied computing burgeoned with projects, proposals, and methodologies centered around the utilization of online groups, video lectures disseminated through social channels and pages, comprehensive analyses, and interactive feedback structured as live comments, measured by likes and emoticon reactions (Sprugnoli et al., 2019).

Now, two decades later, what is the verdict on these once-revolutionary approaches? The situation appears somewhat tangled and contradictory. Especially since the endemic shock of COVID-19, positions of techno-optimism on the one hand and techno-skepticism on the other have emerged, setting us on a dilemmatic path that leads the educational sector to question how to manage its difficult relationship with technologies (Kumar, 2022).

The contradictory and doubtful positions regarding the use of educational technology, however, concern not only the teaching component, as a common bias might lead us to think, but also the students themselves (Zaimakis & Papadaki, 2022).

2. Materials and Methods

This paper employs a qualitative and descriptive methodology, analyzing the use of digital tools in educational settings, particularly the role of AI chatbots like ChatGPT. It combines authors' perspectives in pedagogy, engineering, and media education. The study is framed within the existing literature on educational technology (Martin & Grudzuecki, 2006; Scheibe & Rogow, 2012; Fraillon et al., 2018), social networks (Greenhow & Lewin, 2016; McCrindle & Fell, 2021) and AI (OECD, 2020; du Boulay, 2022; Floridi, 2023) to assess their integration into learning environments.

The study draws from a range of sources, including national and international case studies, conference proceedings, and peer-reviewed publications.

This paper endeavors to offer a retrospective and critical examination of the use of digital tools in education, while also taking into account the evolving discourse surrounding the topic in recent years.

The essay's aim is to provide readers with insightful perspectives and references to comprehensively frame the discourse on Artificial Intelligence (AI) utilization within educational settings, with a particular focus on the ChatGPT tool (Rahman & Watanobe, 2023).

Given its prominence in numerous studies investigating its applicability in education, ChatGPT emerges as a potential candidate for integration into educational environments as a functional tool (Opara, Mfon-Ette Theresa & Aduke, 2023). The authors seek to construct a critical and historical perspective in this paper, serving as a mechanism for unraveling the potential challenges, risks, and opportunities associated with the incorporation of ChatGPT into classroom settings.

3. Results

In the 21st century, educators across all sectors face the challenge of adapting to a rapidly evolving cultural and technological landscape. Teaching is undergoing a significant transformation, growing beyond the traditional transmission of knowledge. The gap between the knowledge individuals acquire during their studies and the skills required to enter the workforce is becoming increasingly evident. According to the World Economic Forum report *New Vision for Education: Fostering Social and Emotional Learning Through Technology* (WEF, 2016), traditional learning methods fail to equip students with the skills they need to thrive and succeed.

Furthermore, Jean Piaget, in his work *Où va l'éducation*, advocated for the use of «active methods, in which the spontaneous exploration of the child and adolescent must predominate, requires that any truth to be acquired must be reinvented by the student or at least reconstructed, and not merely transmitted» (Piaget, 1988). Piagetian learning refers to the natural and spontaneous learning of individuals through interaction with their environment, in contrast to curricular learning, which characterizes traditional schools (Papert, 1984).

From Piaget's constructivist theory, we derive two fundamental principles: 1. personalization and 2. accessibility. The first refers to adapting learning experiences to the individual needs, preferences, and contexts of students. The second emphasizes the importance of ensuring that all students have equal opportunities to engage with and benefit from learning environments.

These principles find a natural application today in modern educational technologies, which are designed to meet the individual needs of students. Technologies are now ready to "surround" students with a knowledge-rich environment, even as they participate in professional activities.

In light of such innovation, teaching is now regarded as a design science. As Laurillard (2013) states, teaching today is better understood as a design science that requires educators to develop innovative, evidence-based strategies to enhance their methods. Every day, teachers design and test new ways of teaching, leveraging learning technologies to support their students. Unfortunately, many of their discoveries remain confined to small areas. By representing and communicating their most effective strategies as structured pedagogical patterns, teachers could collaboratively develop this essential professional knowledge.

While paradigms shift rapidly and the tools offered by technology become increasingly sophisticated, the primary goal remains the same: to provide unique training experiences adaptable to individual needs. Considering the importance of bridging the gap between the knowledge acquired during studies and the skills required in the workforce, as discussed earlier, it is essential for training to align with the professional goals of individuals within organizations. It is precisely the tendency to design learning scenarios, supported by various channels and technological applications (beyond just LMS platforms), that characterizes digital learning, alongside the growing interconnection between professional activities and training. To “wrap” the user in a learning cloud, these experiences can be accessed not only through LMS platforms but also directly within digital collaborative work environments such as Google Classroom, Microsoft Teams, and other applications.

A negative habit of modern learners is that they spend about 19% of their time searching and gathering information on the Web on information sites and social networks, particularly YouTube, Slide Share, or Twitter (Kadakia & Owens, 2020).

Proposing to them a rationalization of this often-dispersive search activity through training products designed and structured for this style of conscious and organized use of cooperative work environments (Meet, Team, or even the LMS) can therefore be an effective way to “surround” with knowledge the operational workstations in the company, but also remotely and/or on the move, and to prevent people from long and often dispersive online searches.

In this context, the adoption of innovative tools such as chatbots can prove particularly useful, as they provide direct and personalized support to students during their learning activities. Recent studies indicate that chatbots in education are experiencing a surge in popularity, with the trend continuing to grow exponentially (Nee et al., 2023). AI chatbots have the potential to revolutionize education by personalizing the learning experience for each student. By using natural language processing and machine learning, chatbots can assess a student's necessities and learning style, and then provide them with tailored training and support. This can help students to have multiple sources of learning, and it can also make education more accessible to students with different learning needs.

A chatbot can help students enhance various learning variables, including performance, interest, experience, activities, engagement, attitude, and motivation, across a range of STEM (Science, Technology, Engineering, and Mathematics) disciplines, as well as language and art concepts (Han et al., 2021).

Here are some of the benefits of using AI chatbots for personalized learning:

- increased student engagement: chatbots can provide students with a more engaging and interactive learning experience. This can help to motivate students and make them more likely to succeed in their studies;
- improved student outcomes: AI-enabled chatbots make it easy to customize instruction according to each student's ability (Han, et al., 2021). Studies have shown that students who use AI chatbots for personalized learning can achieve better grades and test scores;
- more effective use of teacher time: chatbots can take on many of the tasks that are currently handled by teachers, such as answering questions and providing feedback. This can free up teachers to focus on more complex tasks, such as providing one-on-one instruction and developing creative lesson plans. Teachers can reduce the length of their homework assignments and instead focus on creating strategies that guarantee students receive high-quality education through the usage of AI chatbots (Pérez, Daradoumis & Puig, 2020);
- more accessibility for students with disabilities: chatbots can provide students with disabilities with access to education and support that may not be available to them otherwise. For example, chatbots can be used to provide students with visual impairments with text-to-speech narration, or students with hearing impairments with closed captioning. While artificial intelligence and chatbots can be used to improve student learning, they can also serve to support the overall learning process (Garcia-Brustenga, Fuertes-Alpiste & Molas-Castells, 2018).

Overall, AI chatbots have the potential to be a powerful tool for personalizing learning and improving educational outcomes for all students. As AI technology continues to develop, we can expect to see even more innovative ways to use chatbots to support learning.

AI chatbots are currently utilized in various ways to enhance personalized learning. They assist students in tackling homework problems by answering questions and offering step-by-step explanations. These chatbots provide tutoring in subjects like reading, math, and science, among others. Additionally, they can assess students' progress through quizzes and questions. Moreover, they give constructive feedback on students' work, which helps foster meaningful learning outcomes.

As AI chatbots become more sophisticated, we can expect to see them being used in even more ways to personalize learning. For example, chatbots could be used to create personalized learning plans for each student or to provide students with real-time feedback on their learning progress. The possibilities are endless.

The use of AI chatbots in education is still in its early stages, but the potential benefits are clear. By personalizing the learning experience for each student, AI chatbots can help all students to reach their full potential.

4. Discussion

We developed our chatbot, which we called “Vito”. It represents an example of a personalized learning experience. The developed chatbot is based on the OpenRouter environment, an open and unified interface that gathers the APIs of different artificial intelligence models. In particular, the chatbot is configured to have OpenChat 3.5, a free artificial intelligence model, as its model. The design of “Vito” goes beyond providing educational support; it also serves as a deterrent against cyberbullying. In this context, the accessibility of the chatbot can represent an important awareness tool. By creating an environment in which users feel comfortable, the chatbot fosters a sense of privacy that encourages users to open up their emotional and psychological experiences. Additionally, by obtaining objective answers to users’ questions, “Vito” emerges as a versatile and valuable resource for both the learning and well-being of users.

It is also reminding the risks linked with education through information and communication technologies such as cyberbullying.

Recent research has revealed concerning statistics regarding cyberbullying among children and adolescents in Europe. A study supported by Lobe et al. (2021) found that 51% of child participants from 11 European countries reported being cyber-victimized during the pandemic, with 49% stating they had experienced online bullying. This figure increases to 59% in Italy and Ireland, while Germany reports a rate of 58%. Additionally, while assisting a client with a new Facebook case, CL discovered that 57 young individuals under the age of 13 had been solicited for images or coerced into taking them between March and December of last year. These alarming statistics reflect the ongoing challenge of protecting the nation’s youth as they navigate digital environments, a situation that has been exacerbated by COVID-19.

Recent investigations into cyberbullying trends reveal a 44% rise in reported cases of online bullying during the pandemic. However, 22% of children reported a decrease in cyberbullying incidents. These results indicate that while some children faced increased vulnerability to cyberbullying during this time, others managed to reduce or avoid such experiences. This underscores the intricate relationship between youth, technology, and online safety, suggesting that greater digital engagement does not always lead to heightened cyber risks.

These insights prompt us to reconsider the connection between young people and technology. The surge in technology use, especially during the pandemic, does not automatically result in a corresponding rise in cyberbullying. As discussed by Sorrentino and colleagues (2023) in their systematic review, although technology use increased during COVID-19, the effects on cyberbullying and cyber victimization were complex. This suggests that various factors beyond mere exposure to technology influence the prevalence of online bullying, highlighting the need for

more focused interventions that address the underlying causes of cyberbullying rather than solely the use of technology.

Recent studies have shown that one of the most effective ways to reduce cyberbullying incidents is by encouraging bystanders to step in and support victims or confront the aggressor (Zou et al., 2024). However, bystanders often hesitate to act due to fear or a lack of empathy for the victims (Zou et al., 2024).

Utilizing chatbots for real-time support presents a promising solution. These chatbots can mimic genuine social interactions and guide young people on how to intervene in cyberbullying situations, fostering prosocial behaviors and overcoming bystander apathy. For example, a chatbot embedded in a social media platform can provide tips on how to show support to victims or report harmful content while minimizing personal risk. Additionally, the chatbot must adopt an empathetic and encouraging tone, as this can enhance the chances of young bystanders taking positive action.

5. Conclusions

Educators and teachers are increasingly turning to digital devices to enhance the teaching and learning experience. However, the use of technology does not always guarantee positive outcomes. A recent study by Smith et al. (2023) found that implementing chatbots led to a 20% increase in student engagement and a 15% rise in exam scores.

As highlighted in the research by Chee, Yahaya, and Ibrahim (2018), technological convergence will not produce favorable results unless it is adopted and implemented effectively. Research from Nee et al. (2023) emphasizes that integrating chatbots should be done alongside a teacher, as chatbots may not replicate the responses of genuine human interaction. Consequently, many studies suggest that chatbots can serve as a useful tool in addition to, but not as a substitute for, a “live” teacher (Schroeder & Adesope, 2014). Moreover, feedback from both teachers and students indicates that while many see chatbots as a valuable addition, there is a strong desire for training and resources to fully leverage their potential.

We would like to present the following thoughts and suggestions for community discussion. First, it is crucial to ensure that technology meets the needs of training, rather than forcing training to adapt to technological tools. Additionally, establishing common standards for the use of artificial intelligence in education is necessary. Ongoing feedback from research and experiments should be encouraged to refine these practices. It is also vital to invest in the responsible and thoughtful use of technology while striving to close the digital divide between teachers and students.

What Lev Manovich says about cultural analytics also applies in the case of learning:

> *“They refer to the use of computational and design methods including data visualization, media, and interaction design, statistics, and machine learning for the exploration and analysis of contemporary culture [...] The intention is to augment our human capabilities by providing new interfaces and techniques for the observation of huge data sets and cultural streams” (Manovich, 2020).*

The gradual and tumultuous transition of people training methodologies to digital in the post-media society will increasingly enable us not only to design and manage with digital learning methods a much wider range of training methodologies but also to analyze the learning analytics contained in LMSs precisely through artificial intelligence. Educators, administrators, and policymakers need to collaborate in establishing clear standards and ethical practices for the use of chatbots in education. Only in this way can we fully harness their potential to enhance the educational ecosystem of companies, schools, and universities.

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Teachers' perceptions on AI integration into didactics: an exploratory study in the district of Veneto

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Abstract

An exploratory study, in collaboration with the Veneto regional school authority, attempted to investigate the perceptions of over 1000 teachers from all school grades in the area about the subject of a possible integration of Artificial Intelligence (AI) into teaching and learning. Teachers from primary, lower and upper secondary schools, as well as VET (Vocational Education and Training) institutes, responding to a specific questionnaire on the topic, showed a rich variety of nuanced opinions, where optimistic views on AI potential to adapt and improve teaching and learning experiences coexist with several concerns about its possible negative effects and with a strong need for being trained on the topic. Indeed, the results underline a broad consensus on the importance of artificial intelligence literacy for both teachers and students, highlighting the need to acquire specific skills that can effectively address this constantly evolving educational challenge. Above all, important concerns arise regarding ethical implications, data privacy and the potential 'dehumanisation' of educational processes, highlighting a cautious attitude towards this technology. Finally, there is an interesting and strong desire among teachers to be able to collaborate with artificial intelligence developers and policy makers to ensure a responsible and participatory integration of AI in education.

Keywords: AI In Teaching, AI Teachers' Perceptions, AI Teachers Training.

1. Introduction

The prospect of integrating generative Artificial Intelligence in education has recently sparked different reactions among teachers, reflecting a mixture of optimism and concern about the implications on teaching and learning processes and on all the actors involved. However, despite fairly positive theoretical perspectives, the actual perceptions, attitudes and emotional responses of the main actors in this revolution are still unclear. In fact, though several surveys have already researched students' perceptions so far (Idroes, 2023; Zhou, 2024), teachers' opinions cannot be overlooked in order to represent the whole school reality. Their attitudes, in fact, will influence whether – and in which way – A.I. tools will be integrated into classroom use. However, as noticed by Martin et al (2024), there is still relatively little research on school teachers' perceptions of AI, especially as far as its practical integration into classroom settings is concerned. Yue et al. (2024) highlighted, in fact, how even STEM teachers' technological, pedagogical and content knowledge (TPACK, Mishra&Koehler, 2006) is still lacking to allow them enough confidence to teach AI. Addo (2023) has recently noticed how teachers' self-efficacy and autonomy in integrating AI concepts into the curriculum is still little investigated, especially in relationship with their motivation. Trying to fill this gap in research, the present exploratory study was carried out in collaboration with the Veneto Regional School Authority (the General Directorate of the Italian Ministry of Education in Venice) to elicit the opinions of N. 1,223 teachers from all school grades on the topic.

2. Materials and Methods

The regional sample involved in this study included teachers from all school grades in Veneto, the fifth region by number of schools in Italy (N. 4,794) with a total population of N. 47,876 teachers. Respondents included mostly teaching staff from high schools (N.507, 41.4%), lower secondary

schools (N.328, 26.8%) and primary schools (N.331, 27%), with a smaller group from Early Childhood Education and Care (ECEC, N.57, 4.6%).

The study is based on an anonymous survey distributed to K-12 school principals, via a public notice by the regional school authority, so as to evaluate teachers' knowledge of AI and their beliefs on potential benefits and threats of AI integration in the teaching and learning process. Both quantitative and qualitative methods were used to analyse data. The survey was carried out through an online questionnaire that was made available to respondents for about a month in 2024. Jamovi Software version 2.5.5 was used to analyse the quantitative data collected, while quantitative data were coded using QDA Miner Lite software.

3. Analysis and discussion of results

The very large sample of N. 1,223 respondents showed an average age of about 48 years old (48.02), i.e. slightly younger than the teaching population in Italy (50.20 years old, OECD, 2023) and can, therefore, be considered as relatively representative, especially considering that the majority of respondents (64.52%) belonged to the two older ranges. The difference of the sample can also be accounted for by the type of question in the survey, preferring age ranges (25-34; 35-44; 45-54; 55-64+) over a longer multiple choice with all possible ages involved, to avoid excessive length in the questionnaire. Most respondents (98%) held a teaching position, but there were also some principals (less than 2%) among the participants, as well as some teachers with middlemanagement roles (less than 3%) and some digital expert teachers ("Animatori Digitali", less than 2%), who were not statistically relevant and whose responses have been considered, for the scope of the present study, as included in the larger group of teachers.

Most respondents reported having a long or very long teaching experience, as 20,7% (N. 257) had stayed more than 26 years in the position and 11,6% (N. 146) had worked as teachers between 21 and 25 years, which is coherent with the average age in the sample.

Subject areas taught by responding teachers show a preponderance of the Humanities area, with N. 433 (35.4%) of the sample selecting the option "Italian / Foreign Languages / Law / Philosophy/ History / Geography", followed by "Other subjects", selected by N. 321 (26.2%), and by Science & Maths (257, 21%), ICT (N. 81, 6.6%), Visual Arts, Music & Design (N. 72, 5.8%), Physical Education (N. 38, 3.1%) and vocational subjects (N.21, 9.4%).

Table 1 shows teachers' perceptions of their previous knowledge of AI on a Likert scale from 1. (lowest) to 5. (highest), with the average results pointing to a very low average confidence in the ways it could be applied at school.

Table 1 - Teachers' perceived knowledge of AI.

Level		*N*		*%*	
1		316		25.8	
2		423		34.6	
3		358		29.3	
4		110		9.0	
5		16		1.3	
N	*Sum*	*Average*	*Median*	*Mode*	*SD*
1223	2750	2.25	2.0	2.0	0.98

An ANOVA that was carried out to see the correlation of respondents' age groups with three dependent variables – AI previous knowledge; teachers' perceived readiness to integrate AI into their practice; level of actual previous use of AI in classroom practice – confirmed results to be consistent across all ages, with means ranging from 2.18 to 2.41 on a 5-level Likert scale.

The ANOVA correlation between the respondents' subject of instruction and their level of readiness to integrate AI into teaching practices (on a 5-point Likert scale) showed the highest means in ICT (2.88), Music, Design & Arts (2.28) and Maths & Science (2.22), with Turkey's Post Hoc test confirming that the most significant differences could be observed between ICT teachers and all the other groups, with p-values ranging from $p < .05$ ($p = 0.016$, as compared to Music & Performing Arts teachers) to $p < .01$ ($p = 0.001$ as compared to Humanities teachers and $p = 0.009$ as compared to VET subjects), to $p < .001$ as compared to the remaining groups (Maths & Science, PE teachers and other subjects).

The survey also confirmed what has already been reported in the most recent literature: teachers recognise the potential of AI in revolutionising teaching practices, e.g. in its ability to support inclusivity and accessibility through the personalisation of learning paths (N. 663, 54.2%), improve motivation (N. 654, 53.5%), automatise routine tasks such as the creation of tests development (N. 477, 39%), paper grading (N.249, 20.4%), and the possibility to give immediate feedback (N. 375, 30.7%). (Nikolopoulou et al., 2024).

Teachers' opinions on the ways AI could affect students' learning experience were collected via an open question in the survey: qualitative data were analysed through thematic analysis, retrieving three main categories: 1. teachers considering AI as a digital (ICT) tool; 2. teachers' general attitudes towards AI and 3. AI as a tool to develop students through different learning approaches. Table 2 presents an overview of codes emerging from the analysis.

Table 2 - Teachers' opinions about AI effects on students' learning.

Category	*Code*	*Description*	*Count*
ICT	Automatization	Avoid repetitive tasks	54
ICT	Content creation	Lessons or text	39
ICT	Data bank/information retrieval	AI as a research tool	48
ICT	Integration	AI as a subject matter	146
Teachers' attitudes	Awareness	Importance of CPD	13
Teachers' attitudes	Negative attitude	AI useless or harmful	130
Teachers' attitudes	Uncertainty	Lack of AI knowledge	272
Learning approaches	Competence building	Realistic tasks	9
Learning approaches	Creativity	Widening possibilities	18
Learning approaches	Critical thinking development	Comparing outputs	48
Learning approaches	Inclusion and support	Special needs/weak	92
Learning approaches	Interactive and engaging learning	VR/full immersion	155
Learning approaches	Motivation	Willingness to commit	20
Learning approaches	Non-formal and informal learing	Less demanding	1
Learning approaches	Personalisation	Adapting to levels	102
Learning approaches	Problem solving/PBL	Soft skills	9
Learning approaches	Team working/Peer learning	Group activities	15

The survey further investigated teachers' opinions on the use of AI for the automation of tests creation and grading, both asking respondents to rate their level of agreement to these potential AI employment on a 5-level Likert scale. Resulting data (pictured in Table 3) seem to suggest that across all school grades teachers are generally more open to using AI for creating tests, quizzes and schoolwork papers rather than for automating the assessment of students' work. The difference is most pronounced in secondary schools and the least in preschools: such variation across school grades might reflect different needs and concerns at various educational levels.

Table 3 - Teachers' opinions about AI usage for test creation and assessment.

ANOVA a una via (Welch)				
	F	*gdl1*	*gdl2*	*p*
Do you think AI should be used to create tests, quizzes, and assessment tests?	5.54	3	252	0.001
Do you think AI should be used to automate student assessment?	3.82	3	257	0.011

Potential issues related to assessment, such as students cheating in their homework using AI, were also investigated in the survey, retrieving a substantial level of concern in over 54% of the respondents, selecting levels 4. and 5. on a 5-point Likert scale. Possible ways to face and address this issue were also researched through an open-ended question and QUAL data were analysed by using the same three large categories as in the previous thematic analysis (Table 2). Results in the ICT category retrieved a larger group of teachers (N. 134) expressing the intention to integrate AI in their classes as a subject, so as to train students to understand how LLMs work and how they can be better used, while a smaller group (N. 30) manifested the idea to use anti-plagiarism software. The second category "Teachers' attitudes" included a small group of respondents (N. 76) who reported not being worried about AI use in homework, either because of the young age of their students (ECEC or primary school), as well as teachers considering AI as a resource rather than a threat capable of substituting their students' work. However, a large number of responses in this second category (N. 156) were coded as "uncertainty" ("I don't know" or "I haven't considered this issue as yet"), confirming the general lack of knowledge on the subject, possibly reinforced by the fact that over 30% of the sample did not respond to this question. A more positive attitude was shown by respondents included in the third category, "Learning approaches", which included those considering AI as a tool for competence assessment through real-life tasks (N. 218), for critical thinking development through a comparison of human and digital outputs (N. 151) and for the personalisation of students' tasks through adaptation to different levels of instruction and pupils' abilities.

The survey also explored teachers' behavioural intention (BI) to use AI in their classroom and to let students use an AI tutor in their discipline, if available. Results showed that N. 940 (76.8%) respondents had a positive attitude towards this possibility, either with or without their support and supervision, while N. 283 (23.1%) expressed their refusal to let students use AI in their classes.

Teachers' propension to make expert AI tutors in some subjects available to students was also analysed, showing that N. 403 (33%) respondents would allow it with their supervision, while N.234 (19.1%) would allow AI tutors only for specific subject matters to contribute to solve complex problems, and N. 188 (15.4%) would always make it available to students to improve personalisation and comprehension. On the other hand, N. 166 (13.6%) responded they would hardly ever allow it to happen, only in remote education, whenever human interaction was not possible, while N. 131 (10.7%) would avoid it, due to privacy or ethical concerns, and N. 101 (8.3%) would not use AI tutors for fear of being replaced by AI (Mishra & Heath, 2024).

The need for specific regulation on GenAI to be issued by Educational Authorities is strongly fostered by respondents, in association with more collaboration among instructors, AI developers and policy makers: the analysis of data retrieved from the survey is displayed in Table 4.

Table 4 - Importance of AI regulations and policy makers collaboration.

	Mean	*Median*	*SD*
Q21 "How important would it be for Educational Authorities to develop specific regulations on generative AI usage? (left)	4.12	5	1.22
Q27 "How important do you think collaboration among Instructors, AI developers and policy makers is to promote a responsible use of AI in education? (right)	3.96	4	1.22

The importance of providing training to both teachers and students on these issues is recognised by a large portion of respondents: in fact, over 43% think that it is very important (mean 3.82 on the 5points Likert scale) to provide CPD for teachers on AI literacy, while a slightly lower percentage of respondents (31.4%, mean 3.49) think the same about including AI literacy in students' curricula. Actually, 66% of respondents do not feel prepared to integrate AI into their subject curricula, as 33,9% selected '1' on the 5-Likert scale, while 32.1% selected '2' (Mingyeong & Lee, 2023; Galindo-Domínguez, et al., 2024). The strong need for training seems to be reinforced by 67% of respondents declaring they have never previously used AI in their classes and 20% stating little recourse to AI in their practice.

However, despite teachers' recognition of the importance of specific professional development, especially on syllabus-related content (64.3%, N. 786), general AI tools (61.8%, N. 756) and ethical issues (49.1%, N. 600), there is still a large percentage (61.7%, N.754) reporting never attending courses on AI provided by their own school or other institutions, nor profiting from the ever-growing amounts of resources available on the web.

Regarding future perspectives, N. 748 (61.2%) respondents envisage the role of AI as a tool to make enhance interactivity in their lessons, or to adapt classes to students' learning needs (N.555, 45.4%), improve their lessons delivery or assessment process, while 19% of respondents envisage no use at all or a very limited one, as pictured in Figure 1.

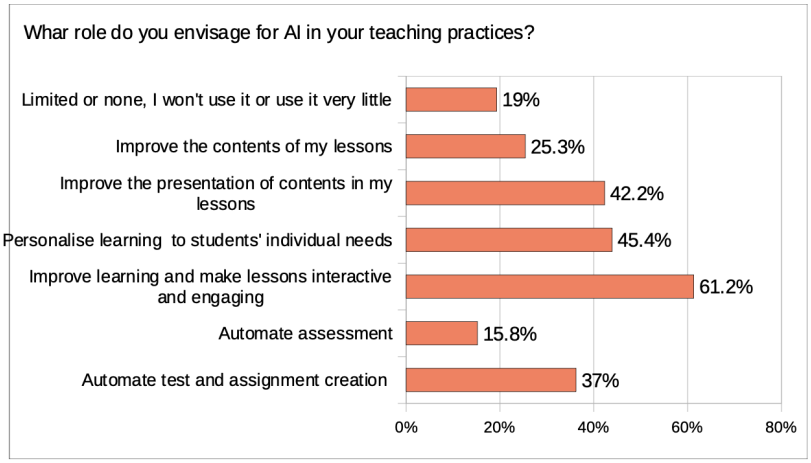


Figure 1 - Teachers' answers to the question concerning potential uses of AI in teaching & learning.

4. Conclusion

Artificial Intelligence poses both opportunities and challenges for all aspects of society, and its integration in education could lead to a significant transformation of teaching and learning practices. Our study offers some insights into teachers' readiness, perceptions, and concerns regarding AI adoption in their everyday practice, in the classroom and outside.

A key finding of our survey is the very low level of AI knowledge among teachers. This result aligns with other studies observations about teachers' feelings of unpreparedness (Menekse's, 2023). Such a knowledge gap underscores the critical need for comprehensive professional development programs focused on AI literacy.

Interestingly, our study revealed that younger teachers (aged 25-34) and those specializing in Information and Communication Technology (ICT) demonstrated higher levels of AI readiness. While some studies, such as Al Darayseh (2023) and Wardat et al. (2024), have reported higher AI acceptance among STEM teachers broadly, our study specifically highlights the readiness of ICT educators. This distinction is important and suggests that direct experience with technology, rather than a general STEM background, may be a key factor in AI readiness among teachers.

Considering the topic of assessment, our results indicate a new approach among teachers. Across all grade levels, educators showed more openness to using AI for test creation rather than

for automating student assessment or evaluation processes. This finding reflects the ongoing debates in the field, as discussed by Farazouli et al. (2024) and Shahid et al. (2024), highlighting the complex considerations involved in integrating AI into assessment processes.

A significant number of teachers (37.7%) expressed concerns about privacy and ethical issues related to AI integration. This aligns with Sperling et al.'s (2024) work, emphasizing the crucial need to address ethical considerations in AI literacy education for both teachers and students. The prevalence of these concerns underscores the importance of developing clear ethical guidelines for AI use in educational settings.

The strong desire for professional development, particularly customized AI training for specific subject areas (expressed by 64.3% of teachers), supports Al-Zyoud's (2020) findings on the importance of tailored AI professional development for educators. This underscores the need for a differentiated approach to AI training that considers the unique contexts and needs of various subject areas and grade levels.

Regarding future perspectives, there is a clear call for the development of policies that activate participatory development processes involving educators in the creation and implementation of AI technologies, especially to ensure that these tools are aligned with educational goals and ethics (Klemke & Jarodzka, 2024).

In conclusion, for teachers AI seems to present significant opportunities to improve educational practices, though it also raises substantial challenges that need to be addressed through appropriate training, and the development of ethical and policy guidelines.

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The changing perception of artificial intelligence in future teachers. A two-year survey among preservice teachers at the University

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Abstract

Born in 1956, artificial intelligence (hereafter AI) reached the attention of the general public with the dissemination of large language models: the production of texts (e.g., Chat GPT) and images (e.g., Midjourney), to name a few. The widespread availability of these tools raises questions about the relationship between AI and education. It raises the need to understand how AI can be used to learn and how to train AI, both teachers and students. As the design of any training course requires, there is the need to understand how best to define practices, perceptions, levels of awareness, and teachers' expectations regarding AI training. In an exploratory survey conducted in 2023 on a sample of second year students at the University of Molise, an unexpectedly marked gap emerged concerning declared AI knowledge on the one hand and actual levels of awareness on the other. In the face of high expectations regarding AI, even as a teaching tool, significant uncertainties emerged regarding its use in the everyday context, even before the professional context. Even though this outcome may be due to how AI works, this discrepancy deserves attention. The design of targeted training pathways, primarily linked to teaching and educational technology workshops, requires an adequate assessment of pre-knowledge and usage practices. Referring to a sample of second-year primary education students, we ran a second survey to verify the data that emerged last year, thus updating the design of specific workshop activities in the university curriculum to become teachers.

Keywords: AIED, Teachers' Perception, Teachers' Training, University's Curriculum.

1. Introduction

Artificial Intelligence (AI) now has a long history: the term, first used in 1955 (McCarthy et al., 2006), was linked to reducing the world's complexity to symbolic, computable models. The element that has recently marked a disruptive change compared to the past is the availability of Large Language Models for the general public: the possibility of using – partly free of charge and without requiring any specific knowledge – generative AIs capable of writing texts, such as Chat GPT or Gemini), and images, like Midjourney or Dall E, has created great attention going far beyond the sphere of individual and specific scientific communities. The development of institutional interventions of a legal nature, as in the case of the European Commission (2021), is further proof of this. Turning to the relationship between AI and teaching/learning processes – a topic that, under the acronym AIED (Artificial intelligence in education), both in the Italian context (Panciroli & Rivoltella, 2023; Ranieri, Cuomo & Biagini 2023) and internationally, as recognised by institutions such as UNESCO (Pedro et al., 2019), is receiving increasing attention – a central issue is the promotion of forms of critical awareness in the belief that the development of AI should be human-controlled and centred on people.

In this context, one of the first issues that can be considered is how much and how AI is known and perceived by those working in education. The first argument that can be brought in support of surveys on perception is given by the fact that the algorithms of AI operate without often making their action evident. While considering intentional uses, AI operates in invisible ways to much of the typical user. Not only that: although AI is necessary as an inevitable tool for the management of quantities of data which are beyond the control of the individual (Manovich, 2020), the ways and its actual impact, beyond a shared and common conviction of its importance, are in the

making and to be defined. As is well known, the history of the relationship between teaching processes and technologies has been interpreted as a cyclical succession of positive expectations and disillusionments masked by the introduction of ever-new tools (Cuban, 1986). Paying attention to perceptions and expectations offers indications on how to rethink interactions and practices. In this sense, it should be stressed that for a proper design of paths related to the acquisition of AI literacy, understood in general terms as a set of competencies related to understanding and using AI, it is indispensable to have a picture of the starting situation not only in terms of knowledge and skills already acquired but also concerning motivations and expectations.

Teachers' perceptions of technology have long been the subject of research (Cope & Ward, 2002). Based on this tradition, studies are increasing on the perception of AI, primarily about the different types of subjects involved in training processes: students (Demir & Güraksın, 2022; Chan & Lee, 2023; Syahrin & Akmal, 2024), preservice teachers (Attwood et al., 2020; Murgia & Bruni, 2023) and teachers (Cong-Lem et al., 2024; Diliberti et al., 2024; Sanusi et al., 2024). Secondly, within the broader AI theme, perception surveys also cover specific issues such as defined disciplinary areas, such as foreign languages (Sumakul et al., 2022), or individual tools such as ChatGPT (Murgia & Bruni, 2023; Syahrin & Akmal, 2024), or students' misuses of AI (Cong-Lem et al., 2024).

Transversal to all the research is the conviction that if training courses on AI are to be proposed, as is appropriate, for future teachers, an effective connection must be found between what is known and practised on the one hand and what is proposed in terms of instructional design on the other.

2. Materials and Methods

Given these premises, the initial survey was conducted in April 2023, using the CAWI (Computer Assisted Web Interview) methodology. The sample, 171 students in the 2nd year of the University of Molise – Faculty of Learning Sciences (primary school preservice teachers), filled out a questionnaire generated with Google Forms and thus answered 28 closed questions on their perception of AI (Bruni & Murgia, 2023) and ChatGPT (Murgia & Bruni, 2023), revisiting an approach known in the international context (Attwood et al., 2020; Sanusi et al., 2024). The second survey was conducted in April 2024, with 133 students, also of 2nd year from the University of Molise – faculty of Learning Sciences, using the same set of questions but introducing Likert-type attitudinal scales measured on a 4-level continuum. The samples are broadly similar in age, gender, educational background, teaching experience and familiarity with digital technologies.

3. Results

We limit ourselves to the presentation and comparison of only five questions, the first three relating to knowledge and relationship with AI in general and the last two related to ChatGPT as a possible educational tool and as an instrument for inclusion. In terms of the declared knowledge of what AI is, starting from the initial figure of a large percentage (86%) who claim to know it (Figure 1), a further improvement emerges one year later with the second survey: none states they do not know it, e only a tiny percentage (3%) say they have a vague idea (Figure 2). Regarding the question "Do you think you have had contact with an artificial intelligence application?" in the first survey, the answer is "do not know" - which concerns almost half of the sample (49.1%) (Figure 3). This response, which will be taken up in the discussion, prompts us to reflect on the levels of actual knowledge and awareness regarding IA: even in the second survey a small percentage remains, but still present (18.8%) of those who claim not to know of a contact with AI services and applications (Figure 4). In relation to the question "Have you used or use any application that uses AI?", a similar situation is found: in the first survey an even more significant majority (63.7) says they do not know (Figure 5), in the second survey the choice of this option falls sharply (12.8) and, in a mirror-image manner the percentage of knowingly using AI rises from 19.9% in the

first survey to 81.2% in the second (Figure 6): over the course of one year the percentage has quadrupled.

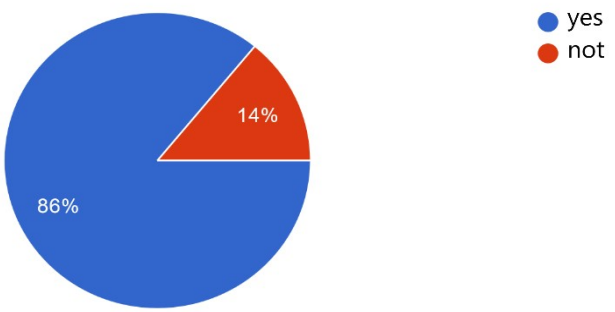


Figure 1 - Do you know what artificial intelligence is? (Survey 2023).

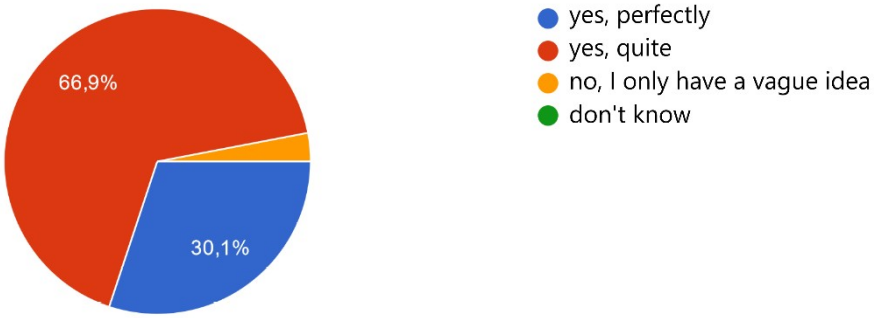


Figure 2 - Do you know what artificial intelligence is? (Survey 2024).

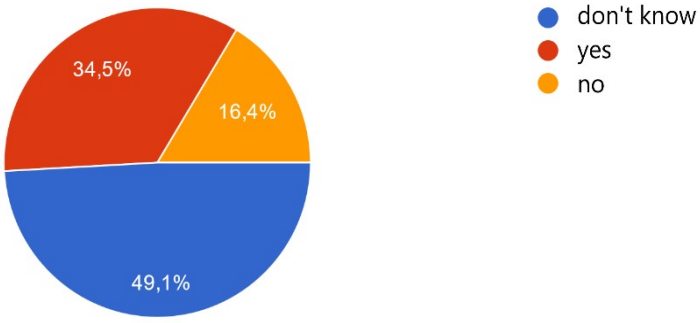


Figure 3 - Do you think you interacted with an artificial intelligence application? (Survey 2023).

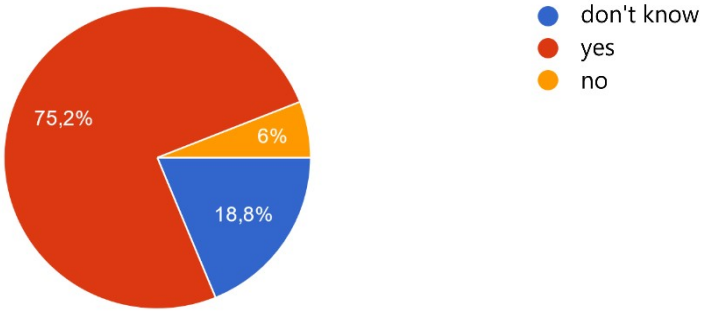


Figure 4 - Have you interacted with an artificial intelligence application? (Survey 2024).

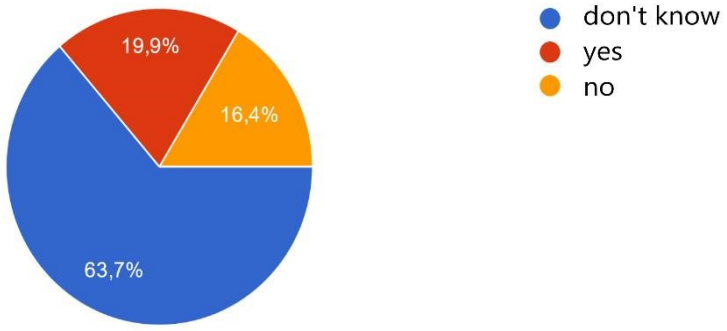


Figure 5 - Have you used or are using any applications that have AI? (Survey 2023).

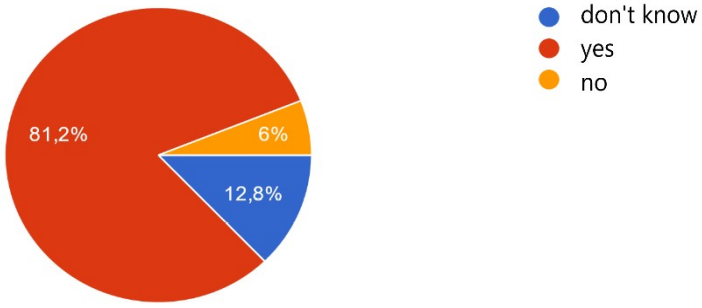


Figure 6 - Have you used or are using any applications that have AI? (Survey 2024).

Going from the more general question of perceptions related to AI and touching on the more specific relation with the educational dimension, a series of questions concerns the didactic use of ChatGPT. In the first survey, what emerges from the question "How likely is it that a teacher will use CahtGPT in class? Is a positive response: 71.9% are in favour, although the majority of the sample (49.1) is in a middle age situation (Figure 7). In the second survey, a slight improvement is to be seen: it intends to use CahtGPT as an educational tool for 73.7% of the sample, even if 51.9% are placed in the "yes, enough" option (Figure 8).

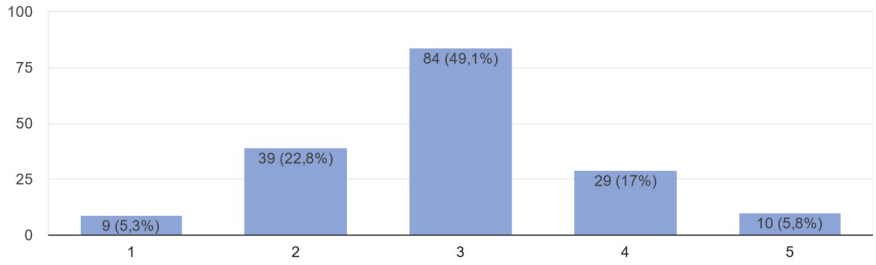


Figure 7 - How likely will you use CahtGPT in class as a teacher? (1 not at all likely, 5 very likely) (Survey 2023).

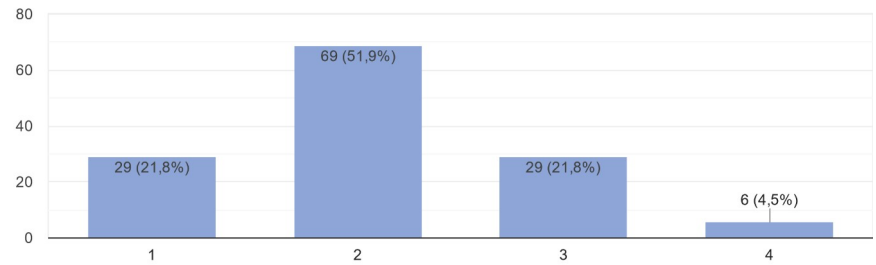


Figure 8 - How likely will you use CahtGPT in class as a teacher? (1 yes, definitely, 2 yes, enough, 3 no, I do not think 4 no, absolutely) (Survey 2024).

As regards the contribution that ChatGPT can offer to the processes of inclusion, it is worth mentioning, on the one hand, the growth of those who consider it useful: the percentage grows from 43.9% in the first survey (Figure 9) to 50% in the second (Figure 10), on the other hand it should be noted that the significant percentage of undecided (option "I do not know", 43.9%) in the first survey turns into a second survey in an opposition position, The second survey sample is split between those in favor and those that are against the adoption of such technologies.

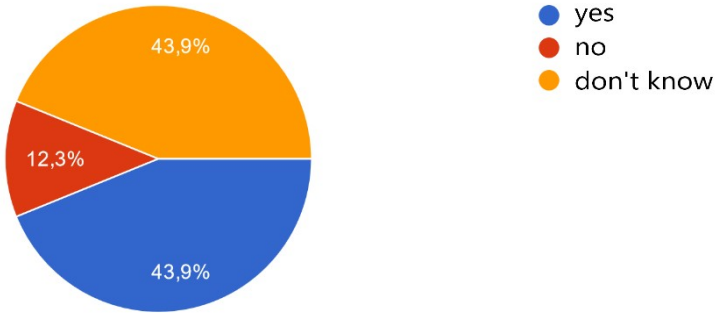


Figure 9 - Do you think ChatGPT school can be helpful for inclusion? (Survey 2023).

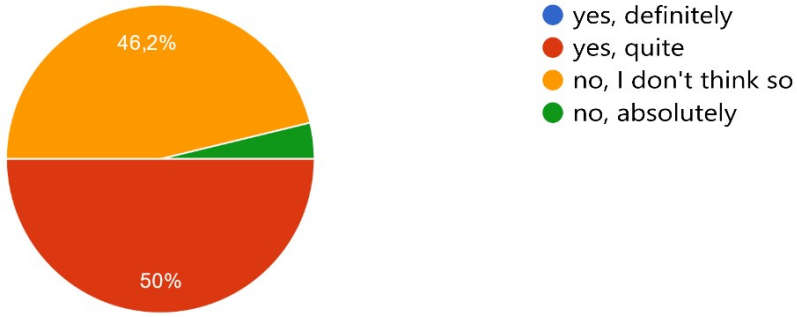


Figure 10 - Do you think ChatGPT school can be helpful for inclusion? (Survey 2024).

4. Discussion

For a proper discussion of the data presented, it should be noted that most of the sample components of the second survey participated in a seminar where the theme of AI and its implications in education was introduced with a short series of small exercises. This seminar, which was part of the course in education technologies, was designed as a follow-up to the results of the first survey. What emerged in the first survey was a substantial gap between stated knowledge about AI and awareness related to usage practices. Levels of declared knowledge have grown, as has awareness of applications that may not explicitly declare AI contribution. These changes may have been because, in addition to the seminar, the AI theme has been given a great deal of attention in the media and the informal communication mechanisms between students.

It should be noted that the intentional and conscious use of IA over a year has quadrupled. A significant percentage (18.8%) still say they do not use AI applications or do not know whether they have used them. The intention to use tools such as ChatGPT in teaching should be noted as a slight improvement: it is a broad but not very strong focus on such use. Expectations and fears should be further investigated more analytically. Finally, the inclusion points to a critical issue: the split of the sample into two opposing positions signals, here, too, the need for a supplementary survey.

5. Conclusions

In conclusion, two aspects can be highlighted. The first concerns the opportunity, about the perception of IA, that surveys are recursive: from one year to the successive marked changes are possible, also related to the rapid evolution of the same AI tools. How would it be helpful to go on with surveys on a national scale: while the importance and usefulness of local surveys that can provide specific indications respecting the specificities of different contexts remains, reference to a national scope is needed. The second aspect of being stressed is the importance of having, through surveys on perceptions and expectations, all the appropriate elements to support university teaching in general terms – just think of the indications that universities are elaborating (Cabitza et al., 2024) The second aspect to be stressed is the importance of having, through surveys on perceptions and expectations, all the appropriate elements to support university teaching in general terms – just think of the indications that universities are developing (Cabitza et al., 2024) – how to design AI literacy pathways for future teachers: promoting higher levels of awareness and promoting inclusive use of AI are, for example, at least for the specific context investigated, indications to be borne in mind.

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Interacting with AI: Prompt Engineering as a Digital Competency for Teachers

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Abstract

Conversational AI systems based on large language models (LLMs) have been popularized with the diffusion of ChatGPT. By leveraging natural language processing, interaction with AI systems is made intuitive, and chatbots and AI assistants can be found anywhere online. Many articles, courses, and tutorials on tailoring the best-performing prompts have been produced for the most diverse kinds of audiences, including teachers and educators. Since LLM-based chatbots seem to be featured in several aspects of postdigital society, including formal, non-formal, and informal education, this paper aims to present the first results of an ongoing narrative review of academic articles on prompt engineering definitions and strategies. Secondly, it discusses prompt engineering from the perspective of teachers in educational contexts characterized by superdiversity, such as teachers of adult students with migratory backgrounds. Prompt engineering can be framed within the European Framework for the Digital Competence of Educators (DigCompEdu) as an emerging digital competency related to AI and Digital Citizenship Education. Teachers' training in this digital competency must deal with the obstacles for non-expert users of prompt engineering and the specificity of communication when interacting with an AI system.

Keywords: Prompt Engineering, Digital Competence, Superdiversity, Teacher Training, Artificial Intelligence.

1. Introduction

Large Language Models (LLMs) are a type of Generative Artificial Intelligence (GenAI) based on deep learning architectures and process an enormous quantity of text data to understand and generate natural language. Despite allowing multimodal interaction, LLMs still perform very well on various linguistic tasks (Qi et al., 2023) by learning from conversational contexts, follow instructions even when provided with unseen tasks, and by reasoning step by step to complete complex tasks (Zhao et al., 2023). Their abilities to generalize and deal with the complexities of communication allow users to interact through plain, natural language. For this reason, LLMs are often used as conversational agents (Cain, 2024; Milana et al., 2024) and provided with a chat-like interface where human users can type (or record) their queries. The user's input is what is called a prompt. Prompts drive user-GenAI interaction toward the generation of an output from the LLMpowered conversational agent. As it will be described in detail later, this interaction successfully mimicking human communicative competence, but it lacks some essential features of human conversations.

LLMs can understand users' input thanks to a series of pre-processing steps (for instance, tokenization) to clean the textual dataset, and thanks to a pre-training process a fine-tuning phase (Brown et al., 2020; Gan et al., 2023; Zhao et al., 2023). During the pre-training phase, the language model is provided with a huge amount of data. By referring to this database, the language model learns the general features of a language, such as syntax, semantics, and logical relationships. After that, the language model undergoes a phase of fine-tuning: according to the tasks it is presented, the model refers again to its database and collects task- and domain-specific data that could be helpful in generating a task-appropriate output. After these pre-training and finetuning phases, LLMs are capable of understanding and processing tasks provided in natural language. Moreover, the ability to adapt according to the types of tasks emerges: LLMs

can achieve better performances than previous AI systems. The textual database used for its training and the inferences from users' input are processed by LLMs through the normalization of the text occurrences, which removes case-specific variations and reduces the models' instability in generating output. As a result, the process of tokenization is more efficient. Tokenization is a fundamental characteristic of LLMs' functioning. It involves segmenting raw text into smaller units, sequences of words, subwords, or unigrams. These individual tokens are then used as inputs of LLMs. The way LLMs segment and process the natural language as a number of tokens does not always follow the categories described in grammars and by which human speakers tend to conceptualize texts.

As the previous section tried to explain by describing the functionings of LLMs, language modeling leverages an extensive textual database and aims to predict the probabilities of future and missing tokens. GenAI is able to craft coherent and grammatically correct texts. Yet, several scholars argue that GenAI's creation is just statistically informed predictions and combinations of textual data transformed into convincing output, indistinguishable (at first glance) from human output. According to this opinion, AI systems seem to produce a never-ending stream of information, repeating text without understanding anything, like «stochastic parrots» (Bender et al., 2021; Floridi, 2023). Another analysis of LLMs' language processing (Roncaglia, 2023) stresses the fact that the numerical and mathematical representation of words in language models generate a sort of «quantitative semantics» (Roncaglia, 2023, p. 94, my transaltion). Such quantitative semantics is based on word embeddings, i.e., the encoding of words, phrases, and sentences into numerical vectors that allow LLMs to process and understand language through quantitative analysis. The process of tokenization and the definition of the numerical vectors embed a large quantity of information that human users would likely consider part of their semantics. Accordingly, LLMs could be considered more than just statistical predictors of what chunk of text or word sequence but are «(also) a sort of formalization of the idea of meaning as use» (Roncaglia, 2023, p. 95, my translation). In other words, LLMs' processing of natural language reached the point of determining, as we human speakers do, the meaning of words as inherently tied to their usage within specific contexts by considering their likelihood of use, and they convey information that the human users could conceive as meaningful because the most probable token is also the one that contributes to creating a meaningful text.

Nevertheless, two considerations arise from comparing human and artificial modes to generate words. First, human communication differs substantially from what has been defined as «artificial communication» (Esposito, 2022). When interacting with an AI system, particularly with GenAI tools, human users are involved in artificial communication with «an entity – the algorithm – that has been built and programmed to act as a communication partner by someone who does not participate in the communication» (Esposito, 2022, p. 13). The «artificial partner» cannot «independently generate» a potentially new text but «can process human-generated [texts] in unprecedented ways, ways that might generate further possibilities […] in interactions with human beings» (Esposito, 2022, p. 15). Human communication, on the other hand, requires both receivers and utterers of a message. Both participants carry a set of expectations and background knowledge about other people and communication itself, and they undertake a process of progressive cooperation and co-construction of the message. This is evident in how human expectancy grammar works (Balboni, 2018, p. 97): given an incomplete input and enough contextualization, a sufficiently competent speaker can predict what part of the message is missing, often with a high degree of precision. The human mind relies on several communication features to complete the message: frequency of use of the wording, semantic relationships between words and within a particular textual context, syntactic characteristics of the phrase, and sociocultural aspects and habits. The difference between human speakers and human interaction with GenAI is that, in human communication, we predict what comes next according to our communicative competence (as described by Balboni, 2015, p. 139), which encompasses a broad range of linguistic and extralinguistic competencies, as well as intercultural and socio-pragmatic competencies that enable a person to act socially by using a language. In artificial communication, it could occur that the artificial agent has insufficient context information; more likely, since LLMs are cultural objects produced and programmed by humans who are historically and culturally situated, it could happen that GenAI tools use biased data and perpetuate

discriminating thinking schemes. If we imagine the use of GenAI tools in contemporary educational contexts characterized by superdiversity (Pasta & Zoletto, 2023; Zoletto, 2023), problems related to the intercultural and extralinguistic aspects of communication could go unnoticed, deepening the divide between the effective, inclusive, and ethical use of GenAI tools. Teachers, as non-AI expert users, should become aware that artificial communication does not happen with a neutral pattern, nor does it occur in a cultural vacuum or in an impersonal manner. Hence, teachers must be the ones who must negotiate and critically evaluate AI-generated content in the classroom, fostering students' critical attitudes towards AI-generated content, too.

The second point that should be kept into consideration when distinguishing artificial from human communication is related to the fact that, following Esposito, 2022 (p. 6), artificial communication is closer to Luhmann's concept of communication:

> *[i]n all forms of communication, […] information is different for everyone and always relative to a specific observer. But a common identity of information among participants is itself not required. […] According to [Luhmann's] approach, communication comes about not when somebody says something, but when somebody understands that someone said something. […] Yet if a receiver understands information that (they believe) someone uttered, communication takes place – whatever this information is to the receiver, and whatever the issuer had in mind. […] The thoughts of the participants are not part of communication itself, leading to an infinite variety of individual understandings.*

As we briefly explained, AI-generated content results from the processing of tokenized textual data from both the dataset and users' inputs. The predictions of what comes next are made by combining the co-occurrence frequency of tokens with the word embeddings. When prompting an LLM, the human users steer the LLM's capabilities toward output generation and directly bias its text generation. Therefore, the role of the human user is central to artificial communication – even more than the role of the receiver in Luhmann's concept of human communication, for two reasons: the process by which LLMs generate texts and the process of prompting LLMs.

On the one hand, the message the users receive and interpret is a product of statistical calculations of the most probable tokens. The frequency of use of words is directly linked with a process of multiplication of the word's meanings and, at the same time, statistically probable words are semantically vague or empty if taken out of their context of use. As adverted by De Mauro, 2004 (p. 134, my translation), in human communication, the more a word is frequent, the more it is statistically probable to be chosen by the speaker and heard by the receiver:

> *Those who study language from a statistical perspective have even been able to establish that the more a word is used, the more numerous its meanings become. Thus, every word can be a source of misunderstanding. The more we extend the "context," made up of other words and phrases, to the left and right, the more we limit the possibility of misunderstanding. But we must be aware of this risk. It is tied to the deeper nature of language: to the possibility of creative use of its vocabulary, to the continuous potential to expand the meanings and nuances of each word.*

In LLMs, the process of desemantization of single, statistically frequent words is solved by taking into account their context of use that defines what meaning corresponds to the specific word occurrence. LLMs became able to consider textual contexts for word prediction and text generation, and their ability to consider textual context is, in fact, one of the factors that makes AIgenerated communication so credible and similar to human communication. Yet, if LLMs predict words and chunks of texts according to how statistically probable they are, could be possible that some process of desemantization occurs not anymore on the word level, rather on a textual level? Said differently, do LLMs produce statistically probable texts based on word frequency that are linguistically correct but semantically uninformative? We cannot answer these questions in this article. It is clear, however, that in an artificial communication where LLMs just predict textual

outcomes following statistical calculations, the responsibility of making sense of the communication relies on the human users only. Since LLMs build their representation of the context knowledge and communicative expectations on the users' inputs, the cultural, linguistic and pragmatic characteristics of the communication need to be established by the human users. It is according to the human users' knowledge and expectations that the AI-generated content can be generated, validated and appreciated.

On the other hand, in such artificial communication, human users' inputs substantially determine the quality of LLMs' outputs. By carefully selecting the words and the phrasing of their queries, users can get helpful output from LLMs; on the contrary, superficial and simple questions make LLMs produce generic and unsatisfactory answers. This action of interrogating and interacting with LLMs, trying different strategies to obtain the "best" output is called prompt engineering. It is important to understand how LLMs work and how to adjust users' prompts in a way that LLMs can follow and function efficiently. Considering that many non-AI expert users are going to prompt LLMs in their work, this article aims to explore the definition of prompt engineering and conduct a first, not exhaustive, mapping of the most effective strategies for prompt engineering by focusing on this research question: if prompt engineering can be considered as a new and emerging digital competency for teachers as non-AI expert users, what are the best strategies teachers should consider when prompting, especially considering the peculiar characteristics of the education contexts they work in?

2. Materials and Methods

To address this question, which frames prompt engineering within the pedagogic perspective of teachers' professional development in digital competence, a narrative review was conducted on the relevant literature for mapping the definitions and strategies of prompt engineering. Most cited articles and pre-prints about prompt engineering were revised to identify current strategies and caveats for prompting, also considering the non-AI expert point of view. Secondary documents mentioned in the references were also analyzed. Then, these strategies were compared with the available frameworks for teachers' digital competence. Since this research considers the perspective of teachers who work with adult students with migratory backgrounds, like the Italian Provincial Centers for Adult Education (CPIA), mostly European frameworks were considered for their relevance in teachers' professional development in digital competence.

3. Results

For a definition of prompt engineering, we start by breaking down the term. A prompt is, generally speaking, an input that describes a query or a task that requires a specific phrasing (Wang et al., 2024). Such descriptions come as textual instructions and examples of the desired interaction with an LLM (Zamfirescu-Pereira et al., 2023), particularly by enforcing rules and ensuring specific qualities and quantities of the generated output (White et al., 2023). In its linguistic form, a prompt can be written as natural language-based sentences or fragments, allowing users to formulate descriptions, commands, inquiries, and requests that trigger AI responses based on patterns learned during model training.

The expression "prompt engineering" refers to fine-tuning questions and commands for LLMs. The aim is to optimize LLMs' performances and obtain the desired output as a precise, coherent, and pertinent response to users' inputs (Lo, 2023). By doing so, users can achieve greater control over the output (Korzynski et al., 2023), unlock the potential of LLMs (White et al., 2023), and maximize LLMs' utility in various tasks (Santu & Feng, 2023). Prompt engineering can also be considered in terms of the synergy of understanding the user's goals, the LLM AI's strengths and weaknesses, and the nuances of language (Cain, 2024). Finally, an effective process of prompt engineering requires the integration of clear objectives, content knowledge, critical thinking, and iterative design (Cain, 2024), in a process that requires multiple trial and error runs (Santu & Feng, 2023). Considering these features of prompt engineering, many researchers have proposed

guidelines or frameworks for crafting effective prompts. Santu & Feng, 2023 consider prompt engineering for complex tasks, marking as necessary the indications about interaction and expression style that the LLM should adopt, but also users' definition of contexts and roles and detailed task specifications (clear goals, data, definition of sub-tasks, evaluation criteria, etc.). Similarly, Lo, 2023 proposes a framework for prompt designing based on brief, clear, structured, and coherent prompts that explicitly identify some features of the expected outcome; Lo's CLEAR framework also stresses the necessity of flexibility and customization of prompts in a continuous process of prompts evaluation and improvement. Wang et al., 2024 refer to two frameworks for, respectively, prompting and assessing the LLMs' outputs: when prompting, the user should bear in mind some specific questions that help define capacities and roles, insights, and statements of LLMs and encourage experimenting with LLMs, by asking to provide multiple answers. At the same time, the users should assess LLMs' answers according to their relevance, clarity, accuracy, and precision. Instead of a general framework for designing prompts, an interesting solution is proposed by White et al., 2023. The researchers see prompt engineering from the perspective of computer science and suggest a list of prompt patterns that, similarly to software patterns, offer reusable solutions to specific problems in order to make users enforce constraints, ensure that relevant information is included, and change the format of interaction with the LLM to better solve problems they face. White et al., 2023's list of prompt patterns is a remarkable resource for users to experiment with prompt engineering. Yet, their utility has to undergo a test in other professional contexts rather than computer science, especially if we consider all the variables when implementing LLMs in socioculturally dense and complex contexts.

The most convincing definition of a framework for prompt engineering for non-AI expert users is described by Cain, 2024, who identifies three core mechanisms of effective prompt engineering: Content Knowledge, Critical Thinking, and Iterative Design. Cain, 2024 argues that a deep understanding of the subject matter is often essential in guiding an LLM AI's responses since it influences the specificity of a prompt and, by extension, the relevance and accuracy of the LLM's response. When prompting a LLM, the users should be able to evaluate, verify continuously, and question LLMs' outputs by exercising their critical thinking to detect hallucinations, biases, inaccuracies, or suitable content. This implies that prompt engineering, mirroring the principles of design thinking, should start with a vision about the task and the general scope of the interaction with AI, and undergo planning, design, testing, and refinement: if the results do not meet the users' expectations, the cycle begins anew.

4. Conclusions

Teachers as non-AI expert users need training and professional development precisely in iteratively prompting LLMs and understanding that artificial communication does not work on the same conditions as human communication. A naïve consideration of GenAI as a tool which is easy to use for a wide range of tasks and provides impressive results does not help address the challenges and the risks hidden in potentially biased data on which LLMs operate. It is unnecessary to conceptualize a new kind of literacy, like LLM-and-prompt literacy (Zamfirescu-Pereira et al., 2023), as it could be included in the concept of AI literacy. It is urgent to provide teachers' professional development and opportunity to develop and implement a new pedagogy related to AI literacy, which encompasses knowing and understanding LLMs, using, evaluating, and applying them in education contexts. Such concept of AI literacy goes beyond considering the technical aspects of prompt engineering, and encompasses the development of AI capabilities (Milana et al., 2024) with a critical consideration of the ethical and intercultural dimensions of teaching AI, teaching with AI, and teaching to AI (Pasta & Zoletto, 2023; Panciroli & Rivoltella, 2023; Zoletto, 2023). Together with Korzynski et al., 2023, it is possible to consider prompt engineering as part of digital competence that teachers should develop to answer the pedagogical challenges in contemporary schools (Redecker & Punie, 2017), if we accept to conceive competence in using GenAI tools as a subcategory of digital competence – and since LLMs operate in an online environment, it would be right to do so, with the *caveat* of including all the overlapping and intersections between all the literacies (information literacy, data literacy,

media literacy, just to mention some) required to interact with AI. Implementing LLMs in education poses the difficult challenge of dealing with a cultural object produced by a determined culture, which is able to mimic real interaction and communication but is (yet) unable to comprehend the complexity of the education environments in which it is deployed because LLMs do not have access to the data about a particular setting con context and because the users are always not able to provide the models with such data. The nature of artificial communication determines that teachers are responsible for critically engaging with AI as a cultural object that affirms one dominant perspective and narrative and integrating AI-generated output with other points of view, narratives, and values that could be different from those infused in LLMs by who programmed them. In complex and superdiverse educational contexts such as Provincial Centers for Adult Education (CPIA), teachers are called to provide the literacy education that enables adult (migrant) students to interact with these tools, understand this new technology and their impact on their lives, in order to actively participate and contribute to the community, while making choices about their personal lives with awareness and critical attitude towards AI. Considering the impact of AI on diverse aspects of society, among the various literacies that are now essential for living in postdigital societies, AI Literacy is emerging as a prominent concept for onlife citizenship education (Pasta & Rivoltella, 2022). Further research is necessary to investigate the impact and the challenges of AI Literacy on adult education, with particular attention to adult migrants, as their cases can be representative of the intersections of various disrupting aspects of contemporary societies. Bearing these complexities in mind, it can be deemed insufficient to design teachers' professional development as technical training on a (new) digital competence. By analyzing the concept and strategies of prompt engineering, creativity and iterative design of interaction with AI seem to gain a central role in human integration of these new technologies in their workplace and in their life. Differently from before, (almost) anybody can access information and technological devices that can potentially and radically change how people learn, work, and create knowledge and narratives. Since anyone is exposed to the risk of a mindless use of AI, everyone must develop not just technical skills but also a critical mindset that constantly interrogates AI. The role of education, and precisely of lifelong learning, is gaining more and more importance, while many stakeholders and society, in general, are looking to teachers to provide the necessary education and guidance for future citizens to develop critical thinking skills. Even if it is helpful to focus on the functioning of AI and LLMs, it should be a priority to expand teachers' education by incorporating new pedagogies intertwined with AI and fostering the citizens' active participation in endeavors for societal change. By doing so, teachers' professional development in AI aspires not to be just training on decontextualized digital skills but help teachers take a stance on actively shaping the onlife society and promoting the dialogue about AI between all groups of a community, including the underrepresented communities of migrants who live in the territory and have the potential to contribute for the future of the community itself.

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Generative AI as a tool to promote collective mathematical discussions: a pilot study at primary school

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Abstract

The advent of Generative AI (GenAI) has given rise to the need for a re-evaluation of the teaching strategies employed in mathematics education. Applying the principles of the mathematics laboratory, collective mathematical discussion, and instrumental approach, we investigate how GenAI can act as a tool to foster meaningful mathematical discourse and knowledge development. This paper presents and examines the initial findings from a pilot study conducted in ten 4th-grade and 5th-grade classrooms. The study aimed to enhance primary school students' understanding of geometrical transformations through the use of GenAI and its integration with other tools in a labbased activity. The present work explores the mathematical discussions that primary students engage in when creating prompts to be presented to a GenAI system and interpreting the feedback it provides. The findings are subjected to rigorous examination and analysis to investigate the potential of GenAI as a teaching-learning tool that can provide support for mathematical discussions, enhancing students' learning. The initial results suggest that students' involvement in the formulation of prompts for GenAI and interpretation of its feedback has the potential to enhance mathematical discourse and facilitate the construction of mathematical meanings. Furthermore, our study underscores the essential role of the teacher in orchestrating collective mathematical discussions enhanced by GenAI. The teacher's deliberate strategies, informed by an understanding of the affordances and limits of the tool and its integration with other resources, played a pivotal role in guiding students towards the learning process.

Keywords: Generative Artificial Intelligence, Collective Mathematical Discussion, Mathematics Laboratory, Instrumental Approach.

1. Introduction

In recent years, the emergence of Generative Artificial Intelligence (GenAI), exemplified by systems such as ChatGPT, has prompted educators to rethink traditional teaching methods and pedagogical strategies. These advanced technologies are known for their ability to create new content by identifying patterns in input data. However, one of the key challenges is to define clear educational objectives and to design effective teaching strategies that fully exploit the potential of these innovations.

Mathematics education can be significantly influenced by the advent of GenAI. This technology can generate a big variety of mathematical problems and solutions, providing students with a wide range of mathematical scenarios to engage with (see Capone and Faggiano, in press). The potential of GenAI goes beyond problem generation – it can also serve as a tool to stimulate collective discussion among students, especially if they are given meaningful problems and encouraged to share their approaches and solutions with each other.

Motivated by GenAI's potential as a learning tool in mathematics, our study takes an educational perspective, focusing on its mediation role in collective learning environments. We are inspired by the concept of a mathematics laboratory, where structured social activities promote mathematical understanding (Anichini et al., 2004). Specifically, we investigate how primary school students' engagement with GenAI during collective mathematical discussions (CMD), a method introduced by Bartolini Bussi and Mariotti (2008), influences their learning process.

The theoretical framework that guides our study is based on the instrumental approach (Artigue, 2002; Trouche, 2004), which is underpinned by constructivist epistemologies and socio-cultural theories of mediation (Vygotsky, 1978). Central to this framework is the concept of the instrument as a combination of an artefact (the physical tool) and the individual's scheme of use or behaviour (Verrillon & Rabardel, 1995). According to the instrumental approach, the process of transforming an external artefact into an instrument of human activity, known as instrumental genesis, involves two key dimensions: instrumentalization and instrumentation. Instrumentalization describes how the artefact evolves to support activities within a specific cultural context, while instrumentation refers to the gradual development of schemes for using the instrument effectively.

In order to investigate how GenAI can act as a tool to promote collective mathematical discussions and knowledge development, a pilot study was conducted in ten 4th-grade and 5th-grade classrooms (Troilo et al., 2024a; 2024b). During this study, GenAI was integrated with other tools in a laboratory activity designed to enhance primary school students' understanding of geometrical transformations. The teaching sessions were recorded and analysed using the framework of the instrumental approach and of the collective mathematical discussions in order to explore the processes of instrumental genesis associated with GenAI.

Specifically, the aim of this study was to explore how students' personal schemes, developed through their interactions with GenAI, progress during peer collaboration in structured, teacher-guided discussions. Results shows that this progression facilitates a more profound construction of mathematical concepts, supported by the teacher's role as mediator. By means of guided interventions, the teacher assists students in generalising their findings, thus transforming them into mathematical meanings (Mariotti & Maffia, 2018).

2. Materials and Methods

This research work is a preliminary qualitative study whose methodology is that of case study. This paper presents an analysis of the results of a project carried out in ten 4th-grade and 5th-grade class in Italy (Troilo et al., 2024a; 2024b). The project aims to provide teachers with practical examples of how digital technologies can be used in the mathematics laboratory to enhance the teaching-learning process. Each student was equipped with an iPad and an interactive whiteboard was used to display and share materials for group discussions. The activities were led by researchers in the presence of the class teacher and integrated into the regular curriculum. Each class participated in two sessions of two hours each, and all sessions were video recorded. Data collection included both these video recordings and observational notes taken by the research team. For the purposes of this paper, specific episodes were selected based on the researchers' notes, transcribed and supplemented with relevant images.

These preliminary findings were then analysed to address our research question: "How can primary students' progression towards the construction of meanings be supported through the use of GenAI as a tool to foster collective mathematical discussions?".

As mentioned above, the mathematical focus was on geometric transformations, specifically axial symmetry. The teaching activities were organised in a series of didactic cycles, incorporating a variety of resources that worked synergically (Faggiano et al., 2018). In some of these cycles, students were tasked to work together in small groups, using digital tools to interact with artefacts and then discussing their findings with the researcher. For example, in the second cycle, students used GeoGebra –a dynamic environment useful for exploring geometry concepts– to create a figure, draw a line, and create a second figure that was symmetrical to the first with respect to the line (Fig. 1). In their groups they were then asked to explore what changes and what remains unchanged when either the original figure or the line is moved. These tasks are aimed at discovering the properties of axial symmetry, mediated by GeoGebra, and the construction (using different tools) of a figure symmetrical to another with respect to a given line. The subsequent group discussion helped students to realise that axial symmetry is a point-to-point geometric transformation determined by both the figure and the line chosen as the axis of symmetry. Activities such as this, designed in line with our theoretical framework, have been thoroughly

tested in previous studies, demonstrating their effectiveness in promoting meaningful student learning (e.g., Faggiano et al., 2018).

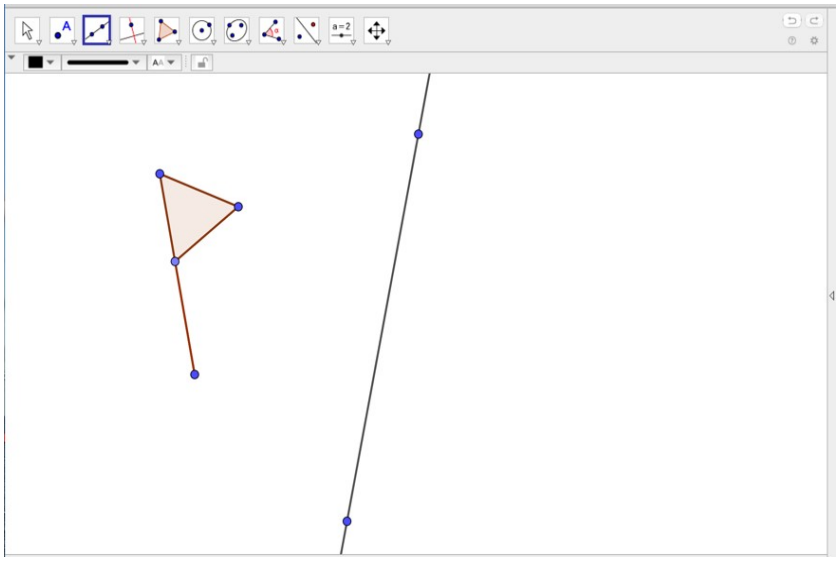


Figure 1 - The activity with GeoGebra: *"Construct the flag that is symmetric to the given one with respect to the given line. Drag the first flag. What happens? Drag the line. What happens? Drag the symmetric flag. What happens?".*

The focus of this paper is the third and last cycle, which is aimed at verifying the extent to which the previous steps resulted in an effective meaning construction. In this step, the whole class engaged in the task, with the researcher leading the collective mathematical discussion. Students were given a sheet of paper on which two figures symmetrical to each other were drawn (see Fig. 2) and they were asked to consult ChatGPT to determine the line used as the axis of symmetry to generate one figure from the other.

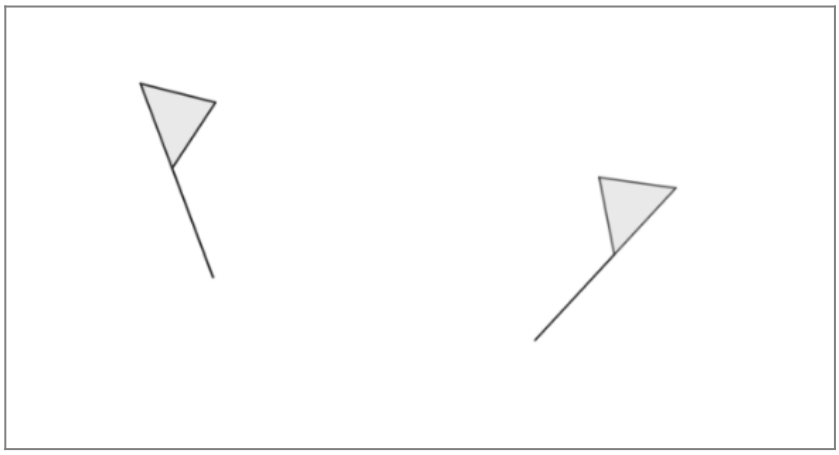
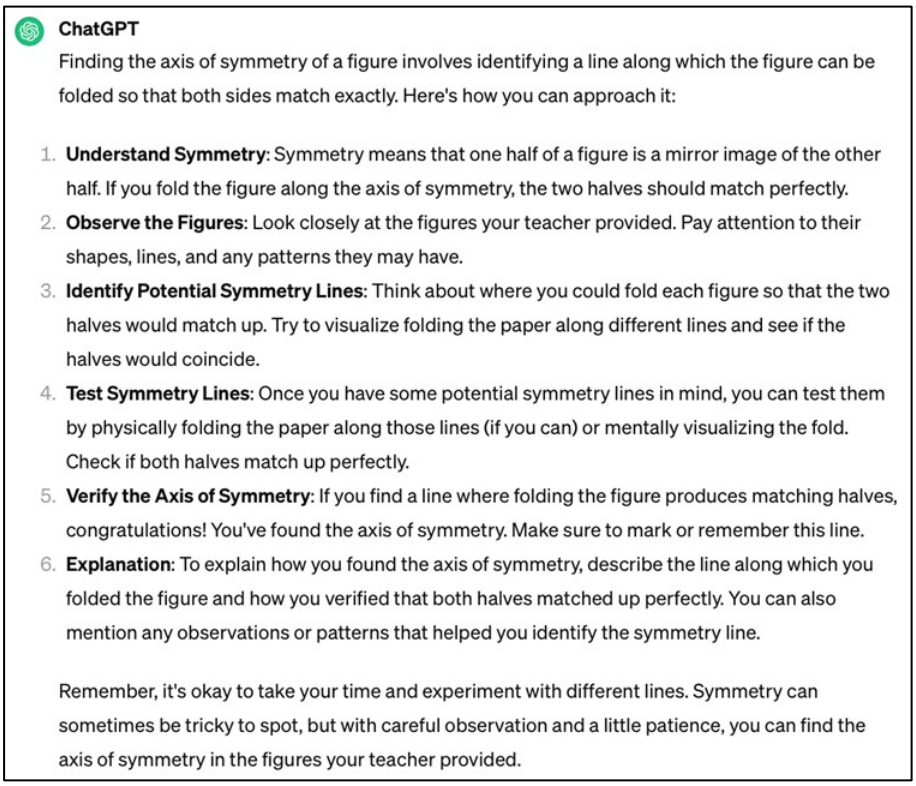


Figure 2 -Thetaskgiven on a sheet "Find the axis".

The decision to use GenAI in this way at this stage was based on the authors' prior analysis of the feedback generated by ChatGPT (version 3.5) in response to the following prompt: "I am a 10-year-old girl, and I received from my teacher a sheet of paper with two figures that are mutually symmetric. The teacher, without adding anything else, asked me to find the axis of symmetry and explain how I did it. How can I do it?".

As shown in Fig. 3, ChatGPT's feedback has the potential to spark a dynamic classroom discussion due to its incomplete and somewhat confusing response to the specific prompt. For instance, it fails to explain how to identify the axis of symmetry between two symmetrical figures, instead vaguely referencing figures that have an axis of symmetry. The Collective Mathematical Discussion (CMD) was designed to highlight the issues in this answer and encourage students to

generate signs and arguments, which could be guided toward a deeper understanding of the properties of axial symmetry.



ChatGPT

Finding the axis of symmetry of a figure involves identifying a line along which the figure can be folded so that both sides match exactly. Here's how you can approach it:

1. **Understand Symmetry**: Symmetry means that one half of a figure is a mirror image of the other half. If you fold the figure along the axis of symmetry, the two halves should match perfectly.
2. **Observe the Figures**: Look closely at the figures your teacher provided. Pay attention to their shapes, lines, and any patterns they may have.
3. **Identify Potential Symmetry Lines**: Think about where you could fold each figure so that the two halves would match up. Try to visualize folding the paper along different lines and see if the halves would coincide.
4. **Test Symmetry Lines**: Once you have some potential symmetry lines in mind, you can test them by physically folding the paper along those lines (if you can) or mentally visualizing the fold. Check if both halves match up perfectly.
5. **Verify the Axis of Symmetry**: If you find a line where folding the figure produces matching halves, congratulations! You've found the axis of symmetry. Make sure to mark or remember this line.
6. **Explanation**: To explain how you found the axis of symmetry, describe the line along which you folded the figure and how you verified that both halves matched up perfectly. You can also mention any observations or patterns that helped you identify the symmetry line.

Remember, it's okay to take your time and experiment with different lines. Symmetry can sometimes be tricky to spot, but with careful observation and a little patience, you can find the axis of symmetry in the figures your teacher provided.

Figure 3 - Feedback that the Authors received by ChatGPT 3.5 during an initial test.

3. Results

In this section we will analyse some of the main results obtained, focusing on two specific episodes that allow us to answer the research question. In order to carry out these analyses, the prompts used to interact with ChatGPT, and the corresponding feedback generated by the system, were formulated in Italian. For the purposes of the paper, the authors then translated into English both the prompts and the feedback of the selected episodes.

The first episode we present aims to illustrate how a digital tool, in this case ChatGPT, can evolve as a supporting tool in teaching activities and how the schemes of use of the tool can gradually emerge and change through practical interaction with it. In earlier stages of the project, students worked in small groups to understand the properties of two symmetrical figures and to draw a figure symmetrical to another with respect to a given line. For the tasks the students used paper, pencil and a pin, and interacted with GeoGebra.

In the next phase, ChatGPT was introduced as an additional tool. The task in this new phase was to find the axis of symmetry of two mutually symmetrical figures. The integration of ChatGPT aimed to facilitate this process by providing hints and explanations. The collective discussion that took place during this phase, from which significant passages were extracted, was aimed at bringing out the processes of instrumentalization and instrumentation. The first refers to the appropriation of the instrument by the students, while the second refers to the development of the students' schemes of use for the instrument. By interacting with ChatGPT, the students progressively developed new skills and strategies for completing the assigned task, demonstrating how the use of the instrument can be a dynamic and constantly evolving process.

Initially, the students were asked to decide which prompt to give and they suggest the following.

Student1:	We can write, "We are fourth graders. We have to solve a problem. We have to find out the axis of symmetry between two polygons".

After sending the prompt to ChatGPT, students read the feedback that comes back. However, after reading ChatGPT's answer, they started to feel confused and felt that the feedback was not really useful ("But it doesn't really help us!") as it was quite complex. As a result, the students engaged collaboratively in an attempt to improve the prompts, trying to make them more useful and relevant in order to obtain more comprehensive answers.

Researcher:	It replies by writing a lot of things.
Student 2:	We can ask it for a summary.
Researcher:	Do we want a summary, or do we want to ask it to guide us?
Student 3:	Yes, we can ask it how to do it... explain it to us.
Student 1:	Yes, we can write, "We are 4th graders, we have to solve a problem. We have to find out the axis of symmetry between two polygons. Guide us step by step."

The discussion then contributed to the development of students' usage schemes. Guided by the researcher, students engaged in a discussion about how to communicate any difficulties or misunderstandings they may have.

Researcher:	Maybe we need to make it understand better what we need – let's try to be clearer with it. Let's describe better our problem.
Student 1:	We can write: "Thank you for your answers, but you didn't help us at all. We have on a sheet of paper two figures, flag-shaped, symmetrical to each other."
Researcher:	That's what we do have. Now we should explain our problem.
Student 1:	We can add: "We need to find the axis of symmetry."

Prompted by the researcher, the class continued to discuss the best way to express the function of the axis of symmetry and finally agreed on the following:

Student 2:	I get it... maybe we need to write: "Thank you for your answers, but you didn't help us at all. We have on a sheet of paper two figures, flag-shaped, symmetrical to each other. We need to find the axis of symmetry that turns one flag into the other."
Researcher:	And don't we want to ask it a specific question?
Student 3:	How do we get it?

To this prompt they received and read the ChatGPT's feedback.

Researcher:	Look…it added something it had not written before: "if the two figures are symmetrical to each other, it means there is an axis of symmetry that transforms one figure into the other". Then it also adds the "Steps to find the axis of symmetry." Better than before, don't you think?!

Student 1:	Yes, now we like it! Let's see what it can suggest now… "Look for the points that appear to be the same in both figures".
Student 2:	The tip of the flag, the beginning and the end of the flagpole.
Researcher:	Ok, so we have them. Then it says: "Observe the lines or segments connecting these points".

The extracts above show how, during the researcher-led discussion, the students were able to gradually improve and refine the wording of their prompts. They could see how the feedback they received became more useful as the prompts became more precise. In this way, students gradually developed their ability to write more precise prompts and noticed positive changes in the feedback they received.

This first episode shows that at the beginning of their interaction with ChatGPT, students noticed that the feedback they received was not quite what they expected. Therefore, they started to work together to improve the prompts, trying to make them more useful and relevant to achieve their goals. With the support of the teacher/researcher, they gradually developed the process of instrumentalization, gaining a clearer understanding of how the artefact could help them to complete the task. At the same time, through their interaction with the tool, their schemes of use also evolved, furthering the process of instrumentation and improving the practical effectiveness of the instrument.

The second episode we present aims to show how the students' instrumental genesis, in relation to the use of ChatGPT during collective discussion, can support the construction of mathematical meaning. This episode was carried out in a class different from that one involved in the first episode. As well as the previous one, the episode concerns a collective discussion, led by the teacher, in which the students were attempting to find the axis of symmetry with the support of ChatGPT.

After an initial phase in which students worked together to identify the most relevant prompt, trying to get answers from ChatGPT that met their expectations and were useful to solve the task, the discussion turned to interpreting the feedback received. The focus was on understanding how this feedback could be useful in advancing the solution of the task.

The concept of 'corresponding points' early emerged. As the meaning of this expression was unknown to the students, this new terminology further complicated the understanding. The intervention of the teacher was needed.

Researcher:	"So, let's try to recap for a moment, go back over. What did you understand? What is it trying to tell us with this "corresponding points"? For example, when I gave you the sheet of paper with the two flags, some of you joined the points. Can you explain why?"

With this intervention, the researcher tries to stimulate reflection in the students by inviting them to review and deepen the explanations offered by ChatGPT on the corresponding points. The aim is to help students to fully understand these concepts, using both the feedback provided by ChatGPT and other supporting tools such as the sheet with the two flags or GeoGebra. Once the meaning of the corresponding points has been clarified, the discussion focuses on analysing their actual usefulness.

Researcher:	Let's see… in your opinion, these two points, the bases of the flagpole, what are these points? Will they have anything to do with what it is trying to tell us? Let's go back for a moment to what it had told us at the beginning: to find this line we have to use the corresponding points... Now what will they be for, these corresponding points?

Student 1:	Let's tell it that we've figured out what the corresponding points are and that we've joined them two by two and ask it what we need to do now.
Researcher:	Okay...let's see...it tells us, “Look carefully at the points you have connected. Imagine a straight line passing right through the middle of these points.”

With the aim of helping students to connect the signs, the researcher focused the students' attention on the concept of middle point and distance, which already emerged in the previous phases of the activity.

Researcher:	Think about what we were doing with GeoGebra, what had we said? We hadn't said that the figures were in the middle, but that the figures were located... if one went away the other one also went away, it did the same. What remained the same?
Student 2:	The distance
Student 3:	I see…we need the middle points because there we have the same distance… that’s why we can fold in the middle.

This episode shows how the students were guided through a meaning-making process. Gen AI, with its constant stimulation and feedback, not only opens up opportunities to return to the task, but also to demand and provide synthesis, thus supporting the construction of mathematical meanings.

These preliminary results suggest that encouraging students to formulate prompts for GenAI and interpret its feedback led to more in depth mathematical discourse and facilitated a variety of teacherled interventions designed to foster signs’ development and meanings’ construction. By maintaining consistent guidance towards the task at hand, by emphasising pivotal aspects of GenAI use, and by providing summaries when appropriate, the teacher facilitated the creation of a dynamic learning laboratory environment. This setting facilitated active student participation and promoted a collaborative approach to knowledge construction. The use of technology, and in particular of Generative Artificial Intelligence, created a more dynamic and engaging learning environment, fostering greater student participation.

4. Conclusions

Our research aimed to show how GenAI can be integrated into educational practices as complementary teaching-learning tool, enriching collective discussions and facilitating active students’ engagement.

The pilot study presented in this paper, aimed to explore the student’s instrumental genesis, focusing in particular on the instrumentalization and instrumentation processes related to the teacher's use of genAI to enhance, promote and facilitate collective mathematical discussions.

The analysis of the initial results shows how the tool, used by the teacher to support the teaching activity, actually contributed to the students’ learning. The episodes analysed clearly show that the students were actively engaged in refining the prompts to ChatGPT, with the aim of obtaining answers that were increasingly appropriate and relevant to solving the assigned task (instrumentation). Moreover, they progressively understood how to effectively exploit the tool to achieve their learning aims (instrumentalization).

This allows us to highlight how ChatGPT, and more generally GenAI, can evolve into a meaningful tool to support teaching and learning. The first episode clearly shows how students were able to refine their prompts, observing changes in feedback as their requests became more precise and focused. In the second episode, it was observed how the students, during a collective discussion led by the researcher, collaborated to interpret and make sense of the feedback received, also linking these responses to the activities previously carried out with GeoGebra, with the aim of developing the mathematical concept of axial symmetry.

We acknowledge that the students were largely guided by the teacher/researcher in their interactions with ChatGPT during the collective discussion. This choice was dictated by the need to optimise the limited time available, preferring a more structured approach that would allow us to purposefully observe the dynamics of interaction with the tool, with the aim of understanding how ChatGPT could effectively promote mathematical discussions.

Although previous studies have already shown that a properly structured Collective Mathematical Discussion (CMD) can lead students to deep understanding without necessarily relying on Generative AI (Faggiano et al. 2018, Mariotti and Maffia, 2018), in this paper we wanted to explore a different approach, namely that this technology can become an added tool to be integrated into educational practices.

Our study still highlights the crucial role of the teacher or researcher in orchestrating these collective mathematical discussions enhanced by generative artificial intelligence (GenAI). Through targeted interventions, such as constant reminder of the task, emphasis on the most relevant aspects of using GenAI and the provision of clear summaries, the teacher succeeded in creating a collaborative and active learning environment in which students were able to engage with the tool in a conscious and constructive manner.

These results highlight the promising potential of integrating GenAI into primary school mathematics teaching. Not only as a technical support, but as a real driving force to promote deeper mathematical discussion and shared knowledge construction. However, it will be crucial to conduct further studies to assess the long-term impact of the guided use of GenAI on students' mathematical skills and to understand how teacher orchestration can maximise the benefits of these technologies in the learning process.

In conclusion, our research contributes to the debate on the use of digital technologies in mathematics education, highlighting how generative artificial intelligence can offer new opportunities to enrich teaching experiences in primary school and promote innovative pedagogical practices.

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AI integration to enhance executive functions through Mind Brain Education: a theoretical analysis

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Abstract

This proposal explores the crucial role of Executive Functions in shaping human life and wellbeing, examining both the beneficial and detrimental cognitive effects of digital tools, especially AI, on human cognition. Aim: The goal is to highlight the impactful role of educational institutions in fostering and sustaining Executive Functions while also leveraging AI-based educational tools designed to enhance memory, behavioral inhibition, and flexibility on one hand, and to stress that the goal is attainable when educators have well-defined objectives and robust pedagogical frameworks on the other hand. To this end, the transformative potential of Mind, Brain, and Education (MBE) pedagogical approach, grounded in neuroscience insights, is advocated. This approach has been further advanced and validated through research and educational initiatives at Harvard University. Its efficacy can be bolstered by evidence-based models, such as those derived from influential Hattie's meta-analyses providing valuable insights into effective teaching strategies, educational interventions, and factors that contribute to student achievement. Methodology: This proposal employs a theoretical analysis, integrating insights from diverse disciplines such as digital technologies, neuroscience, pedagogy, and learning assessment.

Keywords: Artificial Intelligence, Executive Functions, Mind Brain Education, Neuroscience, Evidence-Based Learning.

1. Introduction

As digital technologies become increasingly integrated into learning environments, they present both challenges and opportunities that merit thorough exploration. This paper examines the complex relationship between artificial intelligence (AI), education, and cognitive development, drawing on both national and international literature to contextualise its significance in the current educational landscape.

First, it discusses how AI continues to shape educational practices and the necessity of considering its cognitive implications. Notably, Carr (2010) highlights the effects of the internet on cognitive processes, suggesting that reliance on digital technologies may alter how knowledge is acquired and retained. The influence of AI extends beyond mere automation, impacting fundamental cognitive processes and raising important questions about its role in shaping the future of learning (Crawford, 2021).

Next, the study addresses the significant impact of AI on Executive Functions (EFs), which are vital for both academic success and personal development. Executive Functions, including working memory, cognitive flexibility, and inhibitory control, are essential for students as they manage information, maintain focus, and adapt to new challenges. Research by Miyake et al. (2000) and Diamond (2013, pp. 135-168) emphasizing the importance of these functions in learning and their malleability throughout childhood and adolescence is presented.

Lastly, the paper highlights the urgent need for innovative pedagogical models that effectively integrate digital tools while actively supporting cognitive development. In this context, it presents the combination of the Mind, Brain, and Education (MBE) framework and John Hattie's comprehensive meta-analyses as a strong and promising approach. The MBE model, which draws on insights from neuroscience, psychology, and education, emphasises aligning teaching practices with how the brain learns best. When paired with Hattie's evidence-based ranking of educational influences, which identifies the most impactful strategies for student achievement,

these models may provide a powerful roadmap for enhancing cognitive growth in modern classrooms at both global and national levels. This paper is deeply committed to promoting the understanding and application of these models.

2. Materials and Methods

This paper employs a theoretical analysis approach, integrating insights from diverse disciplines such as digital technologies, neuroscience, pedagogy, and learning assessment. It focuses on a comprehensive review and critical analysis of existing pedagogical models, cognitive development frameworks, and digital technologies. The core materials include foundational theories such as McLuhan's concept of non-neutrality of instrument.

The paper is supplemented by empirical evidence, including data on the cognitive effects of AI and digital tools presented by scholars like Carr (2010), Sparrow et al. (2011), and Uttl et al. (2022). Additionally, it examines the decline in IQ levels and the possible role of digital technology in influencing superficial engagement with information.

It includes key theoretical models and meta-analyses to provide a nuanced understanding of cognitive development and the impact of digital tools in education, such as Mind, Brain, and Education (MBE) and Hattie's meta-analytic ranking of educational influences.

Moreover, a detailed examination of the Executive Functions framework, incorporating insights from neuroscience and psychology, is provided. The analysis is informed by foundational research from authors such as Miyake et al. (2000) and Diamond (2013, pp. 135-168), who emphasise the importance of Executive Functions in academic success.

The paper also surveys AI-supported tools and platforms aimed at enhancing Executive Functions, based on global initiatives from both philanthropic and private sectors. Each platform is evaluated for its potential to support cognitive development through AI, while acknowledging the importance of human educators in mediating technology’s role in learning. The study adopts a critical stance on the over-reliance on digital technologies and highlights the need for evidence-based interventions to counteract potential cognitive impairment.

3. Discussion

According to McLuhan (1967, 1994), no instrument is neutral. Although not explicitly mentioning this concept and using a different language and context, this same idea is poignantly highlighted by Kate Crawford, who likens artificial intelligence to an atlas. Crawford argues that just as atlases offer a specific vision of the world and serve as both acts of creativity and scientific compilations, the field of AI represents an explicit attempt to capture the world in a computationally readable form. However, this representation is far from neutral and currently reflects the worldview of dominant powers (Crawford, 2021).

Moreover, digital technologies, among their various impacts and affordances, have significant potential for harmful cognitive implications. They can potentially make people less intelligent by encouraging superficial engagement and reliance on easy answers rather than deep understanding (Carr, 2010; Sparrow et al., 2011). Additionally, they can create an illusion of competence, as easy access to information can make individuals overestimate their knowledge and skills (Fisher et al., 2015; Roediger & Butler, 2011).

Furthermore, despite the brittleness of AI and the severe potential harms it can cause, there is an enthusiastic belief that AI will soon replace humans in various cognitive and relational tasks: this belief is coupled with a growing conviction that such technological advancements are essential for addressing our numerous overlapping crises (McQuillan, 2022). However, recent research indicates a decline in the IQ levels of undergraduate students over the past several decades. A comprehensive meta-analysis by Bob Uttl et al. (2022) and his colleagues at Mount Royal University aggregates data from studies spanning from 1939 to 2022. Their findings revealed a steady decrease in the average IQ of college students, from approximately 119 in the mid-20th

century to a current average of around 102, just slightly above the general population's average IQ of 100. This trend is particularly noteworthy as it contradicts the Flynn effect (1984), which documented a consistent rise in general population IQ scores throughout the 20th century. Multiple factors may have contributed to this decline. Among them, the over-reliance on digital technologies is suggested to play a significant role in the decline in cognitive skills among students. Easy access to information and the proliferation of digital tools can lead to superficial learning and a false sense of competence. Students may engage less in deep, critical thinking and problem-solving activities, which are essential for the development and maintenance of high cognitive abilities.

The implications of these findings are profound. Institutions of education must reassess and adapt their curricula and academic standards to address the changing capabilities of their student bodies. Employers, too, need to recalibrate their expectations and hiring practices, recognizing that a college degree may no longer be a reliable indicator of superior intelligence or skill. This evolving landscape of education underscores the need for a more nuanced understanding of what constitutes intelligence and how it should be nurtured and assessed in the modern world.

In this context, having pedagogical models that integrate digital tools to enhance cognitive dimensions with effective teaching practices is crucial. A notable example is the Mind, Brain, and Education (MBE) approach, which emerged in the early 21st century as a cross-disciplinary field integrating neuroscience, psychology, and education. The origins of MBE can be traced back to advancements in neuroscience and cognitive psychology, which revealed new insights into how the brain learns. Educational experts sought to apply these findings to enhance teaching and learning processes. Tokuhama-Espinosa's work (2010) was foundational in formalizing the principles and practices of MBE. Pioneers in this field, including institutions like Harvard University’s Graduate School of Education, have been instrumental in advancing MBE as a framework for more effective and scientifically grounded teaching strategies. The core purpose of MBE is to provide educators with a scientifically valid foundation for teaching and professional development. The goal is to create a clearer path for long-term career development, where status is based not only on classroom experience but also on a deep, evidence-based understanding of how learning happens. MBE advocates for teachers to become more grounded in reliable scientific research related to learning and teaching, offering a more professional anchor for the teaching profession. Neuroscience, with its rapid advancements, provides the foundation for this more empirical approach, creating opportunities to improve educational systems throughout a professional career. The idea is to help educators understand how the brain works in learning contexts, thus enabling them to adopt teaching practices that align with brain-based learning principles. Over time, this deeper understanding could help teachers progress not only based on years of service but also on their mastery of the scientific evidence about learning and teaching, ensuring better educational outcomes.

The core of MBE consists of six foundational principles and twenty-one tenets that serve as the bedrock for educational practices (Tokuhama-Espinosa, 2010; 2011, 2021). The principles underscore how learning interacts with the brain’s functions and guide the design of teaching methods:

1. the brain is malleable: the brain has the capacity for neuroplasticity, meaning it can change, grow, and adapt, especially through educational experiences.
2. emotions play a critical role in learning: emotions significantly affect attention, memory, and the learning process, and thus must be integral to educational strategies.
3. learning is social: collaboration and social interaction enhance learning by providing a platform for peer engagement and shared understanding.
4. individual differences influence learning: students have varied backgrounds and neurological profiles, requiring personalised approaches to education.
5. the brain connects new knowledge to prior knowledge: effective learning happens when students can relate new information to what they already know.
6. attention is essential for learning: focused attention is necessary for learning, and strategies to maintain student attention are crucial for success.

Building on these principles, the MBE framework offers 21 tenets that further elaborate on how learning occurs and what factors influence it. These tenets translate the principles into actionable insights for educators:

1. neuroplasticity: learning changes the structure and function of the brain.
2. critical periods: some stages of development are more suited to acquiring specific knowledge and skills.
3. emotion and learning: emotional states influence memory, motivation, and learning outcomes.
4. neurodiversity: every learner has a unique neurological profile, requiring tailored educational strategies.
5. memory systems: teaching should be designed in ways that align with how the brain encodes and retrieves memories.
6. developmental differences: teaching strategies should be appropriate for the learners' developmental stages.
7. cognitive load: educators must balance the amount of information to avoid overwhelming students.
8. physical movement: physical activity enhances cognitive function and supports learning.
9. attention: learning requires sustained attention; distractions need to be minimised.
10. sleep: adequate sleep is critical for memory consolidation and overall cognitive performance.
11. stress and learning: while chronic stress is detrimental, manageable stress can enhance learning.
12. reward systems: praise and reinforcement can motivate students and support their learning processes.
13. executive function: skills like planning, organizing, and emotional regulation are central to learning.
14. mindset: a growth mindset, the belief that abilities can improve with effort, fosters resilience in learners.
15. metacognition: students' ability to reflect on their own learning improves problem-solving and critical thinking.
16. feedback: timely, constructive feedback helps students understand and correct mistakes.
17. social cognition: social interactions, including peer learning, reinforce comprehension and application of content.
18. language and literacy: strong language skills are closely linked to cognitive and academic success.
19. culture and context: education should respect and incorporate the cultural backgrounds of learners.
20. transfer of learning: teaching should provide strategies that allow students to apply what they've learned in different contexts.
21. technology integration: digital tools should be used thoughtfully to support, rather than hinder, cognitive development.

Together these principles and tenets form the basis of MBE's approach, providing educators with a roadmap for improving their teaching methods.

Tokuhama-Espinosa's research closely relates to Hattie's ranking, which is a comprehensive synthesis of over 800 meta-analyses relating to various influences on student achievement. Hattie's work identifies the most impactful educational practices, such as cognitive task analysis, which helps break down complex tasks into manageable components to enhance learning. John Hattie is a prominent figure in educational research, renowned for his ground-breaking contributions to the field of visible learning. This concept centers on identifying effective teaching

practices and assessing their impact on student achievement. Hattie's methodology involves conducting extensive meta-analyses, drawing from an impressive database of over 2,100 meta-analyses, which encompass more than 130,000 studies and involve over 400 million students worldwide. Currently, his ranking comprises 256 influences, encompassing a wide array of factors pertinent to student learning and success (Hattie, 2023). According to this research, cognitive task analysis exhibits the highly promising effect size of 1,29, whereas an effect size greater than 0,4 is supposed to accelerate student learning.

Notably, in the field of cognitive development, the foundational role of Executive Functions is to be considered prominent. The term *executive function*, obscure only a few decades ago, is now widely used. There is also a growing interest in targeting them for intervention, because it is widely recognised that they are malleable throughout childhood and adolescence, but few educational approaches so far capitalise on the malleability of neural networks and target Executive Functions (EF) for intervention. Empirical evidence shows that few schools are able to structure learning environments to support the development of EFs (Hill, Serpel and Faison, 2016).

EFs, as top-down monitoring and controlling processes, are the higher-order neural processing in the brain that take place in the prefrontal cortex (PFC), the front most part of the brain near the forehead. They are essential to learning, planning, reasoning, problem-solving, goal-directed action, and self-motivation. But social, emotional, and physical health for cognitive health are crucial, because stress, lack of sleep, loneliness, or lack of exercise each impair EFs. There is general agreement that there are three core EFs: they encompass cognitive processes such as working memory, cognitive flexibility, and inhibitory control, which are essential for goal-directed behavior inhibition (including self-control/behavioral inhibition and interference control/ selective attention and cognitive inhibition) (Miyake et al., 2000; Diamond, 2013, pp. 135-168). They are more accurate predictors of academic readiness and life success than IQ or any other performance markers: so, there is an important need to offer affordable and effective solutions to today's educational challenges; there is an important need of cognitive training, mindfulness, and EFs skills curricula (Blair & Razza 2007; Morrison et al. 2010; Ahmed et al., 2019).

Working Memory involves the ability to hold attention on a concept or task long enough to complete an association or to generate a conclusion or new thought. The term describes a combination of cognitive processes for managing information, integrating new information with existing ones, and collating results into new information. For making sense of everything that happens over time and for reasoning, working memory is crucial. Additionally, it is crucial for many key academic tasks, including making mathematical calculations without the use of a calculator, considering alternative solutions to a problem, and making connections between seemingly unrelated things. Long-term memory is important since it is where basic concepts and strategies that are often involved in learning are stored. Functional memory is used to tackle it when something new is experienced. To move that information into long term memory, it often takes time and practice. To help with this process, is used a technique called spaced repetition. It involves repeating what has to be retained, but extending the practice over several days, in short, spacing this repetition out. This is why tackling procrastination is so incredibly important: in fact, procrastination and memory are two topics intimately related, because building solid chunks of long term memory, chunks that are easily accessible by the short term memory, takes time. Procrastination is a keystone bad habit that influences many important areas of life, and shares features with addiction (such as a trigger, routine, rewards, and the belief it can be overcome) which offer immediate pleasure and temporary relief.

Cognitive Flexibility is the ability to shift from one mind state or task to another, often responding to environmental stimuli, like a teacher's instruction, or to new social demands. It is necessary for reorganizing priorities and thinking creatively about a problem. It is believed to build upon both working memory and inhibitory control, and includes the skills of attention shifting and attention control. It is also essential for considering another person's perspective (Bailey, 2018). The best way to learn is, in fact, interleaving., i.e. practicing jumping back and forth between problems that require different types of approaches, concepts, procedures, techniques or strategies, because knowing how to use just a particular concept, approach, or problem solving technique is not enough, and it must also be known when to use it. So, if practice and repetition are important in

helping build solid neural patterns to draw on, it is by interleaving that one begins thinking more independently through flexibility and creativity.

Inhibitory control means being able to overcome a strong internal predisposition or external lure by regulating one's focus, actions, feelings, and/or emotions, and instead doing what is more acceptable or essential. Without it, one would depend on conditioned responses, impulses, and old habits of thought, pulling this way or that. Thus, inhibitory control gives the chance to change and to choose how to react and behave. It can also save us from making fools of ourselves. Inhibitory control of attention (interference control at the level of perception) selectively activates attention and focus on what has been chosen, suppressing distraction to other stimuli.

Since EFs are at the heart of cognitive functioning, supporting their development is a social commitment and an investment in students' lifelong trajectory of achievement both in academics and in the complexities of social and emotional contexts (Durlak, 2011).

To address this growing need, we are witnessing on global scale the development of numerous platforms and applications implementing programmes to assess and enhance EFs with the support of AI. Consequently, the ongoing involvement of educators is paramount (Martinez Beltran, 2007). For this reason, the fundamental role of educational mediation cannot be overlooked in relation to learning (Jonassen, 1983, pp. 153-167). Therefore, in the case of AI-supported applications, it is worth noting that technology does not inherently promote skill transfer, and it is not yet well established whether cognitive training programmes transfer to areas beyond those initially trained. Therefore, the role of educator/teacher mediation remains essential. The primary actions involving AI in improving EFs encompass several key areas; therefore, it is crucial to understand which areas of EFs may benefit most from a specific AI tool. Additionally, the presence of AI-driven analytics can identify patterns and trends in students' cognitive performance that human educators might overlook, allowing for more accurate detection of EFs issues. Furthermore, the development of AI algorithms enables personalised learning, adapting to individual learning needs and providing tailored training to target specific cognitive areas. AI can also facilitate real-time feedback and assessment, offering immediate insights into students' performance to support timely interventions. Lastly, it plays a role in supporting metacognition by encouraging students to reflect on their own learning processes, fostering greater self-awareness and self-regulation.

With this in mind, we present a curated selection of AI-supported tools and platforms designed to enhance EFs. These initiatives stem from both philanthropic and private sector efforts, showcasing contributions from various countries. Each entry includes key details such as the product name, primary objectives, access link, and relevant research link, providing a diverse array of resources. The selection, though not exhaustive but rather representative, can be accessed at the following address: https://bit.ly/3VPSlrp

4. Conclusions

This paper has explored the complex interplay between AI, education, and cognitive development, emphasizing the dual nature of technology's impact on learning environments. The analysis has underscored the transformative potential of AI, which extends beyond mere automation to fundamentally reshape cognitive processes. Additionally, the alarming trend of declining IQ levels among students, highlighted through Uttl et al.'s (2022) meta-analysis, serves as a critical warning regarding the cognitive consequences of an over-reliance on digital technologies. This finding calls for a re-evaluation of educational curricula to prioritise deep, critical thinking and problem-solving skills, ensuring that students remain engaged with their learning materials on a meaningful level. Central to this discussion is the concept of Executive Functions (EFs), which are essential cognitive processes, including working memory, cognitive flexibility, and inhibitory control, that play a pivotal role in academic achievement and personal development. Drawing upon foundational research by Miyake et al. (2000) and Diamond (2013), the paper has demonstrated the malleability of EFs and their importance for effective learning

during childhood and adolescence, stressing the need for targeted interventions that can enhance these skills.

To deal with these challenges, the Mind, Brain, and Education (MBE) framework has emerged as a compelling pedagogical model. By integrating insights from neuroscience, psychology, and education, the MBE framework emphasises the brain's malleability and the significant influence of emotions and social interactions on learning. This model, when combined with Hattie's evidencebased rankings, offers a solid foundation for enhancing cognitive development through teaching practices that align with how the brain learns best.

Moreover, while AI holds great potential for supporting EFs, a thoughtful integration of these technologies is essential. AI-driven analytics can provide valuable insights into cognitive performance patterns, allowing for timely, tailored interventions. Simultaneously, personalised learning experiences powered by AI can enhance student engagement and understanding. Finally, the curated selection of AI-supported tools and platforms presented herein represents a

significant advancement in enhancing EFs and cognitive development across diverse educational contexts. However, the effective integration of these technologies requires thoughtful mediation by educators, as technology alone cannot facilitate skill transfer or cognitive growth. Educators play a vital role in contextualising and guiding the use of these tools to ensure they complement and support the achievement of learning objectives.

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Unlocking the power of AI and chatbots in Language Education: opportunities, challenges, and teacher training

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Abstract

Artificial intelligence (AI) has reshaped language education, with tools like ChatGPT playing a significant role. These chatbots mimic natural conversations, offer immediate feedback, and adjust to students' individual needs, improving areas such as speaking practice, vocabulary, and listening skills (Hwang, Lai & Wang, 2020). Despite these advancements, the literature lacks sufficient focus on training educators to effectively implement these technologies (Fryer & Carpenter, 2020).

This study conducted an in-depth literature review on the use of chatbots in language learning, assessing their effectiveness, advantages, and limitations. Additionally, a teacher survey was carried out to examine their perspectives and training requirements regarding AI in education. The data was evaluated using descriptive statistics and correlation analysis.

The findings reveal that teachers generally find AI integration in language teaching beneficial, with the majority rating its usefulness at 4 out of 5. Nonetheless, they emphasized the need for specialized training to use these tools effectively. Overall, while there is a positive outlook on chatbot implementation, the results highlight the critical importance of teacher training to fully leverage AI's potential in the classroom. The abstract (summary) must contain a brief description of the work and not exceed 250 words. The abstract will be made public on the conference website and must be posted in the appropriate area during the submission phase of contributions.

Keywords: Conversational Agents, Second Language Instruction, Professional Development for Teachers, Personalized Learning, AI.

1. Introduction

Artificial intelligence (AI) has revolutionized various fields, and language learning is no exception. In this area, AI-powered chatbots like ChatGPT have emerged as promising tools to enhance the learning experience. These chatbots simulate natural conversations, offer instant feedback, and adapt to the individual needs of learners, which are essential factors in acquiring a second language.

Research on the use of chatbots in language education has grown significantly in recent years. Studies show that these systems can improve students' speaking, vocabulary practice, and listening comprehension (Belda-Medina & Calvo-Ferrer, 2022a; Gonda & Chu, 2019; Tyen et al., 2022). Chatbots provide conversational practice, critical for developing communication skills, allowing students to engage in real-time interaction and receive immediate feedback, something often difficult to achieve in traditional language learning environments.

However, despite initial enthusiasm, there are still significant gaps in the literature, particularly concerning teacher training for the effective use of these technologies. Most studies focus on chatbot effectiveness from the student's perspective, overlooking how teachers can be trained to integrate these tools into their teaching methods (Fryer et al., 2019). Adequate teacher training is crucial, not only for the technical operation of chatbots but also in understanding how to effectively incorporate them into pedagogical strategies. This includes recognizing the limitations and possibilities of chatbots and how they can complement traditional teaching methods

(Holstein et al., 2022). Without proper training, teachers may face challenges in effectively using chatbots in the classroom, potentially limiting the benefits of these technologies.

This study aims to address these gaps by conducting a critical review of the most widely used chatbots in language education and exploring the importance of teacher training in this context. The specific objectives are:

- To evaluate the effectiveness of chatbots in language learning: Analyze the features, benefits, and limitations of current chatbots, such as ChatGPT, and their impact on students' learning processes.
- To explore teacher training in the use of chatbots: Identify the necessary skills and evaluate teachers' perceptions and attitudes toward using chatbots in the classroom.

This study is significant as it aims not only to understand how chatbots can improve language learning but also to prepare teachers to use these technologies effectively. By doing so, we hope to contribute to the development of more innovative and adaptive educational practices that meet the demands of an increasingly digital world. The introduction of a scientific paper not only sets the context and relevance of the study within its field but also immerses the reader in the current state of knowledge, critically reviewing the relevant literature to highlight research gaps and justify the need for the current study.

AI is defined as the ability of a machine to mimic human cognitive functions such as learning and problem-solving. In language education, AI has evolved from simple grammar practice programs to sophisticated intelligent tutoring systems and conversational chatbots. These advancements have been made possible by the development of machine learning algorithms and natural language processing (NLP), which allow machines to understand and generate human language in a coherent and contextually appropriate way (Bolaño-García & Duarte-Acosta, 2023; Tamarit, 2022; Macias et al., 2023).

AI-powered chatbots, such as ChatGPT, use advanced NLP techniques to interact with users in a natural and fluent manner. These systems are trained on vast amounts of textual data, enabling them to learn linguistic and contextual patterns. The key components of chatbots include language models, natural language understanding (NLU) algorithms, and natural language generation (NLG). NLU allows chatbots to interpret user input, while NLG enables them to produce contextually appropriate responses (Ma et al., 2023; Zhang & Huang, 2024).

Chatbots have emerged as innovative tools for language learning, providing real-time interaction and conversational practice. These systems offer students additional opportunities to improve their language skills outside the traditional classroom environment.

The characteristics of chatbots include:

Conversational interaction: Chatbots like ChatGPT can hold conversations in multiple languages, adapting to the user's proficiency level (Kohnke et al., 2023; Naidu & Sevnarayan, 2023; VVAA, 2023a).

Accessibility: Available 24/7, they allow students to practice anytime, anywhere (Vázquez-Cano et al., 2021).

Personalization: They can adjust the difficulty level of responses according to the student's needs, facilitating adaptive learning (Chen et al., 2020).

The use of chatbots in language education offers numerous benefits, such as unlimited practice—students can practice without the pressure of interacting with humans, which can reduce anxiety (Fryer et al., 2019). Chatbots also provide immediate feedback, offering corrections and suggestions in real-time to improve accuracy and fluency (Pham et al., 2018). Additionally, chatbots enhance student motivation and engagement by offering an interactive and dynamic platform (Belda-Medina & Calvo-Ferrer, 2022b).

However, some limitations include contextual understanding, as chatbots may struggle with complex cultural and contextual nuances (Coniam, 2008). There are also technological challenges, as current technology still faces difficulties in natural language processing and generating fully coherent responses (Tyen et al., 2022). Moreover, chatbots require large amounts

of high-quality data for effective training, which can be a challenge in languages with fewer resources (Perdana et al., 2022).

The integration of AI into language education offers numerous advantages. Chatbots can provide consistent conversational practice, allowing students to interact in a safe, judgment-free environment. This is especially useful for practicing speaking and listening, as students can receive immediate and personalized feedback. Additionally, chatbots can adapt to individual learners' proficiency levels, providing activities and exercises tailored to their specific needs (Fryer & Carpenter, 2020).

Successful integration of AI and chatbots in language classrooms depends on proper teacher training. Fortunately, there are increasingly more training programs in the form of courses, webinars, or workshops available both locally and online. It is essential for educators to understand how these LLMs work and to master prompting techniques to maximize their benefits (Lyu et al., 2023; Morales-Chan, 2023; VVAA, 2023b).

2. Methodology

The first step in this methodology involves conducting a literature review on the use of AI-based chatbots in language teaching. This review focuses on identifying previous studies that evaluate the effectiveness of chatbots in language learning, their benefits and limitations, as well as the technological barriers and implementation challenges faced by educators. Academic databases such as Google Scholar, Scopus, and Web of Science will be used to gather relevant articles, offering a comprehensive overview of the current knowledge in this field.

The next phase of the study involves collecting data through a structured survey aimed at language teachers. The purpose of the survey is to explore teachers' perceptions and attitudes toward the use of chatbots in language instruction and assess their training needs in AI. Participants will include educators from various educational institutions, selected through purposive sampling to ensure a diverse representation.

The survey will cover the following areas:

- Experience with AI technologies: Frequency and types of chatbot use in teaching.
- Perceptions and attitudes: Opinions on the effectiveness of chatbots in language education.
- Training needs: Specific AI training requirements.

The collected data will be analyzed using descriptive statistics to draw conclusions.

The final phase will involve providing examples of how to use chatbots in teacher training, with activities that can be easily replicated in the classroom.

The integration of artificial intelligence in language education has led to the development of various tools aimed at enhancing the effectiveness and accessibility of learning. Below is a review of some of the most prominent AI tools used in language teaching, with a particular focus on chatbots.

3. Results

Based on a survey conducted with a sample of 45 language teachers who had participated in AI and language training through the Équipe Formativa Territoriale Toscana, several conclusions can be drawn:

- Need for AI training: 87% of the teachers believe that proper training is essential for implementing AI in language classrooms.
- Perceived usefulness: Most respondents consider AI integration in language teaching beneficial, with a dominant rating of 4 out of 5.

Regarding the ease of use of AI tools, responses are fairly balanced, though there is a slight trend toward finding them user-friendly, with several participants giving ratings of 4 and 5.

Regarding improvement in language learning, most teachers believe that AI can enhance students' language learning, again with high scores averaging 4 out of 5.

These results suggest a generally positive perception toward the implementation of AI in language education, while also emphasizing the necessity of proper training for effective usage.

As for the AI tools most commonly used by teachers, 80% have used or currently use ChatGPT, followed by GeminAI and Copilot. Another chatbot gaining interest for language learning is PI AI, which offers highly natural and empathetic responses.

Next, we will examine practical applications of these chatbots. Tools like ChatGPT are anticipated to make a significant impact in language education, as noted in a study by HolonIQ (2024). These tools offer a range of interactive activities that can enrich classroom learning. Below are practical examples of how ChatGPT can be used in language teaching, as presented in training sessions conducted by Équipe Formativa Toscana. Although ChatGPT is the focus here, these activities are also replicable with other chatbots. Additionally, Mizou, a chatbot that can be customized by teachers, was introduced during training sessions.

Conversational Practice

Example: Simulated conversations

Activity: Order food at a restaurant.

Instruction: Imagine you're at a restaurant. Speak to the waiter (ChatGPT) and order a complete meal, including an appetizer, main course, and drink.

Guided Writing

Example: Essay writing

Activity: Write a letter to a friend.

Instruction: Write a letter to a friend about your vacation. Then send it to ChatGPT for feedback on how to improve it.

Vocabulary Practice

Example: Vocabulary games

Activity: Play hangman.

Instruction: Play hangman with ChatGPT using this week’s vocabulary. Guess the word ChatGPT is thinking of.

Reading Comprehension

Example: Text analysis

Activity: Read and discuss.

Instruction: Read the following paragraph, then answer questions ChatGPT will ask about the content.

Grammar Practice

Example: Error correction

Activity: Grammar correction.

Instruction: Write ten sentences and ask ChatGPT to help correct any grammatical errors.

Role-Playing

Example: Job interviews

Activity: Simulate a job interview.

Instruction: Prepare for a job interview. Answer the questions ChatGPT will ask as if you were a candidate for the position.

Another potential of chatbots is their ability to assist in assessment (Li et al., 2023), allowing personalized feedback to be provided to language learners. However, this will be explored in future research.

4. Discussion

The findings from this study highlight the importance and potential of artificial intelligence (AI) in language education, particularly through the use of chatbots like ChatGPT. Teachers' generally positive perception of AI integration is a promising sign of their readiness to adopt these technologies. The fact that 87% of the surveyed educators believe adequate training is necessary points to a significant gap that needs to be addressed to fully realize AI's potential in language teaching.

Respondents rated the usefulness of AI in language education at an average of 4 out of 5. This aligns with previous research showing that chatbots can improve students' speaking skills, vocabulary practice, and listening comprehension (Belda-Medina & Calvo-Ferrer, 2022a; Tyen et al., 2022). The ability of chatbots to provide instant feedback and adapt to individual student needs is key to their effectiveness.

Despite the positive outlook, teachers expressed challenges regarding ease of use. While there is a slight trend toward finding AI tools user-friendly, the need for training remains clear. This echoes the findings of Fryer et al. (2019) and Holstein et al. (2022), who emphasize the importance of teacher training for the effective use of educational technologies. Without proper training, educators may struggle to integrate these tools effectively, limiting their potential benefits.

The belief that AI can enhance language learning is further supported by the high rating of 4 out of 5. This suggests that teachers recognize the value of AI in providing consistent, personalized conversational practice, which is critical for developing communication skills (Fryer & Carpenter, 2020). However, it is important to consider the technological and contextual limitations of chatbots, such as their difficulty in understanding complex cultural and contextual nuances (Coniam, 2008).

This study has certain limitations, including the sample size and its focus on a specific geographic region, which may limit the generalizability of the results. Additionally, most participants had some level of prior exposure to AI, which may have influenced their positive perceptions. Future research could expand the sample size and explore the perceptions of teachers with no prior AI experience, as well as investigate the effectiveness of specific training programs in various educational contexts.

The discussion provides a deeper interpretation of these findings, placing them in the context of existing knowledge. It analyzes the implications of the results, how they support or challenge previous theories, and their practical or theoretical relevance to the field. Moreover, this section critically addresses the study's limitations, discussing how these may affect the interpretation of the findings and suggesting areas for future research to overcome these limitations or explore new questions raised by the current study.

5. Conclusions

In summary, AI and chatbots offer significant potential to transform language teaching, providing key advantages such as enhanced conversational practice and immediate feedback. However, to fully harness these benefits, it is essential to provide teachers with adequate training. This study emphasizes the need for comprehensive training programs that not only cover the technical

aspects of using chatbots but also focus on their effective pedagogical integration, especially through practical examples that teachers can quickly and easily implement in the classroom. By doing so, the positive impact of AI on language education can be maximized, fostering more innovative and adaptive learning environments.

Additionally, promoting a culture of continuous learning and regular updates for educators is crucial, ensuring they remain informed about the latest advancements in educational technology and teaching methodologies. This includes using AI not only for conversational practice but also for developing critical skills such as reading comprehension and writing.

Implementing continuous assessment strategies and adaptive feedback through chatbots can help identify areas for improvement for both students and teachers. Immediate and personalized feedback is key to adaptive learning, allowing real-time adjustments that enhance student progress.

Finally, collaboration between technology developers, educational researchers, and teachers is essential to design AI tools that are truly effective and user-centered. For instance, OpenAI's Edu version, targeted at universities, serves as a prime example of this collaboration. Such partnerships can lead to technological solutions that are not only functional but also intuitive and accessible, facilitating their daily adoption and use in classrooms worldwide.

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CodeTutor: personalized programming learning through automated feedback and clustering

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Abstract

First-year Computer Science students often struggle to learn Java programming, and this condition can have a negative impact on their academic progress. Recently, an online tutoring system has been developed to help students learn Java programming.
It allows students to execute and check Java code, making the learning process easier. Although the use of this tool has led to improvements in learning, it has been observed that the system has some weaknesses that need to be improved. The gap consists in the lack of specific and personalised feedback for the students. Therefore, a specific software has been developed, with an innovative approach based on machine learning using auto-clustering and neural networks.
The new online tutoring system offers a better personalisation thanks to a graph model tailored to the study plan based on individual performance, by optimising learning effectiveness through video tutorials and Java code evaluations. This system aims not only to increase the academic success of the students, but also to provide instructors with a more precise assessment tool.

Keywords: Machine Learning, Education, Moodle, Tutoring, CodeRunner.

1. Introduction

During the first year of the Computer Science degree program, students often encounter difficulties in acquiring Java programming skills during the course. Research shows that students find learning to program from scratch extremely challenging, leading them to believe they are unable to continue with their studies, potentially resulting in dropout (Robins et al., 2010). For an effective and meaningful learning during the programming course, it is important for students to have the opportunity not only to learn theoretical concepts but also to interpret their mistakes, find examples, and seek solutions to known problems.

Intelligent Tutoring Systems (ITS) have been developed to support programming education by providing personalized instruction and feedback (Sykes, 2002; Abu-Naser et al., 2011; Al-Shawwa et al., 2019). For instance, Abu-Naser et al. (2011) designed an ITS specifically for teaching Java objects to help students overcome difficulties in understanding object-oriented concepts.

ITS have demonstrated a significant impact on student learning across various educational fields (Alrakhawi et al., 2023). To this end, in 2023, the University of Camerino developed an online tutoring system (Tutoring System) that allows students to both execute and verify Java code (Nalli et al., 2023). The analysis of the results reported in the study shows that students who actively used the online tutoring system (Cluster 0) achieved a pass rate of 69%, compared to 55% of students with average activity (Cluster 1) and 22% of less active students (Cluster 2). Despite the significant progress made in computer science education through the implementation of the Tutoring System, we aimed to push the boundaries even further because we believed there was still untapped potential. Developing tutoring systems that provide specific and personalized feedback is essential to effectively support students in improving their coding skills, as highlighted by Hegarty-Kelly and Mooney (2021) and Kochmar et al. (2022). The initial system lacked the ability to provide detailed feedback tailored to each student's needs, which is crucial for addressing individual learning gaps.

2. Materials and methods

To personalize the feedback system, we have enhanced the system developed and implemented in 2023 (Nalli et al., 2023) with a new tutoring system called CodeTutor. This system supports students by providing specific feedback and guiding them towards compensatory strategies (additional exercises) tailored to their needs. While many existing ITS focus on specific educational areas, CodeTutor extends these ideas by applying auto-clustering techniques and neural networks to provide personalized feedback in Java programming, as highlighted by current trends in the field (Alrakhawi et al., 2023). CodeTutor leverages advanced technologies to analyze student code submissions and generate personalized feedback, aligning with current approaches in intelligent tutoring systems (Kochmar et al., 2022).

The new tutoring system implements a new software integrated with the CodeRunner plugin (Higgins, 2024), implemented on the Moodle e-learning platform. Upon entering the Moodle platform, students find open-ended quizzes to fill in with Java code. After writing the code, they must press the run button. The CodeRunner plugin then compiles the code using the local Jobe server, running a series of automated tests. These tests compare the student's program output with the expected output to verify correctness.

At this point, the new software, regardless of the code's correctness, calls an API (Application Programming Interface), which is a set of protocols and definitions that allows different software components to communicate with each other (Fielding & Taylor, 2000). This API populates the MongoDB database with the student's answer after each execution. The server manages the communication between the Moodle platform and the database, facilitating seamless data exchange. All components, including servers and databases, are hosted on a single internal Ubuntu machine within the university. This setup ensures efficient communication between components and simplifies maintenance and security management.

We are using a MongoDB database to store the data in a structured JSON format. The data collected includes:

1. Name and Surname: To identify the student.
2. Email: We save the email of the student to prevent homonyms.
3. Session Key: To track individual sessions.
4. Date: The date the question was answered..
5. Question ID: The question to which the student is responding.
6. Question Text: The text of the question the student must answer.
7. Student's Response: The code submitted by the student.
8. Number of Times a Response Has Been Verified: To track how many times the student has attempted the specific question.
9. Number of Times in a Session Any Response Has Been Verified: To monitor the student's overall activity during the session.
10. Programming Language Used: The programming language used for the submission (currently Java, but since CodeRunner is used for other purposes within the university, the programming language used is saved for future extensibility).

The set of answers collected serves to create a model for determining the formative feedback to be returned to the student. This approach allows the clustering of potential types of mistakes, enabling a deep and detailed analysis of the difficulties encountered by students. To ensure that the system can handle the expected load during student use, performance tests have been conducted using a free online software called Grafana (Ödegaard, 2014). The testing simulated 30 users continuously sending API requests to the server, allowing us to estimate the system’s performance under heavy usage. These tests confirmed that the Ubuntu machine hosting the whole server is capable of supporting the anticipated number of concurrent users during the initial student simulations.

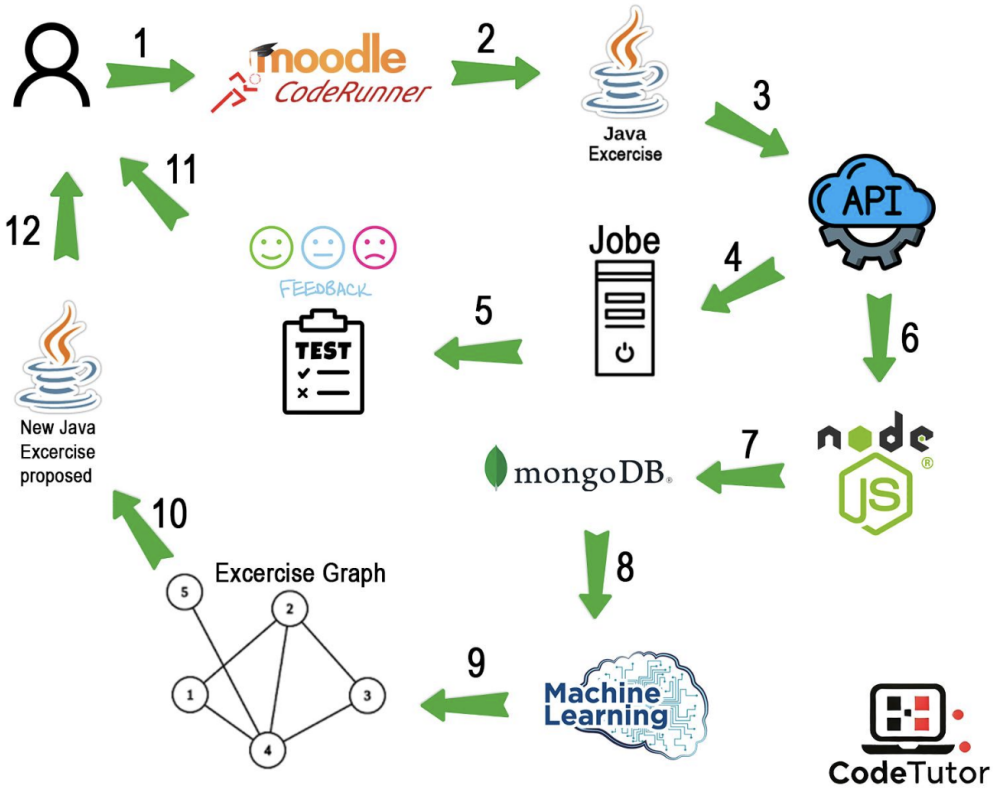


Figure 1 - Visual Architecture.

Once the database is sufficiently populated, machine learning techniques will be used to train the system to recognize and categorize clusters, thereby facilitating the assignment of specific and targeted feedback. Similar to the approach used by Dake et al. (2023), who applied k-modes clustering to identify student learning patterns, we plan to utilize clustering algorithms to evaluate each error made by the student by assessing its severity and comparing it with similar errors made by other students. We plan to use three clusters:

1. Cluster 0: Incorrect responses.
2. Cluster 1: Partially correct responses.
3. Cluster 2: Fully correct responses.

This mechanism will evaluate each error made by the student by assessing its severity by comparing it with similar errors made by other students. The use of auto-clustering algorithms enables the system to identify patterns in student errors, which can then be addressed through personalized feedback and additional resources. Unlike earlier systems (Al-Shawwa et al., 2019, Sykes, 2005) that did not utilize machine learning for adaptive feedback, CodeTutor employs auto-clustering algorithms and neural networks to analyze student code submissions and generate personalized feedback, similar to the methodologies proposed by Kochmar et al. (2022).

Neural networks are also employed to predict potential areas where a student might struggle, based on their past performance and common error patterns. This predictive capability allows the system to proactively provide support and resources to help the student overcome challenges.

Personalized feedback is a crucial component of effective ITS, as it helps address individual learning needs (Banawan et al., 2023). CodeTutor provides specific feedback based on the errors detected in the student's code, guiding them toward understanding and correcting their mistakes. This aligns with the principles of adaptive learning, ensuring that each student receives support tailored to their current level of understanding (Shute, 2008).

In the quizzes, each question has a related weight that determines the difficulty of the next one based on the student's response. If the student answers correctly, the system will propose a more difficult question; if they answer incorrectly, the system will offer a simpler question, providing

feedback in each situation. Moreover, the Moodle platform will direct students to video tutorials and teaching materials related to the topic covered whenever they encounter difficulties during the quizzes. This adaptive approach ensures that the learning path is personalized for each student, which is consistent with effective practices in ITS development.

In addition, the quiz system in CodeTutor is organized as a graph, where each quiz is connected to one or more other quizzes via edges. Based on the specific errors a student makes, the system uses these connections to redirect the student to the quiz that is most appropriate for their learning needs. This graph-based structure allows for a highly adaptive and personalized learning pathway, ensuring that students focus on areas where they need the most improvement.

In designing the quizzes, we have ensured comprehensive coverage of key Java programming concepts. For each major topic in Java, there are at least two quizzes, providing students with multiple opportunities to practice and reinforce their understanding of each concept.

The feedback provided is specific to the errors made, guiding the student towards understanding the mistake and learning how to correct it. Such personalized feedback has been shown to have a significant impact on student learning outcomes (Alrakhawi et al., 2023; Kochmar et al., 2022). For example, if a student consistently makes syntax errors, the system may direct them to resources on Java syntax rules. If logical errors are detected, the system may provide exercises focused on problem-solving strategies.

3. Results

Once the development phase is complete, we will move on to the implementation phase with first-year programming course students in the Computer Science degree program at the University of Camerino. The first experimentation is scheduled to start on October 15th, involving first-year Computer Science students (about 300). The server starts with a maximum workload of 30 students but is designed to be scalable based on the number of students who will use CodeTutor.

To verify the effectiveness of the new Tutoring System, we will analyze students' behavior on the platform, the learning outcomes achieved at the end of the programming course, and their perceptions. Data collected during the experimentation will be used to refine the machine learning models and improve the system's performance.

As previously demonstrated by Nalli et al. (2023), preliminary clustering results have shown a positive correlation between student activity and exam pass rates, with more active students displaying significantly better performances. Building upon prior ITS developments in Java programming education (Al-Shawwa et al., 2019), CodeTutor aims to further enhance learning outcomes through the integration of personalized, machine learning-driven feedback mechanisms. With the implementation of the new tutoring system, which not only evaluates code but also supports students in their learning journey by providing targeted and personalized feedback, we expect even better learning outcomes compared to the previous system, similar to the improvements reported by Kochmar et al. (2022).

4. Conclusion

In the future, we aim to collect more data from students to further improve the precision and effectiveness of the machine learning system. A larger and more diverse database will allow a refinement of clustering and feedback models. Additionally, we plan to expand the system to support other programming languages and potentially extend its use to other courses and institutions.

In addition to clustering, predictive models can be developed to anticipate student performance and learning challenges (Dake et al., 2023). Integrating such predictive analytics into CodeTutor could further improve its ability to provide timely interventions and support.

Future work will involve implementing learner-centered assessment techniques such as pre- and post-tests to thoroughly measure the effectiveness of CodeTutor. We will also collect feedback through questionnaires to gain deeper insights into student experiences and areas for improvement.

The development of CodeTutor represents a significant step forward in providing personalized programming education. By leveraging machine learning techniques and a robust data collection system, we can offer students tailored feedback and adaptive learning pathways. This not only enhances the students' learning experience but also provides educators with valuable insights into student performance and common learning challenges.

Aligned with the findings of Alrakhawi et al. (2023), who identified computer science as one of the primary areas where Intelligent Tutoring Systems (ITS) have been effectively applied, CodeTutor's web-based platform addresses the growing need for advanced educational tools in university settings. By addressing individual learning needs through adaptive feedback and leveraging technology effectively, we believe CodeTutor has the potential to significantly improve learning outcomes and contribute to the advancement of personalized education in computer science.

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Enhancing Design Pedagogy with AI. A theoretical and practical perspective

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Abstract

Generative Artificial Intelligence (GAI) represents a transformative force in university education, reshaping both pedagogical practices and personalized learning. This article examines the innovative integration of AI, from generating educational content to predictive analysis of student success, and how these tools challenge traditional teaching models. Focusing on AI as a collaborative partner in communication design for Master's students, the study builds on prior research from the Department of Design at the Polytechnic of Milan, presented at ISYDE 2023.
The first section delves into the history of Artificial Intelligence in Education (AIeD), highlighting AI's ability to analyse large datasets, predict trends, and tailor learning experiences.
The second section presents two case studies, including a recent experiment at the Polytechnic of Milan. Students used GAI as co-designers to create their assignments, demonstrating AI's potential to enhance creativity and design education Our exploration, grounded in empirical research and practical applications, focusing on the transformative impact of generative AI on pedagogical strategies and educational paradigms. The case studies presented serve not only as an example to the practical usability of AI in enhancing creative educational processes but also as an example for future pedagogical exploration and experimentation.

Keywords: Generative AI, Pedagogical Transformation, Collaborative Design, AI-Enhanced Learning.

1. Introduction

Generative Artificial Intelligence (GAI) has emerged as a transformative force within the landscape of higher education. From reshaping pedagogical methods to enabling personalized learning experiences, its influence extends across a variety of academic domains, also within creative and design fields. This article explores the implementation of GAI within the design pedagogy context, particularly in the Communication Design Master's Program at Polytechnic of Milan. Building upon the research initiated last year, this exploration integrates both historical and practical perspectives on AI in education, emphasizing the evolving interplay between human and machine intelligence and creativity.

This study has followed multiple phases, some of which already presented at ISYDE 2023. The initial phase of our research as well as of our article involved a historical overview of AI (and GAI) in education, which traced its development from the mid-20th century to the present day.

This phase examined how AI technologies, particularly generative models, have progressively become integrated into pedagogical frameworks. Subsequent phases have been focusing on empirical research conducted with students, who were tasked with creating digital culture artifacts using AI as a co-designer and with creating an "AI and Media Education Design Master".

These practical applications offer insights into the collaborative dynamics between students and GAI in the creative design process, shedding light on the broader implications of GAI in reshaping both education and professional design practices.

2. A Brief Overview on Historical Development and Impact of AI on Education

The relationship between AI and education has evolved significantly over the decades, beginning with early mechanical teaching machines and culminating in today's sophisticated generative models. The origins of Artificial Intelligence (AI) can be traced back to the mid-20th century, a period that predates the internet and web technologies. The seminal moment in AI's history began with Alan Turing's pivotal question, "Can a machine think?" (Turing, 1950). This inquiry set the stage for the formal study of AI, which was officially inaugurated in 1956 during the Dartmouth Summer Research Project, led by John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon. Their Dartmouth Proposal outlined a vision for "strong AI," where every aspect of intelligence could be simulated by a machine (McCarthy et al., 1956). This early work established the theoretical foundations for AI, aiming to create machines capable of performing humanlike cognitive tasks.

The focus on "strong AI" continued through the 1960s, with educational applications inspired by behaviourist theories such as B.F. Skinner's "programmed instruction". Skinner's teaching machines sought to objectify pedagogical processes by providing structured, rule-based learning experiences. These machines represented an early attempt to use AI to enhance learning, albeit within a narrowly defined framework of behaviourist learning theories (Skinner, 1968).

Despite initial enthusiasm, the paradigm of "strong AI" faced criticism, particularly from John Searle, who challenged the assumption that machines could possess intentionality or consciousness. Instead, contemporary AI has largely shifted towards a "weak AI" model, where machines do not think autonomously but are designed to emulate specific cognitive functions, such as pattern recognition and predictive analysis (Searle, 1980). This shift in theoretical orientation has enabled AI to gain traction in a wide range of applications, from computer vision to voice recognition, recommendation algorithms, and automation systems (Eugeni, 2021).

The relationship between AI and education has evolved through several distinct phases, each characterized by advancements in both AI technology and pedagogical theory. Researchers such as Rivoltella and Panciroli (2021, 2023) have mapped out these phases, highlighting the key milestones in the integration of AI into educational practices.

Table 1 - AI Evolution in Education.

Time Period	*Phase*	*Key Technologies/Systems and Description*
1945 - 1950	Mechanical Phase	The earliest applications of AI in education were mechanical teaching machines, such as Skinner's Glider. These devices presented learners with multiple-choice questions and automated feedback mechanisms to reinforce correct answers.
1955 - 1990	Programming Phase	Computer Aided Instruction e Computer Based Training (CAI e CBT) Intelligent CAI. This phase saw the development of Computer Aided Instruction (CAI) and Computer Based Training (CBT) systems, such as PLATO. These systems introduced computers as educational tools, using pre-programmed lessons and multiple-choice assessments to deliver personalized learning experiences. Notably, the PLATO system, developed at the University of Illinois, was one of the first to use computers in a structured educational setting, leveraging a specific programming language called TUTOR to script educational content
1970 - 1990	Personalization Phase Self-Adaptive Educational System (SAES)	Automated tutoring systems based on constructivism and algorithms. During this phase, AI systems became more adaptive. The development of Self-Adaptive Educational Systems (SAES) allowed for personalized learning pathways, where algorithms adapted content based on the learner's progress and cognitive profile. This phase marked a departure from the rigid instructionist models of earlier systems, allowing for more flexible and individualized learning experiences.
2000 - until now	Personalization Phase Intelligent Adaptive Learning System	Cloud Computing, Data Mining, Big Data, Generative AI. The most recent phase of AI in education has been defined by the integration of generative AI, cloud computing, and big data. AI systems today can generate new content, predict learning outcomes, and adapt educational materials in real-time, offering unprecedented levels of personalization and scalability in educational settings.

The evolution of AI in education took a significant turn with the advent of "weak AI," which shifted the focus from creating machines that simulate human thinking to developing tools that support learning processes. The theoretical foundation for this shift can be found in constructivist pedagogical theories, particularly the work of David Merril and Seymour Papert (Merril, 1992; Papert, 1993). Constructivist AI systems, such as Self-Adaptive Educational Systems (SAES), are designed to help learners build their knowledge through interaction and discovery, rather than following pre-programmed instructional paths.

As the web revolution of the late 1990s transformed access to information, AI systems in education became more sophisticated, incorporating complex decision-making models based on learners' interactions with content. The introduction of Learning Management Systems (LMS) allowed for the deployment of AI-driven educational tools that could track student progress, adapt content to individual learning styles, and provide personalized feedback. These systems marked the beginning of a new era in educational technology, where AI serves as a collaborative partner in the learning process rather than a prescriptive instructor (Ferri, 1998).

The rise of Web 2.0 technologies and cloud computing has further accelerated the development of AI in education. Today, Learning Management Systems (LMS) and Virtual Learning Environments (VLE) are powered by AI systems that can analyse vast amounts of data and provide real-time feedback to both students and educators. One of the most notable trends in this space is the development of Intelligent Tutoring Systems (ITS) and AI-driven chatbots.

These systems use machine learning algorithms to provide personalized tutoring and support for learners. Early examples, such as AutoTutor, simulated human tutors by engaging students in interactive dialogue and providing feedback based on their responses (Graesser et al., 1999). More recent developments in conversational AI, such as chatbots trained on large datasets, have further expanded the capabilities of these systems, allowing them to assist learners in a wide range of subjects and contexts (Woolf, 2009; Popenici et al., 2019).

In addition to tutoring, AI systems are now being used for predictive analysis of student behavior and learning outcomes. By analysing data from LMS and VLE platforms, AI can identify students at risk of dropping out, allowing educators to intervene early and provide targeted support (Baker & Siemens, 2014).

The integration of AI into education is still an evolving field, with many potential avenues for future research and development. As generative AI systems become more sophisticated, they offer new possibilities for personalized learning, predictive analysis, and content creation. However, the role of AI in education also raises important questions about the balance between human and machine intelligence in the learning process.

As highlighted by recent studies (Tuomi, 2018), AI has the potential to transform not only how we teach and learn but also how we conceptualize the role of educators in the digital age. Ilkka Tuomi focuses on the potential effects of AI on teaching and learning, specifically in secondary education in developed countries. Tuomi's analysis identifies several high- and medium-impact areas where AI is poised to reshape educational practices. These include:

1. *Adapting Teaching Methods and Materials.* AI systems offer the ability to tailor teaching methods and educational materials to the specific needs and interests of individual students. This adaptability enhances personalized learning experiences, ensuring that educational content is relevant and accessible to diverse learners.
2. *Maintaining Accurate and Comprehensive Student Records.* AI enables schools and teachers to manage student records with greater precision, ensuring compliance with legal requirements and institutional policies. Automated systems can maintain up-to-date records of student performance, attendance, and behavior, streamlining administrative tasks.
3. *Evaluating Tests and Assignments.* AI tools facilitate the preparation, administration, and evaluation of tests and assignments. By automating aspects of the assessment process, these tools provide real-time feedback to students and allow teachers to focus more on instructional quality rather than repetitive administrative duties.

4. *Classroom Preparation and Resource Management.* AI-driven systems assist educators in preparing classrooms and teaching materials, optimizing both the physical and digital learning environments. These systems can help identify the most effective resources for specific instructional goals, enhancing the overall efficiency of lesson planning.
5. *Instructing through Multiple Modalities.* AI can support teaching through various formats, including lectures, discussions, and demonstrations in subjects such as English, mathematics, and social studies. The integration of AI enhances the multimodal delivery of content, catering to different learning styles and promoting student engagement.
6. *Setting Clear Objectives and Communicating Them*. AI tools can assist educators in establishing clear objectives for lessons, units, and projects. These systems can also help communicate these goals to students more effectively, ensuring that learners understand the expectations and desired outcomes of their educational activities.
7. *Providing Additional Support for Students*. AI enables the identification of students who require extra help and facilitates the development of remedial programs tailored to their needs. By monitoring student performance and behavior, AI systems can provide early interventions, helping students overcome academic challenges before they fall behind.
8. *Assignment Management and Correction*. Teachers can leverage AI to assign lessons and correct assignments more efficiently. Automated grading systems can handle routine assessments, while teachers focus on providing personalized feedback on more complex tasks.
9. *Enforcing Institutional Policies*. AI systems can also aid in enforcing school policies and rules related to student behavior. By monitoring compliance with administrative regulations, AI tools help maintain discipline and order within educational institutions.
10. *Engaging with Parents and Guardians*. AI enhances communication between teachers and parents, allowing for regular updates on student progress. Automated systems can schedule meetings, generate performance reports, and assist in addressing the specific needs of each student.

Since GAI models became widely accessible in November 2022, we have started a research project to test some of these functionalities, focusing specifically on Tuomi's elements 1, 3, 4, 6, 7, 8 with more than 250 students from Polytechnic of Milan.

3. Reconceptualizing Pedagogic Paradigms. GAI as a Tool for Design Education – Case Study 1

This part of the article will initially focus on analysing the first case study, which investigates the integration of GAI in design pedagogy, and will later extend to include another case study involving the use of GAI with the *Sociology of Media* course from the Department of Design at Polytechnic of Milano. This addition marks the opening of a new phase in our study, building on previous results already presented at ISYDE 2023. The research underscores the transformative potential of GAI in education, particularly its capacity to reshape pedagogical paradigms and introduce new avenues for scholarly exploration and assimilation.

The first case study centres on an empirical investigation conducted during the second half of the 2023 academic year, a period marked by growing interest in Generative Artificial Intelligence systems. This study was part of the *Digital Culture* course of the Master's programme in Communication Design at Polytechnic of Milan, where 55 students participated. The student background was diverse, with almost half hailing from Italy and the rest from various countries across Asia, Europe, the Americas, and the Middle East. This diversity contributed to a wide range of linguistic and cultural perspectives, as well as differing levels of access to and familiarity with various technological tools.

The students were divided into ten groups, with each group tasked with creating a *Digital Culture Artifact*.

To create the assigned digital culture product, each group was required to use at least two generative AI tools. The use of AI was mandatory, not optional, and the evaluation of the final product, in addition to the parameters related to design and digital culture, would include the ability to write effective prompts for creating the desired outcome.

These artifacts were designed within the framework of digital culture, where thus students explored the integration of GAI into various modalities such as Instagram, social media live streaming, digital publishing, and e-commerce. The assignment was designed to foster a critical approach to the use of AI in the realm of Design. Specifically, it aimed to discern:

a) where the traditional production model diverges from a digital culture-assisted model,
b) the areas where the designer remains indispensable in shaping the structure and texture of content,
c) instances where this paradigm collapses, leading to products of diminished value and depth.

The evaluation of this task carried significant weight in the students' final grades, with the assignment representing 40% of the overall evaluation. Each group was given a specific topic, randomly assigned by the professor, to prevent students from selecting topics based on personal expertise or preference.

Table 2 - Pairing between the groups and the topics**.**

Group	*Assignment*
Group 1	Design an Instagram campaign to promote local crafts
Group 2	Design an illustrated album (informative text) for kids to explain the war in Ukraine
Group 3	Design an illustrated album for kids to raise awareness of the water crisis
Group 4	Design a Twitter stream on “silenced women”
Group 5	Design a(n) guide/illustrated album on ethnic food for elder people
Group 6	Design an Instagram campaign to promote a sustainable smartphone
Group 7	Design a Twitter stream to raise awareness of marine pollution
Group 8	Design a fanzine to talk about the marvel heroes from a different perspective (steampunk culture, feminism ...)
Group 9	Design a(n) guide/app for second hand street markets in Milan
Group 10	Design a fb campaign for the protection of minority languages/dialects

As we can see from table 2, the assigned topics ranged from designing Instagram campaigns to raise awareness about sustainability to creating illustrated albums for children on topics such as the global water crisis. Students had the autonomy to choose from various GAI tools, including ChatGPT and DALL-E 2, to help generate content for their projects.

The core objective of this academic exercise was to foster a critical understanding of the role of GAI in design. Specifically, students were encouraged to identify the points at which traditional production models diverge from AI-assisted models and to examine where human designers remain indispensable in shaping content. The exercise also sought to highlight potential difficulties in using GAI, particularly when it leads to the creation of low-quality products.

In this paper, due to limited space, we will only analyse the work undertaken by three groups, specifically Group 3 and Group 6. Both groups are an example of a well-executed product, the use of GAI was effectively understood and contributed—though sometimes with difficulty—to the production of the outcome. The students demonstrated strong prompt-writing skills, and the GAI tools helped bring their creative vision to life.

The first digital culture product we will analyse is the one delivered by Group Three, which worked on an illustrated album for kids to raise awareness of the water crisis. We found this group's work

particularly important considering the potentiality and the limits of using GAI in designing a digital culture artifact.

The thematic was inherently intricate: the endeavour to cultivate awareness among children regarding a crisis that frequently eludes comprehensive understanding even among adults. No specific age range was intentionally mentioned allowing the students a certain flexibility in determining their target audience and, consequently, their methodological approach to their project. The group opted for the formulation of an album enriched with watercolour illustrations to appeal to "even the youngest." The book was conceptualized in its entirety through an assortment of Generative Artificial Intelligence tools, spanning from the watercolour illustrations to the narrative architecture.

One of the "problems that emerged" in using GAI tools to create this product involved the visual aspect rather than the story itself, which was created relatively easily using ChatGPT. The narrative unfolds around Antonello, a raindrop, who becomes disillusioned upon observing human wastage of water and thus embarks on a symbolic protest: a strike. The group was good at providing the right prompt to keep the story coherent and intriguing. As for the visual aspect, opting for a watercolor style revealed its challenges from the very beginning. The main challenge the students faced was getting the GAI to create watercolor illustrations suitable for children, with tones and palettes that would resonate with that audience. As acknowledged by them and corroborated through reviews, requisitioning specific visual renderings from the Artificial

Intelligence necessitated an extended temporal engagement and manifold iterations prior to the realization of the envisioned outcomes. The students had to train the GAI tools, Midjourney and Stable Diffusion, for hours with images and prompts to achieve the desired results. The students also curated a list of keywords, which they meticulously embedded in various prompts. With the tool Midjourney, for instance, they provided detailed, yet precise descriptors about the setting that they repeat over and over again.

The outcome presented by the students was outstanding (Figure 1), so much so that the group received the highest possible score of 30 out of 30 from both evaluators – considering various parameters related to the correct use of GAI for constructing both the images and the story, as well as those concerning communication design and digital culture (such as colours, palette, harmony, readability for the target audience, narration, style, etc.).

The chosen target audience, children between 8 and 10 years old who are capable of independent reading, was particularly persuasive. The nuanced utilization of colour schemes to visually convey the central issue, combined with the narrative structure and the adept integration of GAI in the book's creation, stood out as remarkable components of the project.

The training that the students provided to the GAI used, aiming to achieve the desired product, was also particularly convincing. Finally, they also transformed – using AI tools – the written content into an audiobook format, foreseeing its potential reception by a younger audience.



Figure 1 - Cover and first page of “The Water Strike” - Group 3's assignment.

The second digital culture artifact we will analyse is the one delivered by Group Six, which worked on creating an Instagram campaign for a sustainable smartphone brand, named *Relevo*. The thematic complexity of this assignment lay in the challenge of promoting a sustainable product within an industry notorious for its ecological shortcomings. The group's endeavour was to navigate the contradictions inherent in the concept of a “sustainable smartphone” — a product

often designed with planned obsolescence and composed of materials that are anything but environmentally friendly.

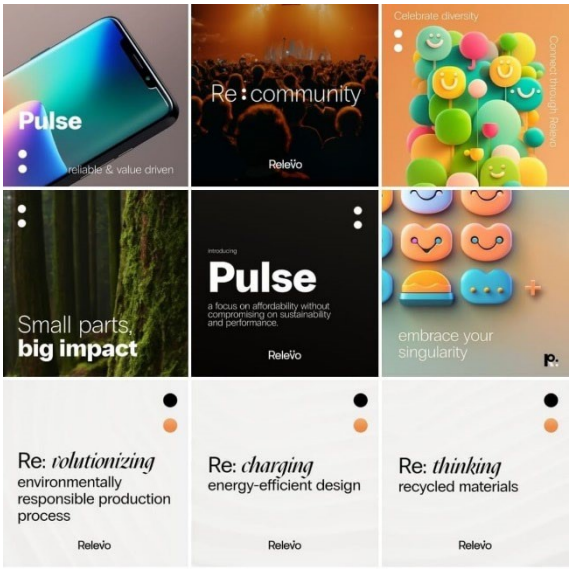


Figure 2 - Instagram campaign “Relevo” – Group 6’s assignment**.**

The target audience was again not strictly defined, providing the group with flexibility in tailoring their content and communication style. They ultimately aimed to reach environmentally conscious young adults who are frequent users of social media platforms such as Instagram.

The project was developed using a variety of generative AI tools, including OpenAI's ChatGPT, CrAIyon, Looka, Brandmark, Stable Diffusion, Leonardo AI, and Lexica. The AI tools played multiple roles in the project, acting as creative directors, content generators, and branding advisors.

The group used these tools to generate everything from brand names to visual content for the Instagram campaign, thereby exploring the strengths and weaknesses of GAI in creative processes.

The campaign also included an innovative feature: transforming written content into audio through AI-generated voiceovers.

The integration of GAI, as evidenced by the two examples, highlights its transformative potential in reshaping educational frameworks, particularly within creative disciplines. The first case study demonstrated how GAI tools, such as Midjourney and Stable Diffusion, were used effectively to create a digital culture artifact, showcasing both the benefits and limitations of AI in creative production. Group 3’s ability to generate coherent and visually engaging content for children, despite challenges in achieving watercolor illustrations, underscores the importance of prompt-writing skills and iterative design processes when using AI. Similarly, Group 6's exploration of branding and marketing for a sustainable smartphone brand via Instagram campaigns revealed the potential of AI tools to serve as creative directors and content generators.

Both case studies confirm the critical role of human oversight in AI-assisted design, emphasizing that while GAI offers creative support, human input and overview remain indispensable in refining outputs and ensuring relevance to specific target audiences.

The findings indicate that GAI can enhance student engagement, promote collaborative learning, and introduce new possibilities for content creation in design education. However, it also highlights the ongoing need for critical assessment of AI’s limitations, particularly in terms of its aesthetic and ethical implications in design and communication.

4. Reconceptualizing Pedagogic Paradigms. GAI as a Tool for Design Education – Case Study 2

Following this initial case study, a second research phase was implemented, incorporating sociology of media students from the same department. This phase opened new dimensions of inquiry, particularly regarding the use of GAI in media and communication design. By engaging students in both disciplines, the research aimed to explore the broader implications of AI across different fields within the design, media and education landscape.

This new phase has also allowed for a deeper examination of how AI can be applied to more theoretical, educational, and sociological frameworks within media studies, bridging the gap between practical design tasks and the critical analysis of media culture and education. The findings from these two case studies continue to inform our understanding of the evolving relationship between AI and pedagogy.

The Sociology of Media course at Polytechnic of Milan involves 200 students, with 30% being international students, divided into two sections. For this study, the students were grouped into 22 teams, each consisting of 5 or 6 members. The primary objective was to develop a hypothetical Master's program titled "AI and Media Education Design Master," which explores the territories of AI-assisted learning. The students were tasked with designing 22 unique courses that integrate AI within the realm of Media Education Design.

The main research questions for this study were:

1. How can generative AI (GenAI) support and enhance the educational process in media studies?
2. What impact does the use of AI as a “co-pilot” in learning have on the quality and effectiveness of educational outcomes?
3. How do students perceive the integration of AI in educational and professional contexts?

The rationale behind this initiative was to transcend the traditional role of AI and position it as a dynamic copilot in the educational journey. While essentially fictional, this project experimented with the practical applications and possibilities offered by modern AI. It ventured into the potential future of AI-driven education, merging scientific rigor with innovative and technological pedagogy, all within a design culture that seeks new directions to work in.

The project utilized a mixed-methods approach, involving both qualitative and quantitative research methodologies to provide a comprehensive understanding of the role of AI in education. The students were involved in an iterative process that combined data collection, content creation, and critical analysis.

To better understand the target audience and validate the project's hypotheses, the students developed an extensive three-part survey to gauge the current understanding and expectations surrounding AI in media education. The survey, which involved approximately 2,000 participants, primarily focused on individuals between the ages of 18 and 30, a demographic that represents the near future of AI adoption and integration. The survey was structured into three distinct sections: demoscopic, AI-specific, and topic-specific.

- *Demoscopic section*: this section aimed to gather demographic data and general perceptions about AI. It revealed that while young people view AI as an opportunity, they still consider it far from being a daily tool for tasks, information gathering, or facilitating everyday life processes. This finding aligns with recent studies that highlight the growing awareness but limited practical adoption of AI among younger generations (Gunkel, 2020).
- AI-specific section: this section delved into the participants' understanding of AI's potential in education. The results showed that students perceive AI as a resource to be understood and developed for study purposes, but with a cautious approach to its correct application. This sentiment echoes the concerns raised by educators and researchers about the ethical implications and potential misuse of AI in educational settings.
- *Topic-specific section:* this section explored the participants' views on AI's role in their future professional lives. The responses indicated that young people see AI as a formula to

be understood, not to be excluded from future job positions, but rather to enhance their professional capital through correct and balanced use. This finding resonates with the growing recognition of AI as a transformative force in the workplace, requiring individuals to adapt and upskill to remain competitive.

Building upon the survey results, the students proceeded to develop the hypothetical courses for the “AI and Media Education Design Master”. Each group was assigned a specific topic, ranging from *AI in journalism and social media* to *AI in film and television production.* The students leveraged various AI tools, including the GPTs models from different companies, a video and image generative models (such as DALL-E 2, Midjourney and other GAI applications), to generate content for their courses.

Each group created a comprehensive volume of support for their course, with lengths varying from 100 to 400 pages. These volumes integrated validated references and AI-generated content to support learning processes in specific educational paths. This process highlighted the importance of human oversight and critical thinking in the application of AI in educational contexts. As Luckin et al. (2016) note, AI should be seen as a tool to augment and support human intelligence rather than replace it entirely.

The development process involved meticulous research and validation of the generated content. The students curated the AI-generated material, ensuring its accuracy, relevance, and alignment with the course objectives. The creation of these courses showcased the potential for AI to support content development while underscoring the necessity for educators to guide and supervise the process.

Furthermore, a reflective analysis of the creation process revealed key challenges in using AI, such as biases in generative outputs and the difficulty in adapting AI-generated content to specific pedagogical goals. These challenges reaffirm the need for skilled educators who can critically engage with AI tools to harness their capabilities effectively while mitigating potential downsides.

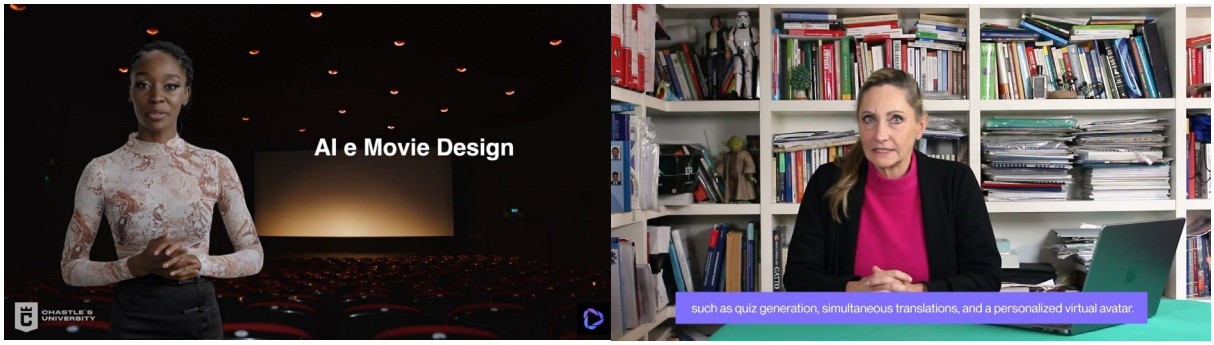


Figure 3 - 2 screenshots from the 22 videos produced.

The culmination of the project was a 60-minute video presentation showcasing all 22 courses (Figure 3). The students employed GenAI expedients and blended digital presentation formulas to create engaging and informative content. The video served as a testament to the creative potential of AI when combined with human ingenuity and design thinking.

To further disseminate the findings and outcomes of the project, an exhibition was held at the Department of Design at Polytechnic of Milan. The exhibition featured the course handbooks, ranging from 100 to 400 pages each, linked to the different topics explored in the hypothetical Master's program. These handbooks served as tangible evidence of the depth and breadth of the research conducted by the students.

The exhibition provided a platform for dialogue and reflection on the future of AI in media education. It sparked conversations about the ethical considerations, pedagogical implications, and societal impact of integrating AI into educational curricula.

The findings from this project offer valuable insights into the perceptions and expectations of young people regarding AI in media education. The survey results highlight the need for a

balanced approach that recognizes the potential benefits of AI while addressing the concerns and apprehensions surrounding its adoption. The development of the hypothetical courses demonstrates the creative possibilities of AI in enhancing educational content and delivery.

The survey analysis revealed that while approximately 72% of participants expressed interest in integrating AI tools into their future educational paths, about 55% also highlighted the importance of adequate training to mitigate ethical risks, such as algorithmic biases and privacy concerns. These findings align with recent discussions in educational research, emphasizing the need for ethical AI literacy among educators and learners alike.

Furthermore, students identified the dual role of AI as both an enabler and a potential barrier. While AI tools facilitated the creation of diverse educational content, students also faced challenges in ensuring that the AI outputs aligned with the intended pedagogical goals. This underscores the importance of developing skills in prompt engineering and critical analysis to maximize the benefits of AI while minimizing its limitations.

5. Conclusion

In conclusion, this article provides an in-depth exploration of the integration of GAI into design and media education. In line with the pedagogical lens through which this study is viewed, our findings resonate with the postulations set forth by Tuomi (2018) concerning the influence of artificial intelligence on instructional practices. Notably, the consequences for the conceptualization and creation of learning resources are reaffirmed. Additionally, there's a noticeable effect on the allocation of assignments and activities, coupled with the proactive guidance extended to learners: as elucidated in Tuomi's items 1, 3, 4, 6, 7, 8.

From a pedagogical perspective, when students undergo thorough instruction, they demonstrate ability to harness the potentialities offered by Artificial Intelligence. Nonetheless, it became evident that the role of the designer was absolutely essential to achieve a high-quality and non-trivial product. Given these insights, we underscore the importance of an experiential research methodology, rather than a purely theoretical stance, emphasizing the integration of AI within the pedagogical framework. This is especially pertinent in our context with Master's degree candidates, where the pedagogue's role evolves towards facilitating learners in their technological explorations. However, the study presented here is an ongoing project, and thus, the results remain preliminary. We plan to repeat the study in 2024-2025 academic year.

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Artificial intelligence in the education system: is quality in higher education compromised or enhanced? A systematic review of the literature

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Abstract

This systematic literature review examines the outcomes and impacts of strategies related to using artificial intelligence (AI) in the higher education system. The review draws upon a range of studies and articles that discuss the application of AI in higher education and its effects on the quality of education. The findings reveal that AI has the potential to enhance the quality of higher education by diversifying teaching roles, personalising learning modes, and introducing intelligent and adaptive teaching methods. However, the review also highlights the limitations and challenges of implementing AI in higher education. These challenges include establishing the limits of AI and technology, addressing the digital divide, and ensuring proper academic training and support. The review emphasises the importance of understanding the scope and implications of AI in higher education to guide the development of effective strategies and policies. Overall, the review provides insights into the outcomes and impacts of AI in transforming higher education, shedding light on the opportunities and challenges arising from its implementation. This systematic literature review investigates the impact of integrating artificial intelligence (AI) into the education system, specifically focusing on its potential to compromise or enhance the quality of higher education. Through a comprehensive analysis of existing research, this review examines the challenges, benefits, and implications of AI-driven educational technologies in higher education contexts. By synthesising findings from various studies, the review seeks to provide insights into the multifaceted relationship between AI and educational quality in higher education.

Keywords: Artificial Intelligence, Education System, Higher Education, Quality, Learning Outcomes, Student Engagement.

1. Introduction

Integrating artificial intelligence (AI) into the education system has generated significant interest and debate (Alghamdi, 2022). According to Deng et al. (2022), AI-driven technologies promise to revolutionise higher education by offering personalised learning experiences, automating administrative tasks, and improving instructional delivery. However, concerns persist about the potential trade-offs between the efficiency gains and the quality of education. This systematic literature review explores AI's dual role in higher education – whether it compromises or enhances educational quality. By analysing the existing body of research, this review seeks to uncover the nuanced relationship between AI and quality in the higher education landscape.

Kharbat et al. (2020) posit that in the era of artificial intelligence, higher education will show the development trend of diversification of academics' roles, the intelligence of teaching mode, personalisation of learning mode, diversification of teaching evaluation, and openness of education ecology (Zhang, 2023). This paper mainly discusses the current application of artificial intelligence in higher education, its influences on the higher education system, and AI's limitations in this field (Zhang, 2023). It is proposed that higher education has reached a historical juncture where change is needed (Zhang, 2023). The pedagogical implications of emerging technologies' impact on how students learn and how higher education is changing are examined, including how AI can automate instructional practices (Slimi, 2022).

Artificial intelligence is applied in higher education and ensures the continuity of learning in crises and emergencies to support pervasive access (Slimi, 2022). AI has witnessed significant growth in

the region to improve the productivity of learning quality (Slimi, 2022). Previous studies have revealed artificial intelligence in higher education in different aspects and majors (Slimi, 2022). Advancements in artificial intelligence have brought new possibilities and challenges for teaching and learning in higher education, which have the potential to fundamentally alter the governance and internal architecture of higher education institutions (Lucena et al., 2019; Alghamdi, 2022). The importance of artificial intelligence (AI) and adaptive learning technology systems (ALTS) in education cannot be overstated (Singh & Hiran, 2022). Many people have misunderstood or are afraid of AI's power, which will require a fundamental shift in the definition of expertise and the nature of teaching and learning (Singh & Hiran, 2022).

According to Bearman et al. (2022), artificial intelligence is an emerging technology that creates computational systems that present intelligent and adaptive behaviours that can learn from their environment, just like humans (Lucena et al., 2019). Reports of global relevance predict that artificial intelligence will be implemented in higher education within four to five years (Lucena et al., 2019). Artificial intelligence applied to higher education is a reality, and beneficial results are being obtained (Lucena et al., 2019). A qualitative research study discussed the potential effects of artificial intelligence on higher education at Prince Sattam Bin Abdulaziz University (Aldosari, 2020). The study showed a decreased awareness of the mechanisms of applying artificial intelligence and the need to further spread awareness in the Saudi environment on the possibilities of using artificial intelligence applications in education (Aldosari, 2020; Gorriz et al., 2020). The use of artificial intelligence in Saudi universities is encouraged. Recommendations include teaching faculty members how to use artificial intelligence in the classroom, emphasising the benefits of implementing AI for educational leaders, offering AI tools, programs, and technical support, as well as offering faculty members incentives and promoting scientific research in the area of AI in higher education (Alenezi, 2023).

Artificial intelligence approaches are being studied to enhance the quality of teaching and learning to change the basic design of higher education institutions significantly (Kshirsagar et al., 2022). The application of the new generation of artificial intelligence in higher education is becoming more extensive (Deng et al., 2022). Colleges need to continuously reform the system and mechanism of academic training and establish new forms such as "Internet + training" and "artificial intelligence + teaching" to promote the deep integration of nextgeneration artificial intelligence technology and training content (Deng et al., 2022). Artificial intelligence has entered people's lives in physical or virtual forms such as intelligent assistance, robots, etc. Technologies like deep learning, big data processing, and face recognition will change college education management (Yu, 2021). Artificial intelligence will make education management more forward-looking, promote the digitalisation, transparency, and management rationality of education management, and reconstruct the education management supervision and correction system (Yu, 2021). Artificial intelligence methods face challenges under different practical operating conditions, but they have potential applications in the family health education public service system (Zhao & Fu, 2022). The rapid development of a new generation of artificial intelligence technology has significantly impacted traditional physical education's content, mode, method, and system (Zhang & Fu, 2022).

Hence, this study explores the emergence of AI in higher education to establish the influence of AI on the quality of education in higher education.

Thus, this study is guided by the following research questions:

- What are the challenges associated with integrating AI into the higher education system?
- How does AI enhance the quality of education in higher education institutions?
- What are the potential risks and concerns related to the impact of AI on educational quality?

2. Literature review: Artificial Intelligence in Higher Education

This systematic review presents a comprehensive examination of the impact of artificial intelligence (AI) in higher education (HE) from 2016 to 2022. The review follows the PRISMA principles and protocol and analyses 138 articles (Lucena et al., 2019). The data from these articles were extracted, analysed, and coded using a priori and grounded coding methods. The study's findings reveal a significant increase in the number of publications on AI in HE in 2021 and 2022 compared to previous years (Zhang, 2023). The rise in the number of AI in HE publications indicates the emergence of new trends in the field (Bozkurt et al., 2021; Zhang & Xu, 2022). One of the trends identified is the diversification of academics' roles and the intelligence of teaching modes. AI technologies enable personalised learning experiences, adaptive learning, and diversifying teaching evaluation methods. These advancements contribute to developing a more open and personalised education ecology (Zhang, 2023). Another trend highlighted in the literature is the automation of administrative tasks and intelligent tutoring systems.

AI can automate routine administrative tasks, allowing academics to focus on more meaningful student interactions. Intelligent tutoring systems can provide personalised feedback and support to students, enhancing the learning experience (Bearman et al., 2022; Zhang, 2023). The impact of AI on teaching and learning in higher education is also discussed in the literature. AI technologies can potentially revolutionise how students learn, and higher education institutions operate. With the adoption of AI, students can have more flexibility in their learning, personalised feedback on assignments, and access to scalable and affordable learning resources (Singh & Hiran, 2022). However, the implementation of AI in higher education also presents challenges. One of the challenges is the need for academics to acquire the necessary skills to effectively integrate AI into their teaching practices (Chaka, 2022; Zhang et al., 2022). Academics must adapt to new technologies and understand how to leverage AI to enhance the learning experience (Deng et al., 2022).

Ethical considerations are also raised in the literature. AI in higher education raises concerns about data privacy and algorithmic bias. It is essential to ensure that AI is used responsibly and ethically to avoid potential negative consequences (Alghamdi, 2022; Zhang, 2022). Furthermore, there may be disparities in adopting and implementing AI in higher education institutions. The scientific production on the application of AI in higher education has yet to be consolidated, indicating potential inequalities in access to AI-enabled education (ZawackiRichter et al., 2019; Chaka, 2022).

In conclusion, the systematic review of the literature on AI in higher education provides valuable insights into the potential benefits and challenges associated with its implementation. AI can enhance the quality of education through personalised learning, automation of administrative tasks, and innovative teaching methods. Deng et al. (2022) argue that there are challenges related to academic readiness, ethical considerations, and potential inequalities in access to AI-enabled education. Yu (2021) avows that it is crucial to address these challenges and ensure that AI is used responsibly to enhance the overall quality of higher education.

Yao (2022) asserts that AI can be considered to enhance the quality of education based on its usage. If academics, students, and administrators perceive AI tools as valuable, they might positively impact various aspects of education. For instance, AI-supported analytics can offer insights into student performance and engagement, enabling timely interventions to enhance learning outcomes. AI's ability to provide personalised recommendations for learning resources can enhance the educational experience (Hannan & Liu, 2021). However, Jaguga and Kwobah (2020) report that AI can compromise quality if not used appropriately. Thus, if AI technologies are perceived as too complex or must be aligned with existing teaching practices, they might lead to academic frustration and resistance (Lucena et al., 2019). Moreover, ethical concerns related to AI's role in assessment, data privacy, and bias could compromise the quality of education if not adequately addressed.

It is important to note that the impact of AI on educational quality is not solely determined by TAM factors (Go et al., 2020). Other considerations, such as the quality of AI algorithms, alignment with pedagogical principles, ethical safeguards, and practical implementation strategies, also play

pivotal roles (Kim et al., 2022). Applying the Technology Acceptance Model to AI in higher education can provide insights into whether the quality of education is compromised or enhanced (Go et al., 2020; Yang et al., 2021). When AI technologies are perceived as valuable and easy to use, they have the potential to enhance educational quality by providing personalised learning experiences, data-driven insights, and administrative efficiency (Slimi, 2022). Conversely, challenges related to complexity, ethics, and alignment with existing practices could compromise the quality of education. The nuanced interplay of these factors ultimately determines AI's net impact on educational quality in higher education settings (Winkler-Schwartz et al., 2019; Mospan et al., 2022).

3. Theoretical framework

The Technology Acceptance Model (TAM) is a theoretical framework that can be applied to understand the acceptance and adoption of technology in various contexts, including higher education (Go et al., 2020). TAM posits that technology's perceived usefulness and ease of use are critical determinants of its acceptance and subsequent usage. In the context of AI in higher education, TAM can help assess whether the quality of education is compromised or enhanced based on academics' perceptions of the usefulness and ease of use of AI technologies. According to Zawacki-Richter et al. (Shukla et al., 2019; Zawacki-Richter et al., 2019), academics in higher education still need to be aware of how to utilise AI technologies and their pedagogical advantages effectively. Go et al. (2020) argue that this uncertainty can influence their perceptions of the usefulness of AI in enhancing the quality of education. TAM suggests that if academics perceive AI technologies as valuable tools that can improve teaching and learning outcomes, they are more likely to accept and adopt them. Therefore, if academics perceive AI technologies as beneficial in enhancing personalised learning, providing adaptive systems, or improving assessment and evaluation processes (Zawacki-Richter et al., 2019), higher education quality can be enhanced.

However, the lack of longitudinal studies and the predominance of descriptive and pilot studies on AI in higher education Zawacki-Richter et al. (2019) indicate that academics still need to conduct innovative research and practice with AI technologies. TAM suggests that the ease of use of a technology is another important factor influencing its acceptance. If academics find AI technologies easy to use and integrate into their teaching practices, they are more likely to adopt them. Therefore, the ease of use of AI technologies in higher education can play a crucial role in determining whether the quality of education is compromised or enhanced. Furthermore, AI's ethical and educational implications in higher education should be considered. ZawackiRichter et al. Zawacki-Richter et al. (2019) highlight the need for critical reflection on the challenges and risks of AI in education and the connection to theoretical pedagogical perspectives. TAM suggests that academics' perceptions of the ethical implications and alignment with pedagogical theories can influence their acceptance and adoption of AI technologies. Suppose academics perceive AI technologies as ethically sound and aligned with pedagogical principles. In that case, they are more likely to accept and integrate them into their teaching practices, potentially enhancing the quality of education.

Integrating AI technologies with learning analytics can improve higher education quality (Ouyang et al., 2023). Ouyang et al. Ouyang et al. (2023) emphasise integrating AI prediction models with in-time feedback to improve students' learning quality. TAM suggests that if academics perceive AI technologies as effective in providing timely and appropriate feedback to academics and students, they are more likely to accept and adopt these technologies (Go et al., 2020). Therefore, integrating AI and learning analytics can enhance the quality of education in higher education. In conclusion, the Technology Acceptance Model (TAM) provides a theoretical framework for understanding the acceptance and adoption of AI technologies in higher education. TAM suggests that academics' perceptions of the usefulness and ease of use of AI technologies and their alignment with ethical and pedagogical principles can influence their acceptance and subsequent usage. If academics perceive AI technologies as helpful, easy to use, ethically sound, and aligned with pedagogical theories, higher education quality can be enhanced. However, the

lack of longitudinal studies and the need for further exploration of ethical and educational approaches in the application of AI in higher education indicate areas for future research and practice (Zawacki-Richter et al., 2019).

3.1 Justification for the Technology Acceptance Model in this study

The Technology Acceptance Model (TAM) is a suitable theoretical framework for studying the acceptance and adoption of AI in higher education. Several studies support the use of TAM in the context of AI and technology acceptance in various fields, including hospitality and tourism (Go et al., 2020; Salas-Pilco & Yang, 2022), intelligent education technology (Siripipatthanakul et al., 2022) and AI-enabled voice assistants (Cai et al., 2022). These studies demonstrate the applicability and effectiveness of TAM in understanding users' perceptions and intentions to use advanced technologies. Go et al. (2020) emphasise the importance of examining the perceived interactivity of technology, which aligns with TAM's focus on perceived usefulness and ease of use. They argue that perceived interactivity becomes crucial in technology acceptance models as technologies improve and become more interactive. This aligns with TAM's emphasis on technology's perceived usefulness and ease of use.

Furthermore, Go et al. (2020) highlight the extensive use of TAM and its extended versions, such as the Unified Theory of Acceptance and Use of Technology (UTAUT), in explaining and predicting consumers' technology acceptance behaviour. This demonstrates TAM's widespread acceptance and recognition as a reliable model for understanding technology acceptance. The application of TAM in the context of AI in higher education is also supported by (Bozkurt et al., 2021), who discuss the use of AI in education and identify adaptive learning and personalisation of education as key research themes. These themes align with TAM's focus on the perceived usefulness of technology in enhancing personalised learning experiences. Additionally, Siripipatthanakul et al. (2022) apply TAM in the context of intelligent education technology. Their study supports the TAM model, comprising perceived ease of use and usefulness. They also find that student satisfaction significantly mediates between the TAM model and the intention to use intelligent education technology.

Moreover, Cai et al. (2022) extend TAM to the context of AI-enabled voice assistants in hotels. Their study proposes an integrative model of the brand of AI-enabled voice assistants and customers' perceptions and behavioural intentions of using AI-EVA in hotels. They examine the moderating effects of construal levels and hotel scales. Finally, Hannan Liu Hannan & Liu (2021) survey the current landscape of AI applications in higher education institutions (HEIs) and recommend future directions. They highlight successful applications of AI technologies in three main areas of college operation: student learning experience, student support, and enrolment management. Overall, the extant studies provide evidence that TAM is a suitable theoretical framework for studying the acceptance and adoption of AI in higher education. TAM's focus on perceived usefulness, ease of use, and the role of user satisfaction aligns with the key factors influencing technology acceptance in the context of AI in higher education. By applying TAM, researchers can gain insights into users' perceptions, intentions, and behaviours related to AI adoption in higher education (Popenici & Kerr, 2017; Rutner & Scott, 2022).

4. Research methodology

This study systematically reviews various literature sources on AI in higher education. The study applies PRISMA in a systematic review of appropriate and in-depth literature. The researcher employs a search strategy in which a systematic search was conducted across academic databases (e.g., PubMed, IEEE Xplore, ERIC) using keywords related to AI, education, and quality in higher education (Moher et al., 2015). The inclusion criteria covered peer-reviewed articles, reports, and studies discussing the impact of AI on higher education quality published from the inception of AI in education till the present (Belur et al., 2018). Screening and selection considered titles and abstracts to identify relevant studies. Selected articles were subjected to full-text review based on their alignment with the research questions (Moher et al., 2015; Gough et al., 2017).

Data extraction and synthesis involved a structured data extraction form to capture critical information from selected studies, including methodologies, findings, and insights (Page et al., 2021). Thematic analysis was adopted to identify common themes and patterns across the literature (Saldana, 2015; PRISMA, 2021).

5. Results and discussion

The findings will be presented coherently, focusing on challenges, benefits, and potential concerns associated with AI integration in higher education. The discussion will critically analyse the implications of these findings for the quality of education, considering both positive contributions and possible drawbacks of AI-driven interventions.

5.1 Challenges associated with integrating AI into the higher education system

Integrating AI into the higher education system presents several challenges that must be addressed. These challenges are supported by various studies, including (Alasadi, 2023 Xu & Ouyang, 2022 Rios-Campos et al., 2023 Cheng et al., 2020; Asatryan & Matevosyan, 2023 Shirin, 2022; Lainjo & Tsmouche, 2023; Akinwalere & Ivanov, 2022; Ilan, 2020; Charow et al., 2021). The challenges associated with integrating AI into higher education are multifaceted; AI's ethical implications in higher education must be carefully examined. This includes issues related to data privacy, algorithmic bias, and the responsible use of AI technologies (Alasadi, 2023). Also, Academics may require training and professional development to integrate AI technologies into their teaching practices effectively. This includes developing the necessary skills and knowledge to use AI tools and platforms (Shirin, 2022).

The successful integration of AI in higher education requires adequate technological infrastructure and resources. This includes access to high-speed internet, computing power, and AI tools and platforms (Cheng et al., 2020; Chu et al., 2022; Xu & Ouyang, 2022; Lainjo & Tsmouche, 2023). Furthermore, ensuring equitable access to AI technologies and addressing potential disparities in access is crucial. This includes considering the digital divide and ensuring that AI-enabled education is accessible to all students, regardless of their background or resources (Asatryan & Matevosyan, 2023; Lainjo & Tsmouche, 2023). The integration of AI should align with pedagogical principles and educational goals. It is essential to consider how AI technologies can enhance teaching and learning experiences and support student engagement and achievement (Xu & Ouyang, 2022). Developing appropriate evaluation and assessment methods for AI-enabled education is a challenge. This includes determining how to measure the effectiveness and impact of AI technologies on student learning outcomes (Xu & Ouyang, 2022; Rios-Campos et al., 2023; Charow et al., 2021).

In addition, the acceptance and adoption of AI technologies in higher education may vary across cultural and social contexts. It is essential to consider cultural norms, values, and attitudes towards AI in educational settings (Shirin, 2022; Cheng et al., 2020). Thus, addressing these challenges requires collaboration among stakeholders, including academics, administrators, policymakers, and researchers. Engaging in ongoing research, professional development, and dialogue is essential to ensure the responsible and effective integration of AI technologies in higher education.

5.2 Contributions of AI to enhance the quality of education in higher education institutions

Integrating artificial intelligence (AI) into higher education institutions can significantly enhance education quality (Go et al., 2020). Several studies highlight the contributions of AI in improving teaching and learning processes, personalising education, and facilitating administrative tasks (Go et al., 2020; Hannan & Liu, 2021; Kim et al., 2022). The contributions of AI to enhance the quality of education in higher education institutions have been established by various studies (Mospan et al., 2022; Ouyang et al., 2023).

AI technologies can analyse vast amounts of data to provide personalised learning experiences for students (Bozkurt et al., 2021; Asatryan & Matevosyan, 2023). By leveraging machine learning algorithms, AI can adapt instructional content, pace, and feedback to individual students' needs and preferences (Bozkurt et al., 2021). This personalised approach enhances student engagement, motivation, and learning outcomes (Peng, 2023). AI-powered intelligent tutoring systems can provide personalised guidance and support to students, offering immediate feedback and adaptive learning pathways (Bozkurt et al., 2021; Asatryan & Matevosyan, 2023). These systems can identify students' strengths and weaknesses, diagnose misconceptions, and provide targeted interventions (Bozkurt et al., 2021). Intelligent tutoring systems have improved student performance and knowledge retention (Song et al., 2022).

AI technologies can assist academics in developing and delivering high-quality instruction. AIpowered tools can automate administrative tasks, such as grading and feedback generation, allowing academics to focus more on instructional design and student interactions (Asatryan & Matevosyan, 2023). AI can also provide data-driven insights to help academics identify areas for improvement and optimise their teaching strategies (Slimi, 2022). AI can analyse large datasets generated by students' interactions with learning platforms and provide valuable insights into their learning progress and performance (Bozkurt et al., 2021; Corsello & Santangelo, 2023). AI-powered learning analytics can identify patterns, trends, and correlations in student data, enabling academics to make data-informed decisions and interventions (Li & Su, 2020). This data-driven approach enhances the effectiveness of educational interventions and supports evidence-based decision-making (Corsello & Santangelo, 2023).

AI technologies can streamline administrative tasks in higher education institutions, such as enrollment management, scheduling, and resource allocation (Lainjo & Tsmouche, 2023). AIpowered chatbots and virtual assistants can handle routine inquiries, freeing administrative staff time for more complex tasks (Bozkurt et al., 2021). This automation improves operational efficiency and allows staff to focus on more value-added activities. AI technologies can support research activities in higher education institutions. AI-powered tools can assist researchers in data analysis, literature review, and knowledge discovery (Corsello & Santangelo, 2023). AI can also facilitate collaboration and knowledge sharing among researchers, enabling interdisciplinary research and fostering innovation (Corsello & Santangelo, 2023). These advancements contribute to the generation of new knowledge and the advancement of research in various fields.

While AI technologies have the potential to address accessibility challenges and promote inclusivity in higher education (Lukianets & Lukianets, 2023), AI-powered tools can provide accommodations for students with disabilities, such as speech recognition for students with hearing impairments or text-to-speech for students with visual impairments (Asatryan & Matevosyan, 2023). AI can also support multilingual education and facilitate language learning for international students (Slimi, 2022). AI offers significant contributions to enhancing the quality of education in higher education institutions; it is essential to address the associated challenges, such as ethical considerations, faculty readiness, and infrastructure requirements (Bozkurt et al., 2021; Lainjo & Tsmouche, 2023). Additionally, ongoing research, collaboration, and professional development are essential to ensure the responsible and effective integration of AI technologies in higher education (Lainjo & Tsmouche, 2023).

Integrating AI technologies in higher education institutions can revolutionise teaching and learning processes, personalise education, improve administrative efficiency, and advance research and innovation. By leveraging AI, higher education institutions can provide tailored learning experiences, support academics in their teaching practices, and optimise administrative processes. However, it is crucial to address the challenges and ethical considerations associated with AI implementation to ensure its responsible and effective use in enhancing the quality of education.

5.3 The potential risks and concerns related to the impact of AI on educational quality

Integrating artificial intelligence (AI) in education brings potential risks and concerns that must be addressed. These risks and concerns are crucial to its adoption and use in higher education (Ouyang et al., 2023). AI in education involves collecting and analysing large amounts of data,

including personal and sensitive information (Akgun & Greenhow, 2021). There is a need to ensure that data privacy and security measures are in place to protect students' information from unauthorised access or misuse (Akgun & Greenhow, 2021). AI systems can be susceptible to biases in the data they are trained on, leading to discriminatory outcomes (Akgun & Greenhow, 2021). If AI algorithms are not carefully designed and monitored, they may perpetuate existing biases and educational inequalities (Akgun & Greenhow, 2021). While AI technologies can enhance certain aspects of education, there is a concern that excessive reliance on AI may reduce opportunities for human interaction and personalised support (Schiff, 2020). The social and emotional aspects of learning may be compromised if students primarily interact with AI systems instead of human academics and peers (Schiff, 2020).

The use of AI in education raises ethical considerations, such as the responsibility and accountability for decisions made by AI systems (Nguyen et al., 2022). There is a need to ensure transparency, explainability, and fairness in AI algorithms and decision-making processes (Nguyen et al., 2022). Academic Training and Professional Development: Integrating AI in education requires academics to have the necessary skills and knowledge to effectively use and integrate AI technologies into their teaching practices (Akgun & Greenhow, 2021). There is a need for comprehensive academic training and professional development programs to ensure academics are prepared to leverage AI in education (Akgun & Greenhow, 2021). Adopting AI in education should not exacerbate existing inequities in access to quality education (Lainjo & Tsmouche, 2023). There is a concern that AI technologies may widen the digital divide and create disparities in access to AI-enabled educational resources and opportunities (Lainjo & Tsmouche, 2023).

There is a risk of overreliance on AI technologies needing to critically evaluate their effectiveness and impact on educational outcomes (Yu, 2021). It is essential to balance the use of AI and the preservation of human judgment, critical thinking, and creativity in education. Addressing these risks and concerns requires a multidisciplinary approach involving academics, policymakers, researchers, and technology developers establishing clear ethical guidelines, ensuring data privacy and security, promoting transparency and fairness in AI algorithms, and providing ongoing training and support for academics in using AI technologies responsibly (Zawacki-Richer et al., 2019). Additionally, regular monitoring and evaluation of AI systems in educational settings are necessary to identify and mitigate potential risks and concerns.

It is crucial to address the risks and concerns associated with its implementation. By addressing privacy, bias, ethical, and equity considerations and ensuring appropriate academic training and professional development, the integration of AI in education can be done responsibly and beneficially (Zhang, 2023).

5.4 Strategies to use AI for quality education among students of higher education institutions

AI has been argued to benefit teaching and learning in higher education. AI can be used to develop adaptive learning systems that personalise education based on individual student needs and preferences (Bozkurt et al., 2021). By analysing student data and behaviour, AI algorithms can provide tailored learning experiences, identify areas of improvement, and offer personalised feedback (Bozkurt et al., 2021). AI technologies, such as deep learning and machine learning, can be utilised to enhance online learning processes (Bozkurt et al., 2021). These algorithms can analyse large amounts of data to identify patterns, make predictions, and provide intelligent student recommendations (Bozkurt et al., 2021). AI can be applied in Medicine and healthcare education to improve clinical decision-making, enhance medical education, and facilitate faster drug development (Corsello & Santangelo, 2023). AI algorithms can analyse medical data, diagnose, and provide evidence-based treatment recommendations (Corsello & Santangelo, 2023). It is important to critically reflect on the challenges and risks of AI in education and consider ethical and educational approaches in its application (Bozkurt et al., 2021). This includes addressing bias, fairness, safety, security, and overreliance on technology (Corsello & Santangelo, 2023).

AI can be used for quality assessment in education, including evaluating online teaching quality and student performance (Li & Su, 2020). Additionally, AI-based tutoring systems can provide personalised support and guidance to students, helping them improve their learning outcomes (Li

& Su, 2020). While implementing AI in education, it is crucial to address equity and inclusion concerns (Lainjo & Tsmouche, 2023). Efforts should be made to ensure that AI-based learning does not deepen existing divides and inequalities and that disadvantaged individuals are not marginalised from AI-based learning (Lu et al., 2021; Lainjo & Tsmouche, 2023). As AI relies on data, it is vital to prioritise cybersecurity and protect student data privacy (Lainjo & Tsmouche, 2023). Robust security measures should be in place to safeguard sensitive information and ensure compliance with data protection regulations. Academic Awareness and Training: Academics should receive awareness and training on AI applications in education (Swamy, 2023). This will enable them to effectively integrate AI technologies into their teaching practices and leverage the benefits of AI for student learning.

Strategies to use AI for quality education in higher education institutions include adaptive learning and personalisation, deep learning and machine learning algorithms, improved clinical decision-making and medical education, ethical considerations and critical reflection, quality assessment and personalised tutoring, addressing equity and inclusion, cybersecurity and data privacy, and academic awareness and training. By implementing these strategies, higher education institutions can harness the potential of AI to enhance the quality of education and improve student learning outcomes.

6. Recommendations on quality use of AI in higher education

Recommendations have been made on the effective use of AI to sustain or attain quality education in higher education. These are:

Personalised Learning: AI can be used to develop personalised learning experiences for students by analysing their individual learning needs, preferences, and progress (Li & Su, 2020). AI algorithms can adapt instructional content, pace, and feedback to optimise learning outcomes for each student (Li & Su, 2020). Implementing AI-powered adaptive learning platforms can provide students with tailored educational experiences.

Intelligent Tutoring Systems: AI-powered intelligent tutoring systems can provide personalised guidance and support to students, offering immediate feedback and adaptive learning pathways (Li & Su, 2020). These systems can diagnose students' strengths and weaknesses, provide targeted interventions, and track their progress over time (Li & Su, 2020). Intelligent tutoring systems can enhance students' understanding and mastery of complex subjects.

Data-Driven Decision-Making: AI can analyse large datasets generated by students' interactions with learning platforms and provide valuable academic insights (Wang & Zheng, 2020). By leveraging AI-powered learning analytics, academics can identify patterns, trends, and correlations in student data, enabling them to make data-informed decisions and interventions (Wang & Zheng, 2020). This data-driven approach can enhance instructional strategies and improve student outcomes.

Virtual Reality and Augmented Reality: AI technologies, combined with virtual reality (VR) and augmented reality (AR), can create immersive and interactive learning experiences (Wang & Zheng, 2020). VR and AR can simulate real-world scenarios, allowing students to engage in hands-on learning and problem-solving activities (Wang & Zheng, 2020). Integrating AI with VR and AR technologies can enhance students' understanding and retention of complex concepts.

Intelligent Content Creation: AI can assist academics in creating high-quality educational content (Rios-Campos et al., 2023). Natural language processing algorithms can generate automated feedback, summaries, and explanations for students (Rios-Campos et al., 2023). AIpowered content creation tools can save academics time and effort in developing instructional materials, allowing them to focus on pedagogical strategies and student engagement.

Adaptive Assessment and Feedback: AI can automate the assessment process by analysing student responses and providing immediate feedback (Wang & Zheng, 2020). Adaptive assessment systems can dynamically adjust the difficulty and type of questions based on students' performance, ensuring a personalised and challenging learning experience (Wang &

Zheng, 2020). AI-powered assessment tools can provide timely and targeted feedback to students, promoting self-reflection and improvement.

Intelligent Course Design: AI can assist in designing and optimising course structures and curricula (Gray et al., 2022). By analysing student data and learning outcomes, AI algorithms can identify areas for improvement and suggest modifications to course content and delivery methods (Gray et al., 2022). AI can also help identify gaps in students' knowledge and recommend additional resources or activities to enhance their learning experience.

Support for Students with Special Needs: AI technologies can provide support for students with special needs, such as those with visual or hearing impairments (Liang et al., 2021; KocJanuchta et al., 2022; Asatryan & Matevosyan, 2023). AI-powered tools can offer real-time captioning, speech recognition, and text-to-speech capabilities, ensuring equal access to educational materials and opportunities (Asatryan & Matevosyan, 2023). Implementing AIbased accessibility solutions can create an inclusive learning environment for all students (Li et al., 2021).

Ethical Considerations and Responsible AI Use: It is crucial to address ethical considerations and ensure responsible AI use in education (Lainjo & Tsmouche, 2023). Academics and institutions should establish guidelines and policies for the ethical use of AI, including data privacy, algorithmic transparency, and fairness (Lainjo & Tsmouche, 2023). Promoting ethical awareness and digital citizenship among students is also essential.

Continuous Professional Development: Academics should receive ongoing training and professional development opportunities to enhance their AI literacy and pedagogical skills (Gray et al., 2022; Kim et al., 2022). Institutions should provide resources and support for academics to learn about AI technologies, understand their potential applications, and effectively integrate them into their teaching practices (Kharbat et al., 2020; Gray et al., 2022).

Gorriz et al. (2020) assert that leveraging AI technologies in higher education institutions can enhance the quality of education by providing personalised learning experiences, intelligent tutoring, data-driven decision-making, immersive learning environments, and adaptive assessment and feedback. However, Gupta and Chen (2022) opine that it is crucial to address ethical considerations, provide continuous professional development for academics, and ensure responsible AI use to maximise the benefits of AI in education.

7. Conclusion

In conclusion, integrating Artificial Intelligence (AI) into higher education is a complex and multifaceted phenomenon that prompts a critical examination of its potential impacts on the quality of education. This systematic literature review has illuminated the diverse perspectives on whether AI can compromise or enhance the quality of education within the higher education landscape. The findings reveal that AI's influence on educational quality is not inherently positive or negative; instead, it is contingent upon many factors, including the context of implementation, the design of AI-driven systems, and the readiness of educational institutions to adapt to these innovations. On one hand, AI-powered technologies have shown great promise in augmenting student engagement, personalising learning experiences, and streamlining administrative tasks. These advancements have the potential to positively transform the learning environment and enable academics to focus more on individualised instruction and meaningful interactions. However, the review also underscores the existence of challenges and concerns. The potential for AI to inadvertently perpetuate bias, reduce human interaction, and create dependency on technology warrants careful consideration. The "black-box" nature of some AI algorithms and the need for robust data privacy measures present areas of caution. Moreover, the shift towards automated assessments and personalised learning experiences raises questions about students' broader development of critical thinking, creativity, and social skills.

Ultimately, whether AI compromises or enhances the quality of higher education is balanced. Instead, it highlights the need for a balanced approach considering both AI integration's advantages and potential pitfalls. The educational community, including institutions, academics, policymakers, and students, must collaboratively shape the trajectory of AI in education, focusing

on maximising its benefits while mitigating its risks. As the landscape of higher education continues to evolve, it is imperative to maintain a critical stance on the role of AI. The ongoing dialogue surrounding ethical considerations, data security, and the holistic development of students will guide the responsible adoption of AI technologies. Ultimately, pursuing enhanced educational quality through AI necessitates a judicious application that respects the intrinsic value of human expertise and interaction.

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The world of Artificial Intelligence in Higher Education: a systematic review about the ethical challenges. A foundation for action

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Abstract

Artificial intelligence (AI) is becoming part of our daily lives. The educational field is not immune to this change, coming to terms with new tools and technologies more and more introduced into learning and teaching processes. Higher Education (HE) is currently facing interesting and controversial challenges. Potential for AI applications is noted, but deep concerns related to the ethical dimension are also raised. Given the necessary urgency of responding appropriately to a revolution already underway, a systematic review is conducted starting from the question "What ethical concerns emerge from recent research related to the use of AI in Higher Education?". Materials are analyzed following the Preferred Reporting Items for Systematic Reviews and MetaAnalyses (PRISMA) drawing from Scopus, ERIC, and Web of Science databases. The findings reveal key ethical challenges in the use of AI in HE, highlighting privacy, equity, academic integrity, impact on learning, job displacement, and transparency as central concerns. A demand for more care and awareness in the research in this field emerges. Manifolds are the possible solutions that can address the various ethical challenges: the proposal for AI literacy programs, AI best practices guidelines, and regulatory policies using technology in HE are emphasized. The study provides an overview of ethical issues discussed up to date in the world of practice and research. It becomes an opportunity to open spaces for reflection that can be a significant starting point for evaluating the implementation of AI, to design and take wise and innovative actions within education.

Keywords: AI Ethics, AI Literacy, Higher Education, Academic Integrity.

1. Introduction

Artificial Intelligence (AI) has emerged as a transformative technology, reshaping interactions between individuals, organizations, and technology across numerous aspects of daily life. It is a crucial innovation embedded in everyday routines and industrial processes, with rapid advancements that promise significant impacts across sectors, from advanced industries to daily life, constantly reshaping experiences and augmenting capabilities (Ramírez & Islam, 2024). AI's influence is evident in various domains, including transportation, healthcare, and finance. In transportation, AI plays a key role in developing smart cities, autonomous vehicles, and intelligent traffic management systems, optimizing logistics and predictive capabilities (Ping et al., 2024; Bibri et al., 2024). In healthcare, AI improves diagnostic accuracy, facilitates personalized treatments, and enhances service delivery (Kasula, 2024). In finance, AI has transformed risk assessment, fraud detection, and algorithmic trading, resulting in improved security and optimized operations. Large language models (LLMs), integrating machine learning (ML), deep learning (DL), and natural language processing (NLP), efficiently process extensive datasets. This enables swift, accurate data analysis, generating market intelligence that drives investments and revenue growth crucial for businesses (Bahoo et al., 2024). AI further supports tailored, scalable marketing strategies by analyzing customer data to refine targeted engagement, offering businesses a competitive edge (Bialkova, 2024). As a key feature of the Fourth Industrial Revolution, AI enhances energy efficiency, cost-effectiveness, and operational safety, supporting processes in various industries, including food, drug discovery, and e-commerce, and extends to sectors like cosmetics, tourism, and environmental management (Malik et al., 2024). AI's presence

is also felt in daily life through virtual assistants such as Siri and Alexa, and smart home technologies that automate aspects like lighting, security, and climate control. AI-powered robots assist with tasks such as product ordering, while self-service portals provide navigation and alarm functionalities (Kondort & Cioc, 2024). These advancements reflect AI's deep integration into everyday experiences, enhancing convenience and fostering more dynamic user interactions (Oluwaseyi, 2024). AI's versatility spans numerous fields, employing technologies like robotics, big data, the Internet of Things, virtual and augmented reality, and computer vision (Rashid & Kausik, 2024).

The educational sector must adapt to advancements in AI, which are reshaping teaching and learning processes. AI is already used in education, driving a significant shift in pedagogical practices and learning environments. Its integration holds transformative potential, revolutionizing various aspects of education to address individual learning needs, enhance student engagement, and improve learning outcomes (Zawacki-Richter et al., 2019). AI-driven personalized learning surpasses traditional models by tailoring instruction to individual preferences, abilities, and learning pace, creating a more accessible and effective learning environment (Ayeni, 2024). AI enables personalized learning through adaptive content delivery, using algorithms to analyze student data and adjust content complexity to align with individual needs. Intelligent systems provide real-time feedback on assignments, helping students track their progress. Additionally, AI-based tutoring systems offer personalized guidance by simulating oneon-one tutoring experiences (Zawacki-Richter et al., 2019). Beyond individualized instruction, AI influences educational technologies like online platforms, virtual reality, and interactive tools, which enhance student engagement and skill development (Familoni & Onyebuchi, 2024). AI also automates administrative tasks, freeing educators to focus on personalized instruction and informing curriculum design through data analysis, identifying knowledge gaps for more relevant course content (Ivanashko et al., 2024).

The influence of AI on Higher Education (HE) is evident. Universities are benefiting from the opportunities offered by this new technology. AI has the potential to revolutionize the way they deliver education, and it can enhance teaching and learning experiences, streamline administrative processes, and open new revenue streams for the academic context. HE is currently facing interesting and controversial challenges involving both teachers and students (Aler et al., 2024). Great potential is noted, but deep concerns related to the ethical dimension are also raised (Vetter et al., 2024, Zeb et al., 2024). The ethical implications of AI applications in teaching and learning processes, as well as in administrative tasks, are considered and play a crucial role. They are essential to choosing if, when and how to use AI in the educational context (Williams, 2024). Addressing ethical dilemmas is imperative for responsible AI integration that upholds educational integrity and equity. The ethical challenges of AI applications in HE are multifaceted, encompassing issues of bias, privacy, and accountability. Biased algorithms can lead to discriminatory practices in admissions and grading, disproportionately affecting marginalized groups (Slimi & Villarejo Carballido, 2023). Additionally, the collection of sensitive student data raises significant privacy concerns, necessitating robust safeguards to protect personal information. Transparency in AI decision-making processes is crucial to ensure accountability and trust among stakeholders (Kumar et al., 2024).

Nowadays there is a strong and clear demand directed at the world of educators, teachers, policymakers, and researchers to experiment with AI but at the same time to take charge of the care of the ethical dimension (Bond et al., 2024). While the literature and the studies for AI applications are substantial and exhaustive, the ethical sphere remains a citation for further study. A superficial awareness of the existence of ethical implications is no longer sufficient, but it is now necessary to outline on which fronts special attention is required to then act responsibly (Aler et al., 2024).

Given the necessary attention to this issue and the urgency of responding appropriately to a revolution already underway, a systematic review is conducted starting from the question "What ethical concerns emerge from recent research related to the use of AI in Higher Education?".

2. Materials and Methods

The review question formulated circumscribes an investigable area of research and defines a theme around which the list of keywords for bibliographic research can be established (Ghirotto, 2020). The review question was formulated following the PICOC method, a tool that allows the consideration of five guiding criteria (P: Population; I: Intervention; Comparison; O: Outcome; C: Context) to develop a clear, specific, and well-defined question, thus facilitating subsequent research and analysis of available evidence (Booth et al., 2016).

1. What ethical concerns emerge from recent research related to the use of AI in Higher Education? This question was combined with two other questions aimed at comprehensively understanding the contexts being evaluated, how the characteristics of these contexts explicitly or implicitly contribute to framing the ethical dimension, and how it is possible to face this situation.
2. What are the characteristics of the contexts in which the ethical challenges are considered?
3. What are the directions for the present and the future?

To answer these research questions, a systematic review was used as the research methodology to collect all studies published from 2007 (Siri introduction) to 2024. A systematic review is a comprehensive protocol-based review and synthesis of data focused on a topic and key related questions (Ghirotto, 2020). It allows the collection of all empirical evidence that meets predefined eligibility criteria to answer a specific research question (Higgins et al., 2023). To conduct a rigorous and focused systematic review, it is essential to establish clear and detailed inclusion and exclusion criteria.

The target population of the systematic review consists of students, teachers, and administrators considered key stakeholder users (Hasanein & Sobaih, 2023). Concerning the intervention, practical applications of AI within the HE context as well as the collection of surveys and interviews related to stakeholders' learning and teaching experiences were analyzed. Regarding the results, studies reporting emerging considerations for the ethical dimension of intervention were included to understand how it is structured, what role it plays in HE practices, and what impact it has on present and future actions and behaviors. Concerning context, studies conducted exclusively within HE were analyzed.

Compared with the PICOC model, five additional criteria used to further refine the screening stage were added. First, the research method: empirical studies were included and contributions focused exclusively on theoretical aspects and literature reviews were excluded. For the type of contribution, only articles, or conference papers, sourced from journals and conference proceedings, accessible to researchers in full-paper versions through the databases available to them and published in peer-reviewed journals were included. Finally, studies published between 2007 and 2023, in Italian and English, were considered.

This review started on the 27th of November 2023 and ended on the 8th of April 2024. The string used was ("artificial intelligence" OR "artificial intelligences") AND "higher education" AND "ethic*. It was declined differently in relation to the procedural characteristics of the specific databases. Keywords have prioritized focusing on AI technologies, context, and the ethical element. The research domain is deliberately broad so that it can encompass results that represent a broad perspective, both in terms of the disciplines, people involved, and applications. Drawing from Scopus, ERIC, and Web of Science databases numerous results related to systematic reviews already conducted on the topic of interest are obtained. Hence, this study exclusively considers primary research, with meta-analyses serving as foundational material to construct theoretical and methodological frameworks. This approach enables a holistic understanding of the subject and by identifying the emerging literature gaps the study tries to leverage and cover them giving some possible perspectives, and new directions for future research and educational practice. The materials are analyzed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, Page et al., 2021). It is here in synthetic mode presented (Figure 1). The database search produced an initial sample of 417 submissions. Duplicates (9) and contributions that did not meet certain inclusion and exclusion criteria (201), such as year, document and

source type, and language, were excluded. Subsequently, the contributions not considered relevant in the screening phase, which was carried out by reading the title and abstract (68), were excluded. 139 contributions were entered into an Excel sheet structured as follows: year of publication, author(s), publication title, DOI/link, inclusion (yes/no), and exclusion criteria, if excluded. Figure 1 details the flow of contribution selection that led the researchers, after the identification, screening, and eligibility stages, to analyze a pool of 25 articles.

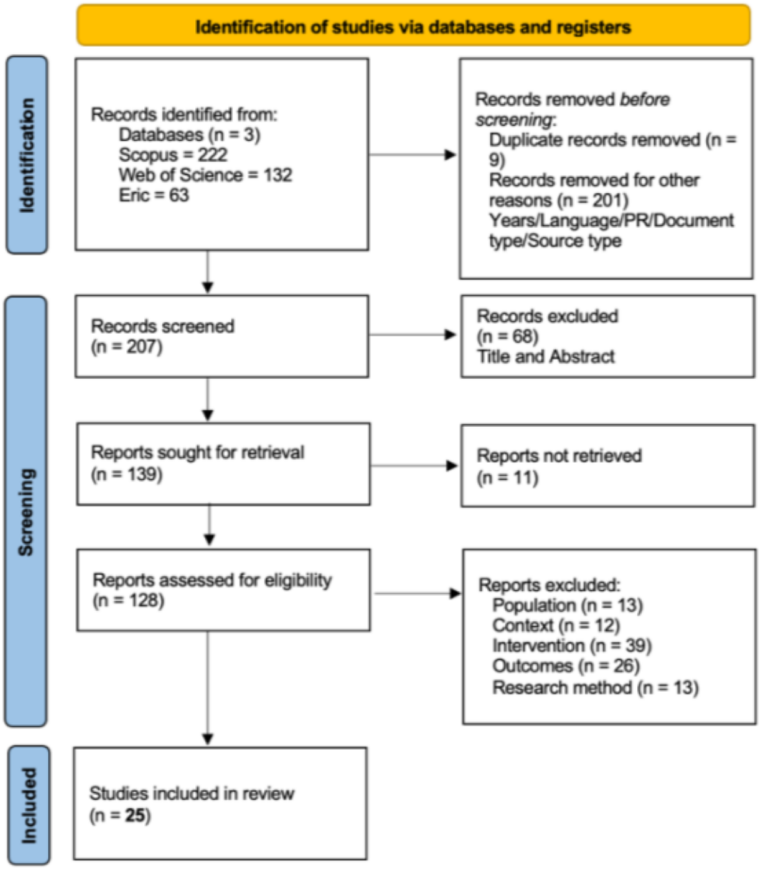


Figure 1 - PRISMA flow diagram.

To comprehensively identify and understand the significant information included in the studies considered, the researchers used a second Excel file to extract the key characteristics of the studies (Booth et al., 2016). Analytical macro and micro-categories considered are the following: the context (country, University, field, and degree course, definition of AI, type of AI), group (target group of the study, year, numbers of stakeholders involved), evaluation method (main objective of the study, research method, research tools for data gathering, research method of data analysis), emerging ethical challenges, implications, other important elements. Following the approach proposed by Sandelowski and Barroso (2006), the researchers read the contributions by extracting from the different sections the quotes useful for understanding the different areas of investigation. These quotes, inserted manually using the Excel sheet, were the subject of content analysis, a systematic process of comparison of the texts and analysis of the relative contents useful for returning a meticulous and accurate description of the phenomenon, highlighting its peculiarities (Elo and Kyngäs, 2008). This method is considered particularly appropriate for analyzing secondary textual or audio sources such as scientific publications (Harris, 2001). For this study, the content analysis, which can be circumscribed within the socio-constructivist paradigmatic framework, followed an inductive approach with a coding process functional to the development of categories and a theory capable of bringing to light the conceptual structure underlying the phenomenon under study (Elo & Kyngäs, 2008). Specifically, all the data entered into the categories above were subject to inductive content analysis.

Stemming from the preferred documents, preliminary findings and reflections are developed.

3. Results

3.1 Characteristics of the Contexts

This analysis categorizes the contexts of the 25 studies analyzed. The categorization is done through distinct themes, examining each through the lens of the multiple research studies included in the review. The thematic categorization helps to clarify the period, geographical, disciplinary, and methodological diversity of these studies, along with the specific types of AI discussed. This section aims to provide a comprehensive understanding of how different contexts shape the ethical discourse surrounding AI in HE, offering insights into the critical issues and potential directions for the future.

Year

The systematic review examined a variety of studies about AI in HE with a focus on the ethical dimension in a period of 17 years (from 2007 to 2024), analyzing data from 25 articles published only in the last four years. The relevant papers for the topic of the review belong to 2021, 2022, 2023 and 2024. In particular, in the year 2023 there is the largest number of articles included in the review (14), followed by year 2024 (7), then year 2022 (3), and with one single paper of year 2021.

This demonstrates a growing interest in the topic in recent years offering numerous studies and an absence of interest in previous years is hypothesized.

Geographical areas

The systematic review took into consideration multiple studies about AI in HE with a focus on the ethical dimension offered in different universities and countries, analyzing data from 25 articles from a wide range of geographical contexts, including Europe (e.g. Ukraine, Sweden), America (e.g. Canada, Peru), Asia (e.g. China, Thailand), Oceania (New Zealand, Australia). 4 studies are conducted globally, involving people from all over the world. In particular, the bar graph in Figure 2 shows that involving multiple countries is the preferred system for conducting this type of studies. Then China has the greatest number of papers included in the review, immediately followed by Finland and London. The other countries, although less represented, offer significant contributions that enrich the overall discourse. China's leading role in the number of papers, followed closely by London and Finland, indicates strong academic interest and activity in these regions. This could reflect factors like the rapid adoption of AI technologies in educational institutions, policy initiatives, or a proactive stance toward addressing ethical issues. This broad spectrum of geographical areas highlights a global interest in considering the ethical challenges posed by using AI in HE.

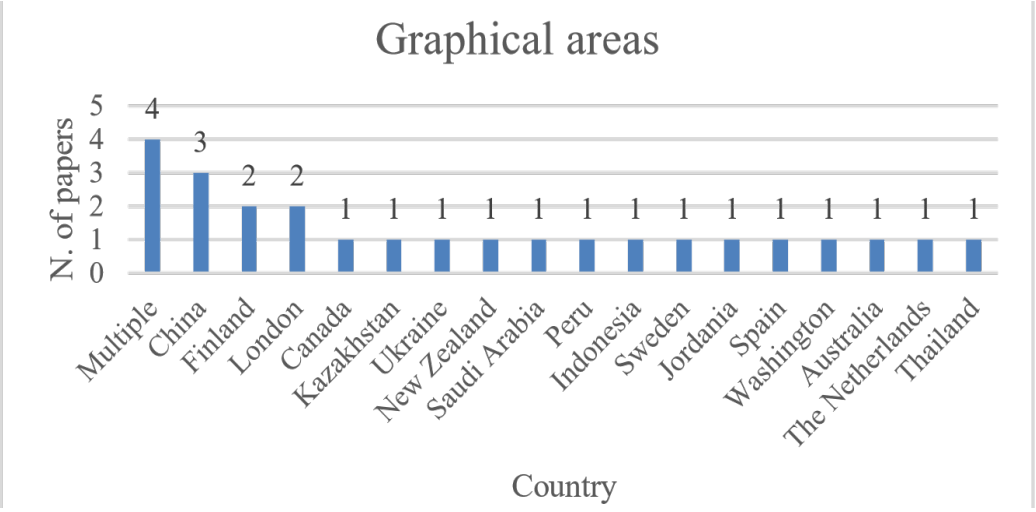


Figure 2 - Distribution of the AI's ethical challenges in HE traced in the articles of the systematic review.

People involved

The papers analyzed in this systematic review considered studies with different participants: only students, only teachers, students and teachers, and institutional stakeholders. This last category includes HE students, HE teachers, administrative staff, researchers, and institutional policymakers. In particular, studies with only students have the most papers (13), followed by the studies comprehending stakeholders (6). The studies with students and teachers and the studies with only teachers are less (4 – 2), but they are still significant. This distribution of the participants underlines attention to students' experience in the ethical dimension of AI and the intention to involve at the same time different perspectives to have a holistic and inclusive understanding of reality.

Disciplines

The systematic review examined a variety of studies about AI in HE with a focus on the ethical dimension conducted in different disciplines, analyzing 25 papers in which hard sciences, social/human sciences and multiple filed of studies are considered. In hard sciences the faculty of Medicine and Statistics are present, in social/human sciences the faculty of Pedagogy, Psychology, Economy, Education, and Music are considered, and 14 studies involve multiple disciplines, defined in a generical way or specific (e.g. Faculty of Architecture, Arts, Business, Dentistry, Education, Engineering, Law, Medicine, Science and Social Sciences). In particular, studies implemented in a multidisciplinary context are the most several (14), the studies in social/human sciences have an important role in relation to the topic of the systematic review (8), and in hard science there are few, but important, studies (3). These figures underscore the necessity for the study and analysis of the ethical dimensions of AI in HE to simultaneously encompass a diverse range of experiences, including those shaped by various disciplinary perspectives. Particular attention is paid to the disciplines of social/human sciences giving them an important role in participating in the discussion of the topic.

AI type

To frame the ethical challenges within a well-defined context, this review analyzed the type of AI considered during the study. In all the articles, albeit with some different declinations, there is a shared definition of what AI is in general. It is defined as a vast branch of computer science concerned with developing intelligent computers capable of doing tasks that typically need human intelligence, and it encompasses various subfields, such as algorithms, data, machine learning, deep learning, neural networks, expert systems, robotics, computer vision, and natural language processing. Speaking about the type of AI, in the 25 articles two are the main options: Generative AI (GenAI) and Non-Specific AI (NS AI). In this systematic review emerges that there is a balance between them, visible in the graph of Figure 3. This result highlights how within the HE context and the ethics, AI is taken into consideration with a privileged view towards GenAI. Furthermore, it should be noted that 5 out of 12 articles that consider GenAI explicitly refer to ChatGPT, suggesting that this specific tool plays a prominent role in current conversations about AI's ethical implications.

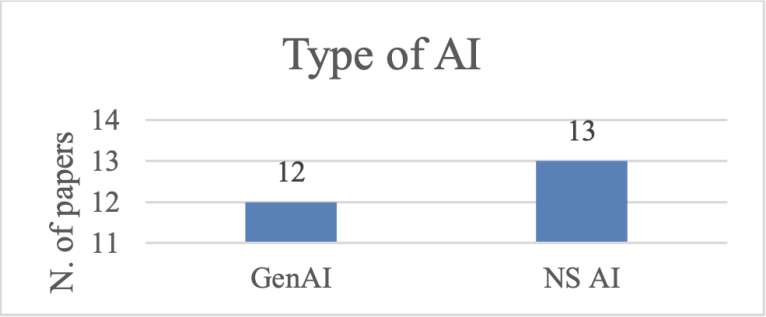


Figure 3 - Type of AI studied in the papers included in the systematic review.

Research

The papers selected for this systematic review include a mix of qualitative, quantitative, and mixedmethod studies. A balance is struck between studies examining AI applications and those analyzing the stakeholders' perspectives. The 25 papers present a near-equal distribution between qualitative (12) and mixed-method (11) approaches, while there are two quantitative studies. Related to the mixed-method research the tools used are surveys with closed and open questions or questionnaires with closed and open questions, and focus groups. The data are analyzed through descriptive analysis, thematic coding analysis, comparative analysis, and descriptive and inferential statistics. Related to the qualitative method research, case studies or semi-structured interviews are chosen then the data are analyzed through thematic coding analysis. Related to the quantitative method research the instrument is a survey and the data are analyzed with descriptive statistics. These results evidence that the field of the ethical dimension of AI in HE needs to be investigated with a deep gaze that allows reality to emerge in its complexity and totality.

3.2 The emerging ethical challenges of AI in HE

This analysis categorizes the concerns that emerged from the 25 papers analyzed. The categorization is done through distinct themes, examining each through the lens of the multiple research studies included in the review. The thematic categorization helps to clarify the nature of the concerns, their implications for stakeholders in education, and the frequency of each theme's discussion across the literature (Table 1). The categories include privacy, equity, academic integrity, impact on learning and skills development, job displacement, and transparency and accountability. Each theme is discussed with specific references to the papers addressing them.

Category of the ethical concern	*References*
Privacy (7)	Holmes et al., 2023; Chan & Lee, 2023; Bobrytska et al., 2024; Al-Mseidin et al., 2023; Saleem et al., 2024; Dávila Cisneros et al., 2023; Xu et al., 2024
Equity (6)	Dávila Cisneros et al., 2023; Qian, 2023; AlMseidin et al., 2023; Holmes et al., 2023; Tapalova & Zhiyenbayeva, 2022
Academic integrity (5)	Yuk & Hu, 2023; Fuchs & Aguilos, 2023; Yusuf et al., 2024; Chen et al., 2022; Ou et al., 2024
Impact on learning and skills development (6)	Chan & Lee, 2023; Malik et al., 2023; Zouhaier, 2023; Holmes et al., 2023; Qian, 2023
Job displacement (4)	Chan & Lee, 2023; Dávila Cisneros et al., 2023; Yuk & Hu, 2023; Popenici, 2023
Transparency and accountability (5)	Yuk & Hu, 2023; Saleem et al., 2024; Qian, 2023; Butson & Spronken-Smith, 2024

Table 1 - Categories of the ethical concerns identified with the corresponding references.

Privacy

Privacy issues are among the most frequently discussed ethical challenges when incorporating AI in HE. This theme centers on the risks associated with data collection, storage, and usage. For instance, Holmes et al. (2023) emphasize the rights of students and teachers to data security, including informed consent and data ownership. They also underscore the necessity for institutions to respect these rights through adherence to regulations. Similarly, Chan & Lee (2023) highlight concerns about transparency in how personal data is managed, as students and educators express anxiety over how AI systems handle sensitive information. This concern is echoed by Bobrytska et al. (2024), who note that transparent data usage policies are critical for maintaining user trust.

Equity and Access
The theme of equity in AI applications addresses disparities in access to AI tools and technologies, which may deepen existing social inequalities. For example, Dávila Cisneros et al. (2023) discuss the "digital divide" in access to advanced AI tools and reliable internet connections, which could marginalize some students while others benefit from advanced technology. Qian (2023) and Al-Mseidin et al. (2023) emphasize the need for fair AI systems that do not perpetuate biases, ensuring that educational tools are accessible and fair across diverse populations. Holmes et al. (2023) also recognize the potential for inequality in the use of AI, which may prioritize the needs of industry over those of students.

Academic Integrity and Plagiarism
A prominent concern in the use of AI, particularly GenAI, is its impact on academic integrity. Many scholars note that AI can facilitate academic misconduct, such as plagiarism, by providing easily accessible content that students may use dishonestly. For instance, Yuk & Hu (2023) and Fuchs & Aguilos (2023) note that AI's ability to generate content challenges traditional plagiarism detection mechanisms. Yusuf et al. (2024) explore how GenAI's potential to enable cheating has led to a divergence in attitudes, with some students acknowledging the risks while others remain willing to exploit these technologies for academic gain. These observations underscore the need for revised assessment practices and policies to maintain academic standards.

Impact on Learning and Skills Development
Another significant theme concerns the potential negative impact of AI on students' learning experiences and skills development. Chan & Lee (2023) argue that over-reliance on AI can hinder the development of critical thinking and creativity among students, as AI-generated outputs may be used as shortcuts in learning. Malik et al. (2023) also highlight concerns about the loss of originality and innovation when students rely heavily on AI for assignments. Similarly, Zouhaier (2023) points out that AI may undermine the human cognitive and ethical dimensions of education, emphasizing the importance of human involvement in assessment processes. This theme is closely tied to the broader concern that AI may shift focus away from human-to-human interactions, which are vital for deeper learning.

Job Displacement and Career Implications
The potential for AI to displace human jobs, particularly within educational settings, has raised widespread concern. Several authors discuss the anxiety felt by both students and educators about the possibility of AI replacing human roles. Chan & Lee (2023) address fears that AI could replace teachers, potentially devaluing human interaction in the educational process. Dávila Cisneros et al. (2023) further note that students worry about the impact of AI on their career prospects, fearing that AI advancements could render certain job roles obsolete. Yuk & Hu (2023) reinforce these concerns, noting that job replacement is a critical issue as AI transforms various sectors, including education.

Transparency and Accountability
The theme of transparency and accountability is central to discussions on AI ethics in education. This theme addresses concerns about the opaque nature of AI systems and the difficulty of understanding their decision-making processes. Yuk & Hu (2023) point out that AI systems often operate as "black boxes," where the rationale behind outputs remains unclear to users. Saleem et al. (2024) emphasize the importance of transparency in model training and data sourcing to ensure user trust. Qian (2023) and other authors stress the need for openness and accountability in AI deployment, advocating for frameworks that ensure AI is used responsibly within educational institutions.

3.3 How to face the ethical challenges?
This analysis focuses on the implications and avenues for future research related to the ethical challenges of incorporating AI in HE presented in the 25 papers analyzed. Key topics identified in this section of the review include AI literacy, policy and regulation development, support and training for educators, integration and ethical frameworks, and balancing human and AI roles. The

number of papers related to the categories is presented (Table 2). Each topic is discussed in detail with references to the contributing authors.

Category of solution	*References*
AI literacy (3)	Chan & Lee, 2023; Yuk & Hu, 2023; Walczak & Cellary, 2023
Policy and regulation (4)	Chan & Lee, 2023, Holmes et al., 2023; Yusuf et al., 2024; Zouhaier 2023
Support and training (3)	Qian, 2023; Chan & Lee, 2023; Bobrytska et al., 2024
Ethical frameworks (3)	Zouhaier, 2023; Tapalova & Zhiyenbayeva, 2022; Qian 2023
Balance between humans and AI roles (3)	Fuchs & Aguilos, 2023; Xu et al., 2024; Dávila Cisneros et al., 2023

Table 2 - Categories of solutions identified with the corresponding references.

AI Literacy

AI literacy is frequently mentioned as a crucial area for both students and educators, encompassing the need to understand AI tools, their capabilities, limitations, and the ethical considerations surrounding their use. Chan & Lee (2023) emphasize the importance of fostering critical thinking, digital literacy, and AI literacy among students, helping them evaluate the credibility of AI-generated information and use AI responsibly. Yuk & Hu (2023) also highlight the necessity for students to develop a solid understanding of AI, including the ethical principles that should guide its use. Walczak & Cellary (2023) further suggest that integrating AI literacy into curricula can help create a culture of responsible AI usage, promoting transparency and accountability.

Policy and Regulation Development

The development of policies and regulations is seen as critical for guiding the ethical use of AI in HE. Many authors stress the need for institutions to establish clear guidelines to ensure responsible use. Chan & Lee (2023) point to the urgency of creating evidence-based guidelines that foster equitable learning experiences. Holmes et al. (2023) suggest that international regulations should be developed to maintain high standards and control the deployment of AI in educational contexts. Similarly, Yusuf et al. (2024) emphasize the importance of culturally responsive policies that align with societal norms and expectations. These discussions reflect a consensus that well-designed policies are essential for addressing the complex ethical issues AI presents in education.

Support and Training for Educators

The need for targeted support and professional development for educators is a common theme, particularly in helping them adapt to AI technologies in their teaching practices. Qian (2023) underscores the importance of providing educators with technical assistance and training to effectively integrate AI in their classrooms. Chan & Lee (2023) recommend support for teachers of different generations to bridge gaps in their perceptions and expectations regarding AI tools. Bobrytska et al. (2024) emphasize the need for inclusive training programs that address varying comfort levels and expectations among diverse demographics. These findings indicate that supporting educators is vital for the successful and ethical implementation of AI in educational settings.

Integration and Ethical Frameworks

Integration of AI in education requires the development of ethical frameworks that guide its use while respecting human values. Zouhaier (2023) calls for institutions to ensure that AI applications adhere to ethical principles that prioritize humanity, privacy, and dignity. Tapalova & Zhiyenbayeva

(2022) suggest embedding human rights principles in AI system development to minimize risks and maximize benefits. Qian (2023) also stresses the need for institutions to develop explicit ethical norms for the use of AI, emphasizing the importance of algorithm fairness and data privacy. This category reflects a growing awareness of the need for frameworks that balance technological innovation with ethical considerations.

Balancing Human and AI Roles

A central discussion in the future use of AI in HE concerns balancing the roles of AI systems and human educators. This balance is important to ensure that AI serves as a complement rather than a replacement for human expertise. Fuchs & Aguilos (2023) emphasize that while AI tools like chatbots can enhance learning, they should not replace the personalized feedback and human interaction that educators provide. Xu et al. (2024) argue for a nuanced approach to AI integration that recognizes the strengths and limitations of AI while maintaining a focus on human-centric educational goals. Dávila Cisneros et al. (2023) suggest that AI should be used to enhance educational experiences without undermining the irreplaceable value of human interactions in the learning process.

4. Discussion

There is a trend in the research focus on the ethical dimension of AI in HE over the past few years. This surge in publications during 2023 suggests a heightened interest and urgency in exploring ethical concerns around AI in HE during that year. Several factors could contribute to this trend, such as increased adoption of AI technologies in educational contexts, a growing awareness of the ethical implications of AI in society, and possibly global events that might have influenced the academic discourse around technology and education ethics. The distribution of the papers over the years suggests that the topic may have only recently gained traction, becoming a significant area of academic research around 2023. The rapid rise in publications could indicate that ethical concerns have become more pressing as AI technologies become more embedded in educational practices (Bond et al., 2024). The preference for studies involving multiple countries suggests a recognition of the global nature of AI's impact on education and the need for collaborative, cross-border perspectives. Such international studies likely provide a broader and more nuanced understanding of how different cultural contexts can influence ethical considerations. This broad geographical scope demonstrates a collective, worldwide concern about the ethical implications of AI in HE, showing that this issue transcends national borders and is being actively addressed in various cultural and institutional contexts. It also suggests that the ethical dimensions of AI in education are seen as a critical topic requiring international collaboration and dialogue to fully address the complexities involved (Bond et al., 2024). There is an emphasis on understanding the ethical dimensions of AI from the student's perspective, while simultaneously striving for a comprehensive and inclusive approach that integrates various viewpoints. Such inclusivity is vital for fostering a well-rounded discourse on AI ethics, as it acknowledges the multifaceted reality and lets the users be the protagonists in building new directions (Du, 2024). The studies span hard sciences, social/human sciences, and multidisciplinary fields, indicating a broad interest in this topic across different academic domains. There is the recognition of the complexity of AI's ethical implications that cannot be fully addressed by a single discipline alone. It is important to understand AI's ethical impacts on human behavior, social structures, and educational practices. The technical dimensions of AI intersect directly with ethical considerations. The prominence of studies in the social and human sciences, alongside multidisciplinary approaches, suggests a growing acknowledgment that ethical analysis must be informed by a broad range of disciplinary insights to fully understand AI's impact in academic contexts (Tang & Su, 2024). The review identifies two primary categories of AI considered in the studies: GenAI and NS AI. This balance between GenAI and NS AI suggests that while there is a broad interest in understanding AI's ethical challenges in general, there is particular attention to the emerging and complex issues associated with GenAI technologies. This may reflect the increasing influence of tools like ChatGPT in educational settings, where their capabilities and ethical considerations are being

actively explored (Acosta-Enriquez et al., 2024). The emphasis on qualitative and mixed-method research highlights the need to delve deeply into stakeholders' experiences and perspectives, allowing the complexity of ethical considerations in AI to emerge more fully. This approach suggests that understanding the ethical implications of AI extends beyond numerical data, requiring in-depth exploration of the human and contextual factors that shape these issues (Pflanzer et al., 2023).

The analysis has identified six main categories of ethical concerns: privacy, equity, academic integrity, impact on learning and skills development, job displacement, and transparency and accountability. The prevalence of privacy concerns highlights the tension between the capabilities of AI to enhance learning experiences and the risks associated with handling sensitive student data. This is particularly relevant in a digital age where data breaches can have long-lasting repercussions on individuals. AI adoption in education must prioritize robust data protection measures to maintain trust among students and educators (William et al., 2024). The issue of equity reveals significant challenges regarding access to AI tools and their impact on existing social inequalities. There is the possibility of a dangerous digital divide that could exacerbate disparities in educational outcomes, raising questions about fairness and inclusivity in AI-enhanced learning environments (Du, 2024). The advent of generative AI tools has complicated the enforcement of academic standards. AI tools can enhance learning by providing students with tailored support, but the ease of using these tools for misconduct suggests a need for revising assessment strategies. Educational institutions must balance the benefits of AI against the potential for misuse, perhaps by focusing on fostering students' critical thinking and ethical use of technology (Tang & Su, 2024). Over-reliance on AI tools could hinder the development of critical thinking and creativity particularly in fields that rely on higher-order cognitive skills (Chan & Lee, 2023; Malik et al., 2023). This highlights a need for frameworks that guide the appropriate use of AI in education (Yusuf et al., 2024; Chan & Lee, 2023; Holmes et al., 2023; Zouhaier, 2023). The fear that AI might replace teaching roles or render certain job skills obsolete creates anxiety among both educators and students. Its role should be seen as complementary to human educators rather than as a replacement.

Addressing these concerns requires clear communication about the role of AI in educational contexts (Xu et al., 2024; Fuchs & Aguilos, 2023; Dávila Cisneros et al., 2023). To overcome the opacity of AI, institutions must adopt practices that ensure transparency in how AI systems operate, including the development of clear guidelines on the use of AI-generated outputs and the processes behind AI decision-making. Accountability frameworks are also necessary to address the ethical implications of AI and to ensure that any negative outcomes can be managed effectively (Tang & Su, 2024).

To face these ethical challenges five solutions are hypothesized: AI literacy, policies, support for educators, ethical frameworks, and balance between AI and human roles. This highlights the need for curriculum adjustments that foster responsible AI use, and the necessity for clear, evidence-based guidelines to ensure that AI is used equitably and responsibly, while also reflecting cultural and societal norms. The request to give support suggests that stakeholders may lack the technical skills or confidence needed to integrate AI into their teaching and learning practices. The findings stress again the importance of using AI to complement, rather than replace, humans, ensuring that personalized, humancentric interactions remain central to the learning process. These insights point to a future where AI and human educators work in harmony, supported by robust policies and ethical considerations (Al-kfairy et al., 2024).

5. Conclusions

The analysis of the 25 studies selected for this systematic review highlights a recent surge in academic interest in the ethical implications of AI in HE. Geographically, the studies reflect a global focus, with significant contributions from China, London, and Finland, as well as multinational studies. A variety of participants are considered, with a particular emphasis on students' perspectives, followed by institutional stakeholders. Disciplinary analysis reveals a

predominance of multidisciplinary approaches. The studies address both GenAI and NS AI, with GenAI, including tools like ChatGPT, being frequently mentioned. Methodologically, the research is balanced between qualitative, quantitative, and mixed-method approaches, emphasizing the need for a comprehensive understanding of AI's ethical dimensions in educational contexts. The analysis identifies key ethical challenges in the use of AI in HE, highlighting privacy, equity, academic integrity, impact on learning, job displacement, and transparency as central concerns. Key priorities for future research and educational practice presented in the documents include developing AI literacy, crafting robust policies, supporting educators, establishing ethical frameworks, and maintaining a balance between AI and human roles.

These themes underscore the need for thoughtful integration of AI technologies, connected with an inclusive, collaborative, and holistic gaze (Bond et al., 2024). Addressing these areas will be critical to ensuring that AI enhances educational outcomes while preserving the ethical standards that underpin HE. As AI technologies continue to evolve, ongoing research will be essential to adapt ethical frameworks and policies to the dynamic needs of educational institutions and their stakeholders, ensuring that AI serves as a complement rather than a threat to the goals of HE (Aler et al., 2024; Bond et al., 2024; Zawacki-Richter, 2019).

This systematic review helps to have an overview of the current situation of the ethical dimension of AI in HE. It emphasizes that while AI presents significant opportunities for innovation in HE, its ethical implementation requires a deep understanding of the risks involved. By addressing these ethical concerns thoughtfully, educational institutions can leverage AI's benefits while safeguarding the values central to teaching, learning, and human development. Future research should focus on developing and testing new literacies and frameworks in real-world educational settings, evaluating their effectiveness in mitigating the ethical problems associated with AI.

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· Section 8 ·
Collaboration Projects and Networks

eTwinning for future teachers: innovating initial teacher education through the digital European education area

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Abstract

eTwinning is a prominent initiative in teacher education, fostering collaboration and exchange among teachers across various countries through technology and online platforms. Since its experimental phase in 2012, eTwinning ITE (Initial Teacher Education) has become a staple in the European teacher education landscape. In Italy, a pioneer of ITE experimentation, eTwinning has significantly impacted teacher education, with 32 universities participating actively to date. The initiative emphasizes integrating eTwinning modules into curricula and encouraging student engagement in real eTwinning projects, thereby directly involving future teachers in the educational process with schools and European peers. Considering the recent reform in Italy's initial training for secondary school teachers, eTwinning ITE offers a framework that aligns well with the new regulations, equipping trainee teachers with essential skills for digital teaching, collaboration, and fostering European and global citizenship. This paper will review eTwinning's implementation models within ITE for pre-primary and primary teachers in Italy, aiming to discuss potential models for integrating eTwinning into secondary teacher education, leveraging eTwinning's recognized effects on teacher training.

Keywords: eTwinning, Initial Teacher Education, Digital Innovation, Inclusive Teaching, Professional Development.

1. Introduction

Teacher education is widely recognized by researchers and policymakers as essential for ensuring highquality teaching and improving student learning outcomes. Quality initial teacher education (ITE) and effective support for new teachers are seen as pivotal for reducing teacher turnover and increasing the appeal of the teaching profession (Eurydice, 2021). This need is particularly urgent in teaching, a profession facing significant challenges and a vocational crisis in many European countries. The European Commission emphasizes that "becoming a teacher should be seen as a gradual process including initial teacher education, the induction phase, and continuing professional development" (European Commission, 2010, p.6) stressing the importance of equipping future teachers with the core professional competences and attitudes essential for their role.

Musset (2010) highlights that initial teacher education represents the entry point to the teaching profession, setting a foundation that influences both teacher quality and retention. Through a structured ITE, countries can standardize the competencies of teachers and ensure consistent educational quality. Nevertheless, a clear consensus on how best to incorporate pedagogy into teacher education remains elusive. Schwille and Dembélé (2007) illustrate that while some scholars advocate for content-specific pedagogies, others stress the need to prepare teachers to manage diverse learning environments, thereby reflecting the complexity and variability of contemporary classrooms.

In this search for optimal teacher preparation, eTwinning has emerged as a promising initiative in ITE, particularly for its role in promoting international collaboration, digital literacy, and intercultural competence among teachers. eTwinning connects educators across countries through technology, enabling them to share resources, engage in joint projects, and participate in professional development. The 2023 European Monitoring Report (Mouratoglou et al., 2023) underscores the effectiveness of eTwinning's integration in ITE, illustrating how collaborative

projects can enhance student teachers' intercultural, digital, and pedagogical skills while building confidence and practical experience. Recent studies (Castaño Muñoz, 2023; Kowalczuk-Walędziak, 2023; Eirín Nemiña, 2023) further support these findings, noting that eTwinning not only fosters essential competencies but also increases the profession's attractiveness by providing meaningful, hands-on training opportunities.

In Italy, eTwinning has proven particularly impactful for in-service teachers, enhancing pedagogical, digital, and collaborative skills (Fabbro et al., 2021). Since its extension to pre-service teachers through the "eTwinning for Future Teachers" initiative in 2019, the program has gained increasing recognition at a systemic level. The Italian National Support Organization (NSO) has successfully advocated for its inclusion in national teacher training programs, with eTwinning activities formally recognized and catalogued in the Ministry of Education's professional development offerings. This integration aligns with broader European educational goals, which promote resilience and inclusivity in teacher training through cross-border collaboration.

The recent reform of Italy's ITE for secondary school teachers, formalized by the August 4, 2023 Decree, presents a timely opportunity to explore how eTwinning can be expanded to this level of teacher education. Unlike the concurrent model used for pre-primary and primary teachers, Italy's secondary ITE follows a consecutive model as in many other European countries (Eurydice, 2021, p. 64), requiring candidates to hold a relevant Master's degree and complete a one-year, 60 ECTS program. The compressed structure of this program, integrating both pedagogical and subject-specific content along with practical internships, emphasizes the need for flexible yet impactful training methods that bridge theory with practice.

Building on Italy's successful experience with eTwinning in primary education, this study seeks to explore the potential for extending this model to secondary ITE. Therefore, the central research question of this paper is: *How can eTwinning be effectively integrated into 60 ECTS secondary initial teacher education programs to support secondary teachers' professional development?*

2. Materials and Methods

In Italy, there is a long-standing experience of eTwinning ITE within the Primary Education Science Courses aimed at the initial training of pre-primary and primary teachers.

These are single-cycle Master's degree programs (LM-85 bis), lasting 5 years for a total of 300 university credits (ECTS) and divided into several areas: Area of Pedagogical and Psychological Disciplines, Area of Teaching Disciplines and Methodologies (including teaching labs and labs on the use of ICT in education), Area of Basic Disciplines, Direct and Indirect Internship (30 ECTS), and Area of Foreign Language. The flexibility of eTwinning, characterized by its ability to promote innovative teaching, European dimension, and professional development of teachers, is particularly well-suited to support such a pathway (Figure 1).

Indeed, since the first experimental phase of the ITE initiative, Italy has been a pioneer in the introduction of eTwinning into university courses and has seen an ever-increasing number of university participating, demonstrating its perceived effectiveness (Figure 2).

To provide support and scientific evidence for the benefits of eTwinning, ten years after the first experiment, the Italian NSO, conducted two studies in collaboration with the Department of Education, Languages, Interculture, Literature and Psychology of the University of Florence: one (2021) aimed at investigating the impact of eTwinning on the competencies related to the professional development of in-service teachers, and a more specific one on the impact in initial training (Tosi, 2023). This latter study aimed at identifying the practices and organizational models adopted in various Italian universities, as well as the benefits and obstacles that have enabled or hindered the integration of eTwinning in initial teacher training in our country. A multiple evaluation case study on 5 Universities (University of Florence, Catholic University of the Sacred Heart of Milan, University of Salerno, University of Roma Tre, University of Padova) was carried out to answer the following research question: Which pedagogical and didactic competences promoted by eTwinning training are indicated by stakeholders in different contexts?

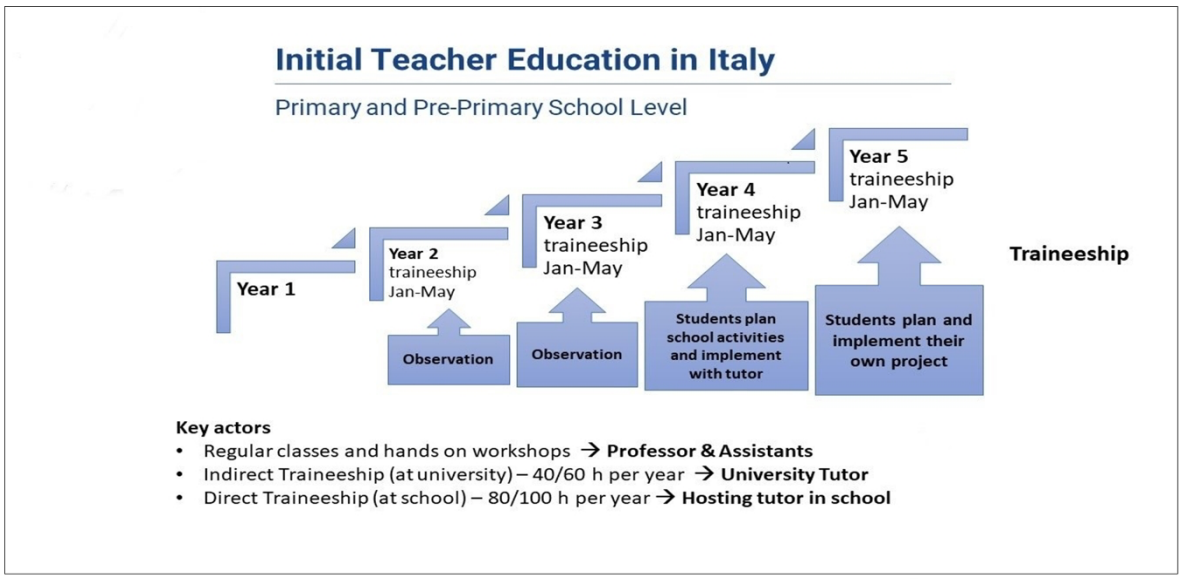


Figure 1 - Model of integration of eTwinning in primary education course- Traineeship.

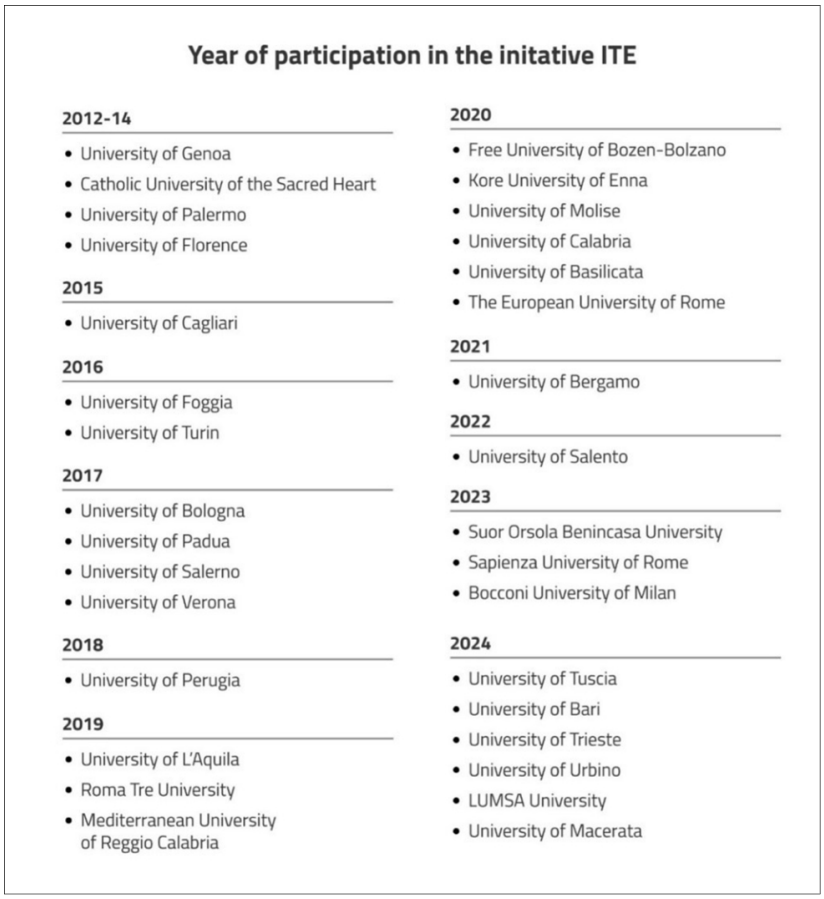


Figure 2 - eTwinning ITE Universities, data updated to 2024.

The results of the study show significant benefits for student teachers, especially on the teaching dimension, such as the development of digital and teaching skills, facilitated by regular use of the platform and peer collaboration, the growth of collaboration skills and the improvement of foreign language skills. In addition, the eTwinning model has shown progress in several areas, such as effective learning design with a focus on authentic tasks and Problem Based Learning (PBL), diversification of teaching methods and integration of digital technologies. These changes have had a positive impact on classroom management and teaching strategies, especially in blended or distance learning contexts. In terms of assessment, eTwinning has facilitated several

assessment strategies, including self- and peer-assessment, which have enabled deeper understanding and adaptation to different teaching contexts (Ancillotti I. et al., in Tosi, 2023).

The research examined the ways in which eTwinning is integrated into university curricula through a survey of the Italian universities participating in ITE in the academic year 2021-22, which totaled 22 institutions. The results (Tosi, 2023) demonstrate the flexibility of eTwinning, which allows for its experimentation within the various areas that encompass the initial training of future teachers. Curricular integration of eTwinning can be variable among universities and may change over time based on the involvement of key stakeholders as well as on the strategic direction of the institution. Data from the academic year 2021-22 shows a predominant inclusion of eTwinning in indirect internships and laboratory courses, with varying levels of student engagement.

The ITE initiative manly consists in two possible activities (Figure 3): 1) integration of one or more modules on eTwinning within a Course or Lab in the Initial Teachers Education curriculum; 2) students' participation to eTwinning projects, either among universities, thus involving student-to-student collaboration, or during students' traineeship at school, collaborating with pupils and "regular" eTwinning teachers in Europe.

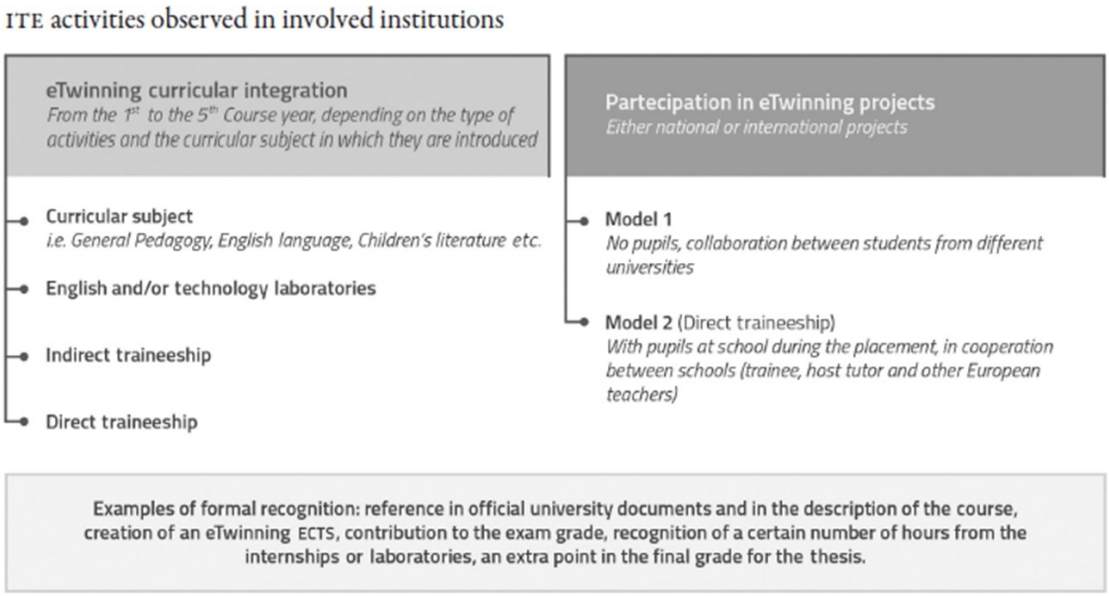


Figure 3 - Model of eTwinning ITE Activities in Primary education course (fig. cit. in Tosi, 2023, p. 21).

Integrating eTwinning modules into the training curriculum for future pre-primary and primary school teachers can take various forms, depending on the institution (Figure 4). In Italy, eTwinning is included in specific subjects or in technology or English language labs, or as part of indirect internships. Training is usually provided by experienced eTwinning ambassadors, but sometimes university teacher educators, who have been previously trained in eTwinning, may also conduct the training. In some cases, the same individuals serve as both ambassadors and university tutors, enabling deeper integration. These training sessions for students and educators are integrated into regional eTwinning work plans, agreed upon by the NSO and Regional School Offices.

Another way to integrate eTwinning is by engaging students in eTwinning ITE projects. These projects typically fall into two categories: a. student-to-student eTwinning ITE projects, where students from different national or international universities collaborate remotely. In these projects, two teacher educators from different universities agree on a shared work plan and organize collaborative activities through the eTwinning platform. Despite logistical challenges like differing schedules and formats across universities, these projects foster international collaboration, peer learning, and virtual mobility, enhancing students' learning experiences. b. eTwinning projects with pupils, initiated by students during their school placements in Italy, typically during their fourth or fifth year of study. These are standard eTwinning projects where student teachers collaborate with school tutors and partners to plan and execute activities, giving future teachers firsthand

experience with eTwinning's impact on teaching and learning. Over time, universities have developed a variety of project models, blending elements of these two types. These projects range from collaborations between students and teachers to experiments in methodology, with some also incorporating Erasmus mobility programs alongside eTwinning's virtual mobility. The initiative continues to evolve as institutions creatively adapt eTwinning to their local needs.

While some universities involve a large number of students in short training sessions, others offer more in-depth training to smaller groups, including hand-on workshops and students' registrations to the platform.

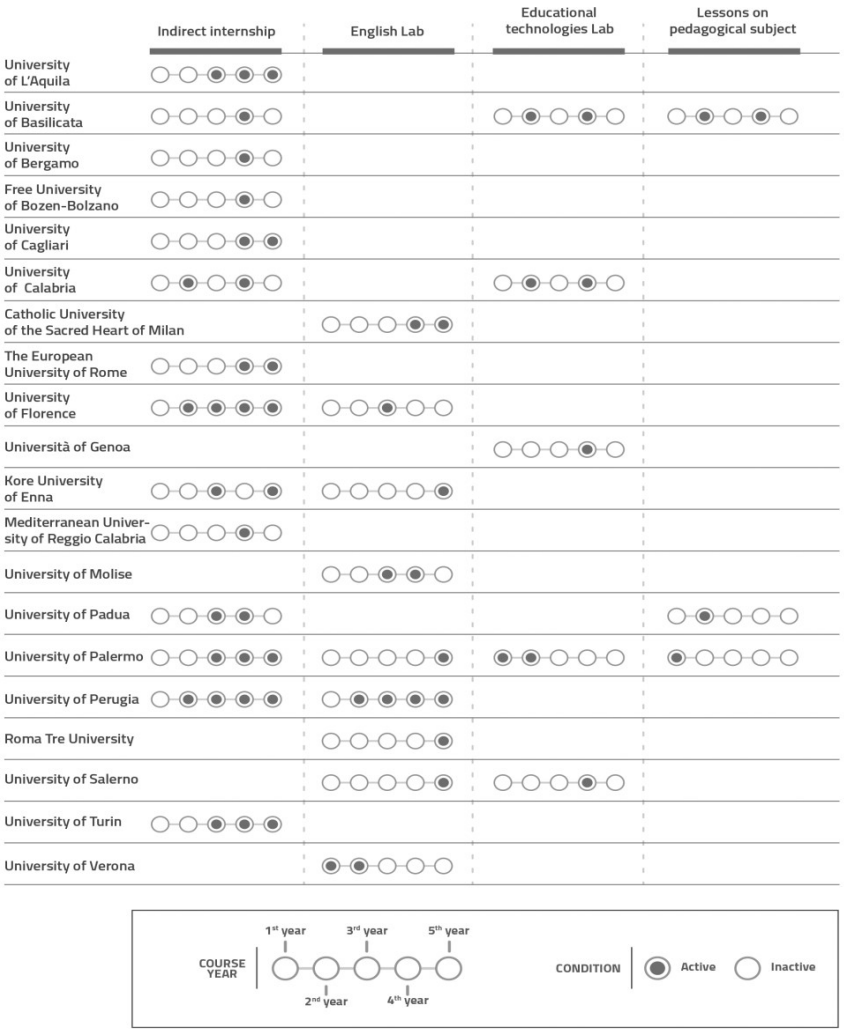


Figure 4 - eTwinning curricular integration in Primary Education in a.y. 2021-22 (fig. cit. in Tosi, 2023, p. 30).

Despite the challenges in organizing real projects, a growing number of students are participating in eTwinning activities, often with a progressive increase in engagement during the final years of their study program (from the third to the fifth year, when their internship allows for more autonomy and requires some project planning). The formal recognition of eTwinning ITE activities varies across universities, with each institution determining its approach on a case-by-case basis. In some instances, these activities are voluntary, while in others, they are integrated into the curriculum and awarded course credit. Recognition may range from accrediting a few hours of lab or internship work to contributing to the final exam grade, or even enhancing the thesis grade. This formal acknowledgment plays a significant role in motivating students to participate actively in the initiative, as it reinforces the value of their engagement within their academic pathway.

Overall, the integration of eTwinning into university curricula is a gradual process, but once introduced, it usually becomes a systematic and well-integrated model within the entire training pathway.

Given these premises and the experience related to Primary Education Courses, and considering the current Teacher Training reform in Italy, we conducted an experimental study aimed at investigating the possibility of extending the eTwinning ITE experience also to the initial training of secondary school teachers in Italy. In this study, we employed the World Café methodology (Brown, & Isaacs, 2005) to explore the potential and challenges of this possibility, questioning some stakeholders and key actors of the initiative.

This methodological approach was chosen for its ability to facilitate collaborative dialogue among diverse stakeholders, encouraging participants to draw from their experiences and knowledge. Research indicates that this method is particularly effective for exploring complex issues where solutions are not immediately apparent, allowing for creativity and the emergence of collective wisdom. It serves as a powerful tool for facilitating meaningful dialogue among diverse groups. The use of the World Café methodology promotes the importance of active listening, open sharing, and creating a climate of trust. The goal is to inspire participants to use meaningful conversations to address complex challenges. In this context, one significant challenge for universities is the activation of 60 ECTS secondary teacher preparation.

The World Café was applied during an ITE National Coordination Meeting held in Naple on 16-17 May 2024. The meeting gathered approximately 100 participants from 27 universities across Italy: teacher educators, academic staff, tutors, ambassadors, student teacher and regional representatives.

Participants were organized into eight discussion tables, each hosted by a university representative identified by the Italian NSO. Each table was assigned one of four core topics related to the integration of eTwinning in Initial Teacher Education (ITE):

1. Curricular Integration of eTwinning
2. eTwinning Projects
3. Research Activities linked to eTwinning
4. eTwinning ITE for future secondary school teachers

The discussions were structured around two focused questions:

- *What models for integrating eTwinning into ITE can be imagined for the training of future secondary school teachers (60 ECTS)?*
- *If the Italian NSO were to offer an online course to facilitate this integration, what features should it have?*

Participants rotated randomly between tables every 15 minutes to ensure that everyone contributed to all four topics. This rotation allowed for the cross-pollination of ideas, a hallmark of the World Café methodology. Each table produced a summary poster reflecting the key points of their discussions, which were later presented and further discussed in the plenary feedback session.

Following the initial phase of the discussions, the hosts of each table provided written revisions of the outcomes to ensure accuracy and completeness. The data collected from the summary posters and plenary feedback were analyzed thematically to identify common ideas, challenges, and potential operational guidance. This analysis aimed to provide actionable insights for NSO Italy to support the integration of eTwinning into university-level teacher education programs.

The primary objective of this research was to connect ideas that emerged from the discussions, building on prior conversations to offer strategic recommendations for integrating eTwinning into the curricular framework of secondary teacher education. Specifically, the research sought to address how eTwinning could be incorporated into teacher training, what online resources or courses could support this process, and how such integration could enhance the professional competencies of future teachers.

The insights gained from this World Café discussion will inform the development of operational guidelines for NSO Italy, aiding universities in the effective incorporation of eTwinning into their ITE programs.

3. Results

The World Café discussions provided valuable insights into the integration of eTwinning within Initial Teacher Education (ITE) programs for secondary school teachers.

Participants at the national conference, and thus at the World Café, involved eTwinning ambassadors, teacher educators, professors and university co-ordinators, thus providing an ideal audience that combined both the political perspective of those responsible for designing the new 60 ECTS courses for future secondary school teachers, but also the operational perspective of those who actively worked on the implementation of the eTwinning ITE initiative.

The participants in the seminar and discussion held during the World Café included some representatives responsible for both primary and secondary teacher training programs, who therefore have in-depth knowledge of previous experiences and are currently facing the challenges brought by the new teacher preparation process. When inviting participants to reflect, we presented the structure of the course as outlined in the August 4th Decree and asked them which model of integration they saw as possible and desirable for experimenting with eTwinning ITE.

Table 1 - ECTS for the initial training of secondary school teachers.

Decree, 4th august 2023
• Pedagogical area (24 ECTS) [including: teaching and learning methodologies, inclusion, linguistic and digital competencies] • Teaching methodologies specific subject area (16 ECTS) • Direct and indirect internship (20 ECTS) • Final examination
Total: 60 ECTS

A consensus emerged among participants that incorporating eTwinning into these courses would be beneficial, offering potential for pedagogical innovation and cross-disciplinary collaboration.

Participants suggested that eTwinning could be integrated into all three core areas of the 60 ECTS framework for secondary teacher training: the transversal/pedagogical area, the disciplinary area, and the internship component. However, the consensus was that a pilot implementation should begin in the transversal pedagogical area. This area was seen as particularly relevant for leveraging eTwinning to enhance both the methodological and interdisciplinary dimensions of teacher training. By doing so, the program would help future teachers develop a stronger foundation in innovative teaching practices that encourage collaboration and interdisciplinary learning.

The discussions resulted in a proposed integration model for eTwinning within ITE programs. Participants suggested a 1 ECTS (25-hour) module that could be delivered face-to-face, online, or through a blended approach, with universities managing the delivery. This module may also include the possibility of recognizing participation in regional eTwinning events, organized by the eTwinning NSO and Regional School Offices, to provide practical, hands-on experience for future teachers.

Given the diverse nature of teacher education programs across different universities, with varying timelines and curriculum structures and the administrative difficulties in delegating an internal training task to external experts, participants recommended a decentralized management approach for the eTwinning module. This decentralized model should be designed in close collaboration with the eTwinning NSO and regional experts, ensuring the module could be tailored to the specific needs and contexts of different institutions while maintaining a standard of quality across the country.

To ensure the quality and uniformity of the eTwinning integration across universities, participants emphasized the importance of leveraging eTwinning's existing training model. This would include the use of teaching kits, collections of good practices, and a registry of eTwinning experts and

ambassadors to support its implementation. Additionally, a "training for trainers" approach was proposed to equip university instructors with the necessary skills and knowledge to effectively deliver the eTwinning module, or the creation of a list of experts from which the universities could draw, entrusting them directly with the training task. A help-desk support system was also recommended to assist both trainers and students in addressing any technical or pedagogical challenges.

The World Café discussions highlighted a clear enthusiasm for integrating eTwinning into secondary teacher education programs, with a focus on creating a scalable and flexible model that could be adapted to different university contexts while ensuring consistent quality and support nationwide.

4. Discussion and conclusions

Building on a robust foundation of successful collaboration with ITE universities for primary and preprimary teachers, Italy is now poised to embrace a comprehensive model for secondary teacher training.

Until 2023, the Italian eTwinning NSO avoided significant investments in the initial training of secondary teachers, constrained by the brevity of their programs (24 ECTS) which limited opportunities for a complete eTwinning experience, including platform registration and active participation. In contrast, the well-structured, multi-year training programs for primary teachers enabled a gradual integration of eTwinning, with reliable identification and support of future educators.

Despite the substantial success of the ITE initiative in Italy, where it now reaches a significant number of primary education programs, expanding it to secondary education has remained challenging. However, the 2023 reform (Decree of August 4, 2023) introduces an ideal opportunity to incorporate eTwinning into the preparation of all future secondary teachers. The experience gained over a decade of integrating eTwinning into the Primary Science Course across 32 universities provides a flexible model that aligns with key elements of quality education highlighted in the European Commission’s guidelines: subject knowledge, pedagogical theory, and classroom practice.

eTwinning offers student teachers more than cross-border collaboration and access to various training resources; it also bridges theory with practice by embedding innovative pedagogical approaches directly into their traineeship experiences. Serving as a natural channel for Project-Based Learning, eTwinning introduces a multidisciplinary approach often missing in secondary education, where teachers traditionally concentrate on their specific subjects. This platform can therefore help alleviate the isolation commonly felt by secondary school teachers, fostering an inclusive and collaborative professional environment.

Collaboration is an essential skill underscored by European education policy (Schools policy Education & Training 2020). However, many teachers, particularly in secondary education, were not exposed to collaborative learning in their initial training. eTwinning not only promotes these practices but also allows future teachers to experience collaboration firsthand, working with European peers or engaging in projects during their placements.

Extending eTwinning to secondary ITE presents promising opportunities, but it also necessitates thoughtful consideration of the most scalable and sustainable model for universities and the Italian NSO. During the discussions presented in the paper, participants observed that the centralized model used in Primary Education, where all eTwinning training is centrally managed and funded, is unlikely to suit the needs of secondary education due to its broader subject range and larger student base. The limited number of eTwinning Ambassadors, who are already engaged in other commitments, further challenges the feasibility of a centralized approach.

An initial proposal of a national, 25-hour online course for all universities was dismissed due to scheduling and regulatory hurdles, as universities vary widely in their timetables and adherence to limits on synchronous and asynchronous hours. A centralized course structure also risks lacking formal recognition, complicating its integration into academic curricula. A more feasible solution

emerged from the discussion: a decentralized model allowing universities to conduct a 25-hour eTwinning module autonomously while maintaining a common structure. The Italian eTwinning NSO would provide a standardized module that universities could adapt to fit their specific needs, with options for direct support from expert Ambassadors and customized mentoring.

Placement within the curriculum remains a key consideration. While past experiences suggest that eTwinning is most effective when integrated into the indirect internship, the limited hours available in the condensed 60-ECTS secondary ITE program may make this difficult. Participants recommended embedding eTwinning within the pedagogical area, as it aligns with the cross-disciplinary skills emphasized in recent curricular reforms, particularly in supporting the new civic education mandate in Italy (Law 92/2019, Ministry Decree 183/2024).

To ensure consistent quality and sustainability, the initiative requires standardized training materials, ongoing support through helpdesks, and extensive monitoring to provide feedback and address challenges. Although resource-intensive, such measures are essential for maintaining the quality of decentralized training. Given the time constraints of the secondary ITE program, a 25-hour module may encompass introductory sessions, best practices, platform navigation, and a project design exercise. Simplified ITE project templates may support initial project collaboration, perhaps with a focus on Italian universities before scaling to international partnerships.

As a next step, we propose piloting a standardized "eTwinning Learning Unit" with select universities to refine the model. This pilot will focus on assessing the impact of eTwinning on student teachers' development in collaboration, digital literacy, and interdisciplinary teaching. Insights gained will guide a potential nationwide implementation of eTwinning in secondary teacher education, ensuring it meets the diverse needs of future educators.

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Fostering global learning through Erasmus+ Blended Intensive Programmes

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Abstract

This paper examines the transformative impact of Erasmus Blended Intensive Programs (BIPs), which integrate both digital and physical mobility to foster global learning. By promoting accessibility, interdisciplinarity, and digital skills development, BIPs play a key role in democratizing international education and enhancing cooperation across higher education institutions (HEIs). Drawing on case studies from the University of Pavia, this paper discusses the success of BIPs in fostering innovation, collaboration, and inclusivity in higher education. We conclude by discussing the challenges of implementing BIPs and the potential for further development in the context of global education.

Keywords: Erasmus+, Blended, Intensive, Programmes (BIPs), European University Alliances, Internationalization, Inclusion.

1. Introduction

1.1 Background and Importance of BIPs

In recent years, higher education has experienced profound shifts driven by technological advancements, globalization, and the need for flexible, interdisciplinary approaches to learning. Blended Intensive Programmes (BIPs), introduced under the Erasmus+ initiative, aim to address these changes by providing a hybrid model of learning that combines short-term physical mobility with collaborative online learning experiences.

The Erasmus+ program has long been a flagship initiative for promoting international education and cooperation across Europe and beyond. As part of its 2021-2027 strategic framework, Erasmus+ introduced Blended Intensive Programs (BIPs) as a means of responding to the evolving needs of higher education in a globalized world. BIPs offer a hybrid format, blending physical and virtual mobility to create more flexible and accessible learning opportunities.

This paper explores how key factors – innovation, inclusion and diversity, interconnection, internationalization, flexibility, scalability, and digital pedagogy – shape the design and impact of BIPs curricula.

By analysing how these elements shape curriculum development, we demonstrate the potential of BIPs to enhance global educational practices, foster intercultural competence, and promote the acquisition of digital literacy skills. The findings suggest that BIPs offer scalable and adaptable models for future curricula that can address the evolving needs of higher education in a rapidly digitalizing world.

BIPs are particularly innovative because they address several key challenges in international education, such as the need for more sustainable travel options, the demand for interdisciplinary collaboration, and the inclusion of students who face barriers to traditional mobility programs. These programs leverage the benefits of both digital and face-to-face learning environments, allowing students and educators to engage in meaningful transnational education experiences without the limitations of geographic location.

With the impact of the COVID-19 pandemic, BIPs have become even more relevant. The pandemic forced many institutions to adapt quickly to digital learning, which accelerated the acceptance and development of virtual mobility. BIPs provide a structured way to combine the benefits of virtual learning with the critical interpersonal interactions that come from in-person exchanges.

1.2 Objectives of the Paper

This paper aims to provide a comprehensive analysis of BIPs and their role in fostering global learning. Specifically, the paper seeks to:

1. Examine the structure and implementation of BIPs, focusing on how they integrate digital and physical learning.
2. Analyse the impact of BIPs on enhancing students' mobility and promoting inclusivity, especially for students who are traditionally underrepresented in international exchanges.
3. Evaluate the effectiveness of interdisciplinary and transnational collaboration fostered through BIPs, with a particular focus on case studies from the University of Pavia.
4. Identify challenges and opportunities for scaling BIPs within broader internationalization strategies.

The paper is structured as follows: Section 2 outlines the structure of BIPs and the Impact on the internationalization process of HEIs, with a focus on the case studies from the University of Pavia. Section 3 presents the results of these case studies, examining the impact of BIPs on global learning and student participation. Section 4 discusses the challenges and opportunities in implementing BIPs. Finally, Section 5 concludes the paper by summarizing key findings and suggesting directions for future development.

2. Structure of Erasmus BIPs

Blended Intensive Programs (BIPs) are an innovative format introduced under Erasmus+ 2021-27 to combine short-term physical mobility with virtual learning components. They aim to foster collaboration across institutions and disciplines while making mobility more accessible, especially to those who may face challenges in participating in traditional long-term mobility programmes.

Blended Intensive Programmes must be developed and implemented by at least three higher education institutions (HEIs) coming from at least three EU Member States and third countries associated to the Programme and can be repeated during more than an academic year. Institutions jointly design the BIP, outlining the learning objectives, virtual and physical components, and assessment methods. A lead institution typically coordinates the program. Partner institutions promote the BIP to their students and staff. Selection criteria may vary depending on the nature of the program, but they generally seek participants who will benefit from international collaboration and intensive learning. A crucial component of a BIP is a period of physical mobility, where students and/or staff from different countries gather for a short, intensive experience (from a minimum of 5 to a maximum of 30 days) at the host institution. This period focuses on hands-on activities, workshops, or collaborative projects that require in-person interaction. Before and/or after the physical mobility, participants engage in online learning activities that may involve preparatory coursework, collaborative projects, or follow-up work to deepen the learning experience. IPs can be addressed to both students and staff. They are especially helpful for students who may not be able to commit to long-term mobility programs, such as those with work or family obligations.

BIPs are inherently innovative by design, leveraging the affordances of both digital and physical learning environments. The incorporation of innovative teaching methods, such as flipped classrooms, gamified learning, and Collaborative Online International Learning (COIL), enables students to engage with content interactively, facilitating deeper learning experiences. Furthermore, the curricular innovation offered by BIPs allows for the integration of interdisciplinary approaches, fostering creative problem-solving skills and the ability to address complex global challenges.

In the context of BIPs, several key elements can drive the success of curricula in terms of innovation, inclusion and diversity, interconnection, internationalization, flexibility, scalability, and digital pedagogy and literacy. One of the core goals of BIPs is to promote inclusion and diversity in higher education. The blended nature of these programs reduces financial and geographical barriers, making international experiences more accessible to students from diverse socio-

economic backgrounds. By engaging students from underrepresented groups, BIPs cultivate diverse participation, ensuring that a wide range of perspectives are represented in the learning process. In addition, BIPs adopt inclusive pedagogical practices, supporting students with varying abilities and learning needs through flexible and accessible digital learning tools.

The concept of interconnection is central to BIPs, as they are designed to bring together students and faculty from multiple disciplines and cultural backgrounds. This fosters cross-disciplinary collaboration, enabling participants to approach problems from multiple perspectives and apply integrated knowledge to real-world challenges. BIPs not only encourage academic collaboration but also help to build global networks, promoting long-term partnerships between universities and international institutions.

BIPs contribute significantly to the internationalization of higher education by offering students and faculty opportunities for intercultural exchange and global learning. Through virtual mobility and short-term physical exchanges, BIPs foster cultural exchange and the development of global awareness, enhancing participants' ability to navigate and thrive in increasingly interconnected global contexts. The program also strengthens institutional partnerships by facilitating collaborations between higher education institutions across borders. A key strength of BIPs is their flexibility in accommodating diverse student needs. The hybrid structure of BIPs allows for adaptable learning models, providing students the opportunity to engage in both physical and virtual components based on their personal, academic, or logistical needs. This flexibility not only increases participation but also supports tailored learning paths, where students can customize their experiences based on their academic and professional goals.

Therefore, the modular design of BIPs makes them highly scalable. The use of virtual components enables institutions to expand the program's reach without significant increases in costs. By offering modular curricula, BIPs can be adapted and replicated across various disciplines and educational contexts. The digital nature of BIPs also enhances their scalability by making it easier to involve a larger, more diverse cohort of participants from around the world.

One of the most critical aspects of BIPs is the emphasis on digital pedagogy and the development of digital literacy. The incorporation of technology into both the delivery and content of the curriculum prepares students for the demands of a digitalized labour market. Participants in BIPs gain valuable digital collaboration skills, learning to navigate digital platforms, manage online teamwork, and develop critical thinking regarding the use of technology in education.

Participants in BIPs are eligible for Erasmus+ grants to support their mobility. These grants cover travel and subsistence costs during the physical mobility component. The virtual part does not receive separate funding but is supported through the program's operational budget, but single HEIs may decide to cofound it by internal or external funds. The host institution, which organizes the physical mobility, collaborates with partner institutions that recruit participants from their student and staff communities.

BIPs are designed to raise transdisciplinary learning outcomes with collaborative, cross-sectoral learning. BIPs often bring together students and staff from different academic disciplines and institutions to work on shared projects or themes. This fosters interdisciplinary learning and international cooperation. The virtual component encourages participants to enhance their digital literacy and use technology for academic collaboration, aligning with Erasmus+ goals for digital transformation in education. Like traditional mobility programs, BIPs promote intercultural exchange, even with shorter physical stays. The virtual part also enables more participants to engage in international learning experiences.

After completing the BIP, participants usually provide feedback through surveys or reflective reports. The program's success is evaluated based on participant satisfaction, learning outcomes, and the impact on future collaborations.

A typical BIP includes an online preparatory phase, during which students are introduced to the course content and collaborate virtually with peers from different countries. The preparatory phase often incorporates Collaborative Online International Learning (COIL) projects, where students work together on research assignments or problem-solving tasks. These online

interactions are crucial for building intercultural understanding and setting the stage for the in-person mobility phase, which typically lasts between 5 and 10 days.

The physical phase is an intensive experience where students and faculty gather in one location to engage in hands-on learning, workshops, or practical applications of the concepts explored during the virtual phase. This phase also provides opportunities for cultural immersion and face-to-face collaboration, which are essential components of the overall learning experience.

2.1 Integrating Blended Intensive Programmes into Internationalization Strategies in Higher Education

Internationalization is a key strategic priority for higher education institutions, driven by the need for global cooperation, cross-cultural competence, and the development of academic partnerships that transcend national borders. Internationalization strategies in higher education often encompass several levels of mobility, each serving different objectives. The key levels include credit mobility and degree mobility, development of structural long-term partnerships each contributing uniquely to global engagement.

Credit Mobility involves short-term exchanges where students earn academic credits, typically through:

1. Study abroad programs,
2. Traineeships, and structured mobility windows within degree programs
3. Teaching and professional training programmes

Degree Mobility focuses on long-term academic engagement, such as:

1. Double or multiple degrees, where students earn academic titles from two or more institutions,
2. Erasmus Mundus Joint Master's Programs (EMJM),
3. The emerging concept of the European Degree, designed to foster deeper integration between European higher education systems.

Therefore, BIPs offer a unique positioning within this structure by blending aspects of both credit and degree mobility, while adding a significant digital component to enhance flexibility and reach.

Blended Intensive Programmes provide an innovative platform for multilateral partnerships by facilitating the co-development of academic modules between multiple institutions. The collaborative nature of BIPs allows for the pooling of expertise from diverse academic and cultural backgrounds, making it possible to design transdisciplinary curricula that address global challenges.

BIPs are particularly effective in:

1. Testing academic cooperation through joint teaching initiatives, allowing universities to pilot cocreated course modules in an intensive format.
2. Engaging faculty from different countries or regions, which enhances the richness of the educational experience and fosters international academic cooperation.
3. The flexibility provided by virtual mobility in BIPs allows institutions to engage students and staff across diverse geographical regions, creating a dynamic learning environment that reflects the increasingly interconnected global academic landscape.

A key factor in the success of BIPs is the participation of faculty members from multiple countries or regions. This cross-border collaboration is fundamental to the pedagogical framework of BIPs, as it brings diverse academic perspectives into the classroom, enriching the learning experience for students. Moreover, the involvement of students from partner higher education institutions (HEIs) is essential for the effective implementation of BIPs. Student participation not only enhances the intercultural learning experience but also strengthens the bonds between the partnering institutions, thus promoting sustained collaboration.

The hybrid nature of BIPs provides a flexible and scalable model for internationalization. Through the integration of virtual learning platforms, BIPs enable institutions to overcome geographical and financial barriers that may limit participation in traditional mobility programs. This flexibility

makes BIPs an accessible option for a wider range of students, particularly those from underrepresented or with fewer opportunities backgrounds.

Additionally, BIPs offer institutions the opportunity to experiment with innovative pedagogical approaches. These include the integration of digital tools, collaborative learning technologies, and asynchronous learning, all of which are essential for developing the digital literacy skills needed in the 21st-century global workforce.

3. Case Studies from the University of Pavia

The University of Pavia has been a leader in the implementation of BIPs, coordinating thirty-one BIPs and participating in ten as a partner.

UNIPV consider BIPs as a structural component of its internationalization strategy that have positioned as a leader in securing international funds through Erasmus+, with €760,000 allocated over four years. This strategy includes strong governance commitment, administrative support, innovative teaching approaches, and the integration of cross-disciplinary learning focused mainly on the Sustainable Development Goals (SDGs). A total of twelve Departments involved 248 incoming international students (38% respect long-period mobilities) and 156 students from UNIPV have been involved in BIPs. The university has adopted several innovative blended teaching approaches that enhance the international learning experience, including:

1. Intensive Schools: These programs are either supplementary or integrated into the curriculum, bringing together international students and teachers in a cross-cultural blended learning environment. The summer schools provide a platform for students to engage in global discussions and apply their learning in an international context.
2. Visiting Professors: The institution leverages international academic networks to bring visiting professors to campus at no additional cost. This initiative enriches the educational experience and fosters international collaboration in teaching and research.
3. Cross-Disciplinary Teaching: Approximately 45% of the teaching focuses on cross-cutting topics related to the Sustainable Development Goals (SDGs). This experimental teaching approach integrates multiple disciplines, promoting critical thinking and collaboration among students from diverse academic backgrounds.

One of the cornerstones of the university's internationalization strategy is the formal, non-formal and informal recognition of student achievements through ECTS and the Open Badge project led by the University of Pavia. These initiatives ensure that students' learning outcomes, both in traditional courses and in international programs are formally recognized and recorded in the academic career as digital credential. The Open Badge system further supports students by providing digital certifications that can be used to demonstrate skills and competencies in international job markets.

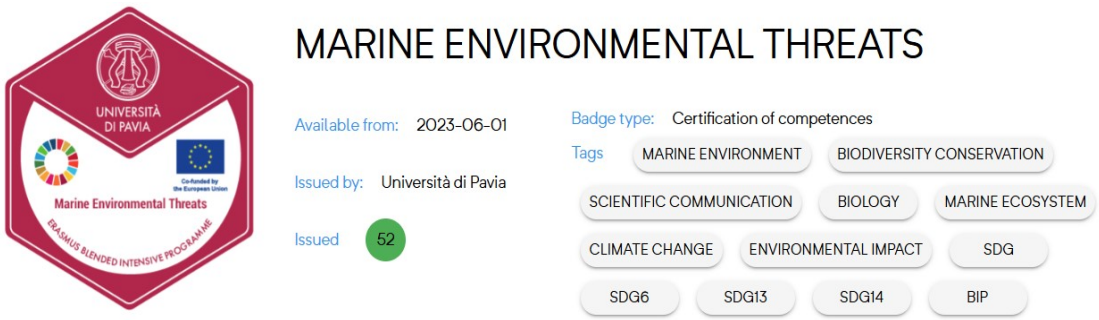


Figure 1 - Example of UniPV Open Badge of BIP in Marine Environmental Threats.

These programs have involved a wide range of academic disciplines, from engineering to entrepreneurship, and have attracted students from across Europe and beyond.

Therefore, the following case studies highlight in which thematic BIPs can be addressed, such as:

• Development European University Alliance Initiative • Engagement with the local communities • Global Cooperation and EU attractiveness • High-Level Trainings for early career researchers	• Inclusion of under-represented groups in international education • Innovative Pedagogical Approaches • Professional Development • Smooth connection with Industry • Achievement of Sustainable Development Goals

Entrepreneurship Goes International

Headed by Prof. Birgit Hagen, Department of Economics and Management (University of Pavia)

TAG: Innovative Pedagogical Approaches; Smooth connection with Industry

This BIP, developed in collaboration with the Department of Economics and Management, used experiential learning to engage students in real-world business challenges.

In a comprehensive retrospective analysis of the BIP project, a strong sense of achievement emerges from the notable success achieved in executing the program. This comprehensive evaluation delves into the insightful input received from a wide range of participants, including students, academic partners, startups, and company partners. One characteristic that has set the BIP experience apart is the excitement that every participant has shown. Their collective acknowledgment highlights the importance of programs that let students put their skills to use in the real world and develop their collaborative and cross-cultural skills.

A significant feature that deeply impressed the students was the opportunity to engage in interactive activities with qualified experts. These exercises not only offered direction but also promoted an engaging and varied learning environment. Students were able to ask questions, get practical insights, and experience a real-world setting by working in a multifaced context. The students' diversity, which included a range of nations and academic backgrounds, enhanced the collaborative experience by introducing participants to new ways of working and thinking.

The creation of internationalization plans for actual companies was the result of the collaborative spirit at the heart of the BIP initiative. Through this program, students were guided through the difficulties of international business by applying theoretical knowledge in a practical setting. They navigated challenges pushing beyond conventional boundaries, this project is also useful to train and develop the students' problem-solving skills and strategic thinking.

In addition to the professional and academic facets, the BIP program was successful in forging a sense of community among participants. Students found new friends from different countries, establishing connections that transcended cultural boundaries. As a result, the initiative gained a social component and a supportive community that went beyond the BIP structure. The effectiveness of these interpersonal relationships was seen not just in the dynamics within the group during BIP-related activities but also in extracurricular activities, such as participation in a soccer game where BIP students showcased a unified front.

Despite the great success, some improvements are still possible, e.g. earlier involvement of university partners to improve cooperation and recruitment of students and start-ups. Furthermore, our objective is to broaden the global outlook by actively incorporating further foreign startups. Also, we think it will be useful to increase coaching efforts from professors, tutors, and experts to provide better support, especially for groups that are struggling with the assignment from a content point of view. Lastly, acknowledging the importance of feedback, we propose that project insights be systematically shared with all partners and students for further future improvements.

The BIP was done in Pavia in 2023 in cooperation with the Université Jean Moulin Lyon 3 (Lyons, France), LUT University (Lappeenranta, Finland) and the Universität Zu Köln (Cologne, Germany), and 2024 in cooperation with the Eberhard Karls Universitaet Tuebingen (Tübingen, Germany) and the LUT University (Lappeenranta, Finland). It will be repeated in Pavia in 2025 with new partners and startups.

VERY-M Valuing challEnges on aRchitectural tYpologies- Modernity

Headed by Prof. Raffaella De Marco, Department of Civil Engineering and Architecture (University of Pavia)

TAG: Innovative Pedagogical Approaches, Global Cooperation and EU attractiveness

This BIP Project carried out intensive lectures and workshops aimed at the application of 3D models and virtual environments for the narration of Cultural Heritage, with a specific focus on modern architecture across the Mediterranean. The lectures were conducted in both virtual and in-presence modalities, gathering international lecturers from Italy, Portugal, Germany, Romania, Ukraine, England, Turkey, and Palestine. The presence of international students, from the same partner institutions, allowed for a broad coverage both geographically and in terms of fields of study (architecture, engineering, art, landscape, social sciences) and of cultural background to contribute to the scientific view on the topic.

The topics of the virtual lectures covered debates and case studies on Cultural Heritage values, under the thematic panels of: HISTORY_Architectural Changes facing past and present, MEMORY_Mapping and Communicating Heritage in the Contemporary Society, IDENTITY_Addressing Documentation to Heritage Valorization.

The topics of the in-presence lectures were Culture of Encounter. Restoration's Projects, The role of Digital Drawing in architectural documentation and analysis, Palestinian Heritage and Modernity Perspectives: features of connection and analysis, Modernity and Other Modernities: architectural features from a social and cultural perspective, Virtual Heritage and its representation challenges towards the Metaverse dimension, Digital Repositories and Virtual Environments on Cultural Heritage: opportunities and advances for intangible narratives on Architecture, Recognition of heritage values - a key factor in activating public interest in historic places, Archival research and cataloguing experiences for Architectural Modernity: digital tools, practices and horizons of history, Cultural Heritage and Territorial Transformation, Heritage and policies: from governmental approaches to the role of citizens.

Partners collaborated in the scientific implementation, providing an interdisciplinary vision of mentoring and content of lectures, ranging from digital heritage to art history, architectural design, heritage values, drawing and territorial policy.

Students were able to experiment with Web 3.0 solutions for building virtual museums of cultural heritage narratives. The creative action of cultural connection between Mediterranean architectural examples was supported by the provision of free Metaverse digital tools and Web Repositories of 3D models. In this way, the activity was also accessible to cross-disciplines between engineering and social science subjects. The results produced are accessible online as virtual environments for interaction and enjoyment of the exhibition route, with 3D, 2D and textual content to illustrate the themes narrated.

The results have been collected and a digital brochure is being developed for their promotion, which will be disseminated by all partners involved through their institutional channels.

Clinical Skills Training for Pharmacists

Headed by Prof. Giovanni Ricevuti, Department of Drug Sciences (University of Pavia)

TAG: Innovative Pedagogical Approaches, Inclusion of under-represented groups in international education

This BIP awarded 3 ECTS and brought together students from Université Paris-Saclay (Paris – France) and Trinity College Dublin (Ireland).

The project was the first European didactical project on Clinical Pharmacy, an important skill to develop a highly effective and good practice in healthcare.

The main aim of this project was to allow the students to carry out theoretical and practical activities in order to be able to understand the future role of a clinical pharmacist on the territory and in the hospital, and to acquire the abilities that the new pharmacist of the post-Covid area must have in terms of knowledge and practice.

Above all, several intercultural sessions were organized on specific topics (clinical, organizational, practical, medical, pharmacological, communicative, political, experimental) with direct role and involvement of the students.

To give a theoretical and practical preparation to the students, several blended and on-site teaching methods were proposed. Participants used Bloom's taxonomy with a mix of proven teaching techniques and innovative pedagogy: frontal and online lectures, students as teachers, flipped classroom, simulations and clinical cases, direct observations, and practical activities. The teaching was based on the conventional pedagogy techniques previously described, such as the reconciliation of information (S-A-L-S-A: Share-Ask-Listen-Share AgainAsk again) or the method of feedback Ask-Tell-Ask. This program was an opportunity to share good practices in pedagogy between the three partners, an advantage for students but also for teachers.

The most significant elements of the project to underline are:

1. The project was endorsed by the Italian Minister of Health.
2. Excellent student-teachers and student-student interaction and active participation of students and teachers in practical activities.
3. Organization of two practical training courses for procedures to be carried out in pharmacy both as a relationship with citizens, both as POC-POCT (point of care testing and therapy), and as a relationship with the team.
4. Organization of a BLSD COURSE with use of the defibrillator completely new for teachers and students from Paris and Dublin, who followed and practiced it obtaining the international certificate.
5. Organization of a day of practical activity with a population screening in a Pavia area.
6. Organization of sessions on NHS organizations in different countries and on the distinct roles of community pharmacists. There was also the intervention of the representatives of the organizations of Italian pharmacists.
7. Organization of an OSCE (objective structured clinical examination) experience to evaluate the preparation of students with two sessions, one to assess ability to reflect on specific clinical situations, the second on how to answer a specific question of a citizen.
8. Organization of meetings with international experts including the President of the European Society of Clinical Pharmacy and the other with the president EPhEU - Employed Community Pharmacists in Europe.

This BIP not only enhanced students' practical skills but also promoted intercultural understanding and collaboration. The BIP was done in Pavia in 2023, then in Paris in 2024 and will probably be repeated in Dublin in 2025 with University of Pavia as a Partner HEI.

Architecture(s) of Care: Designing Relational Ecologies

Headed by Prof. Nadia Bertolino, Department of Civil Engineering and Architecture (University of Pavia)

TAG: Innovative Pedagogical Approaches, Achievement of Sustainable Development Goals; Engagement with the local communities

The BIP successfully enhanced the competencies of Master and PhD students in sustainable design strategies and interdisciplinary collaboration. Combining online seminars and a five-day in-person workshop, the program facilitated comprehensive learning and engagement. Participants developed deeper insights into sustainable design and the complexities of urban ecological spaces while fostering a collaborative environment where students from diverse backgrounds enriched their learning experience. The program emphasized rigorous research methodologies and the integration of innovative design proposals, with the quality of research being a critical aspect of evaluation.

Learners actively participated by engaging in structured conversations, critical thinking, and international teamwork, demonstrating their learning through final presentations and research-by-design evaluations. Teachers and tutors facilitated seminars and workshops, guiding students through complex topics and ensuring active engagement while assessing participants' performance across various metrics, including communication skills, critical thinking, and collaborative abilities.

Cooperation among the partner institutions was integral to the program's success, with each institution contributing specific expertise. The University of Pavia provided expertise in ecological public spaces design, Opole University of Technology - Politechnika Opolska (Poland) in heritage reuse in historical city centres, the University of Thessaly (Greece) in sustainable design of the built environment and the Universidade de Lisboa (Portugal) in integrated design and previous experience with similar programs.

Key lessons learned included the importance of diverse academic and cultural backgrounds in enriching learning outcomes and fostering innovative solutions, the necessity for clear communication and structured conversations in international and interdisciplinary settings, and a deeper understanding of sustainable design practices and their application in real-world scenarios. Results from the seminars and workshops will be compiled into an edited book and displayed in a 2-day exhibition during Sharper Night 2024 (27th and 28th September 2024).

The program received support from local members of the civic society (Calypso APS, Biblioteca Mirabello Scala, Associazione Asti-Senegal) and the endorsement of CSV Lombardia Sud. Representatives of the City Council attended the final presentation, with Pavia mayor Michele Lissia and deputy mayor Alice Moggi providing feedback on the design proposals.

The long-term impact includes the establishment of enduring research networks among partner institutions, promoting continued collaboration and potential joint ventures in future projects. The BIP successfully implemented a blended learning approach, achieving significant educational and collaborative outcomes, and laying the foundation for sustainable future endeavors.

Marine Environmental Threats (MET)

Headed by Prof. Agnese Marchini, Department of Eeart Science (University of Pavia)

TAG: Innovative Pedagogical Approaches, Achievement of Sustainable Development Goals; Inclusion of under-represented groups in international education

The BIP was coordinated by the University of Pavia with the partnership of the University of Azores (UAç; Portugal) and the University of the Basque Country (UPV/EHU; Spain), under a trilateral agreement. Its first edition was in 2023, the second in 2024 and there will be a third one in 2025.

MET combines two modules of synchronous and asynchronous online lessons taught by UAç and UPV/EHU and a week physical mobility in Pavia. In the context of the UNESCO Ocean´s Decade 2020-2030, MET deals with several aspects related to the causes and consequences of the threats that are jeopardizing the future of our oceans, with focus on climate change, marine pollution (including underwater sound pollution), bioinvasions and overfishing. The online component evolves simultaneously to other curricular subjects and students develop digital competences, communication, and time management skills. The activity in presence includes a combination of seminars, computer models, laboratory, and field work, complemented by a final theatre workshop to stimulate self-expression and creativity. The mix of teaching modalities impacts on the students' personal growth through the development of soft skills, which are recognized in the final diploma with a digital certificate (badge) for the acquired competences, along with the transcript of records worth 6 ECTS.

At the end of the 2024 edition, the contents of the classes were disseminated to the community of international students of UniPV through a live performance that mixed art and science: "Can you *sea*?", where MET students went on stage and executed theatrical lectures on the “marine environmental threats”, followed by aerial performances of a local company of young acrobats. Before-after questionnaires were submitted to the public (over 100 participants) to measure the emotional impact of the show and the level of transmission of scientific concepts.

Skeleton, from new research technologies to therapeutics

Headed by Prof. Antonella Forlino, Department of Molecular Medicine (University of Pavia)

TAG: Innovative Pedagogical Approaches, High- Level Trainings for early career researchers

The BIP organized by the University of Pavia, University of Ghent and University of Paris Cite was successfully realized with online classes held January 8 to 16 2024 for a total of 12 hours and in presence activity in Pavia in June 2024. The program involved a total of 7 professors. Prof. Eckhard P Witten and Prof. Adelbert De Clercq from the University of Ghent, Belgium who provided classes on Bone: evolutionary developmental biology; Prof. Martine Cohen-Solal and Prof. Amelie Coudert, from Paris Cite, France who provided classes on Modelling skeletal diseases: from cells to mammals; Prof Natàlia Garcia-Giralt and Prof. Susanna Balcells from the University of Barcelona who provided class on Genetics and Omics; from Common to Rare bone diseases. Furthermore, two professors from the University of Pavia, Prof. Antonella Forlino and Prof. Roberta Besio, provided classes on Innovative therapy targeting bone signaling pathway. The BIP was accredited as 3 ECTS course within the Biotechnology medical and pharmaceuticals Master of the University of Pavia, and it was attended by twenty-two learners. The learners were Master and PhD students from the four Universities.

The BIP contributed to strengthening the knowledge on skeleton and diseases standing for the first course addressing such topic in the participant University courses. It provided a stimulating environment for discussions among teachers and students the basic and cutting-edge technology in the field of biochemistry and molecular biology of bone. The mixture of basic, applied, and clinical science contributed to stimulating the interest of the participants fostering interdisciplinary learning.

Discovering the unknown: AI in healthcare

Headed by Prof. Valentina Beretta, Department of Economics and Management (University of Pavia)

TAG: Innovative Pedagogical Approaches; Development European University Alliance Initiative

The implementation of the BIP "Transforming Healthcare: An Interdisciplinary Approach (THIA)" has been a success, delivering meaningful outcomes for both learners and educators. The program's interdisciplinary approach provided participants with a comprehensive understanding of AI's role in healthcare. The program was well-attended, with a diverse group of learners and trainers from various academic and professional backgrounds, which enriched the learning experience. The key achievements of the BIP included, for the students, their successful engagement in interactive lectures, workshops, and discussions and, for the teachers, fostered networking opportunities and encouraged collaboration among the participants. Indeed, the partnership cooperation was a critical factor in the program's success. At this purpose, the involvement of multiple universities and departments, each contributing their unique expertise, has been critical to ensure that the main topic of the BIP, namely the application of AI in the healthcare sector, has been tackled from different perspectives. This ensured the integration of various disciplines and perspectives into the program. With regards to the lessons learnt, firstly, the importance of a multidisciplinary approach was underscored, as it allowed participants to gain a holistic view of AI in healthcare. Secondly, the need for continuous adaptation and innovation in teaching methods was highlighted, particularly in response to the evolving landscape of AI and healthcare.

As a result of this program, participants are now better equipped to contribute to the advancement of AI in healthcare. The program also succeeded in raising awareness of the ethical implications of AI, fostering a culture of responsible innovation among future healthcare professionals.

B.SURE - Building Sustainable Reuse

Headed by Prof. Marco Morandotti, Department of Civil Engineering and Architecture (University of Pavia)

TAG: Innovative Pedagogical Approaches, Achievement of Sustainable Development Goals; Development European University Alliance Initiative

The United Nations Sustainable Development Goal (UNSDG) 11 “SUSTAINABLE CITIES AND COMMUNITIES” is assumed here as one of the reference topics for the development of appropriate national and supranational policies. The BIP was strongly multidisciplinary and focused on a strategic topic at international, national, and local level. The BIP intended to include in its activities a representative of students and teachers from each EC2U partner as opportunity for cooperation between the universities involved in the programme.

The European Campus of City-Universities (EC2U) is a multi-cultural and multi-lingual Alliance consisting of eight universities from diverse regions of the European Union: the University of Coimbra, the University of Iași, the University of Jena, the University of Linz, the University of Pavia, the University of Poitiers (Coordinator), the University of Salamanca and the University of Turku.

Starting from this background B.SuRe, which is in its third edition in 2024, is proposed in BIP mode for the first time since it was organized. The didactic program was organised by the experimental didactic and research Laboratory PLAY and STEP of the Department of Civil Engineering and Architecture of the Pavia University. The program was focused on frontal lectures and practical workshop activities that will involve students from the different countries to collaborate in the challenging production of digital output and interactive platform for documentation and valorisation of the disused buildings.

Main topics of B.SuRe: Innovative technologies for heritage representation and valorisation; Sustainable reuse of an historical architecture. The school is organised in different activities: Lectures with international lecturers on the topics of conservation, documentation, reuse, and valorisation of Cultural Heritage; Practical activities – workshops – for the design of the new functionalisation of a historical building important and preserved for its cultural importance in the city of Pavia. This activity was conducted by the participants divided into groups. The aim of the didactic experience is to develop team-building skills, brainstorming activities, and deepening expertise regarding methodologies for documenting, digitally describing heritage and develop strategies for the reuse of built heritage. All the methodologies tested during the workshop represented new approaches that students could apply in their own research field with the support of the tutors and professors.

UniPV Staff Training Week - The future of international mobility

Headed by the international Mobility Unit of the University of Pavia

TAG: Professional Development; Global Cooperation and EU attractiveness

This is an example of a BIP addressed exclusively to academic and administrative staff focusing on International Mobility and participants acquired advanced skills in managing Blended Intensive Programmes (BIPs) and Erasmus+ KA171 projects, which are essential for implementing an international strategy withing an HEI.

Learners also had the opportunity to connect with colleagues from various countries, strengthening relationships and enhancing international collaboration. The week featured a series of seminars and networking activities that facilitated the sharing and learning of best practices. Additionally, participants explored the importance of digitization in international mobility and developed strategies for its effective implementation. The in-person component, held in Pavia, further enriched the experience by allowing participants to immerse themselves in Italian culture and appreciate local history.

The program covered the following topics:

1. Introduction to Topics (online) and preparation of interventions during the presential part.
2. BIP design, implementation, promotion, and dissemination.
3. International Credit Mobility - KA171 design, implementation, promotion, and dissemination.

With 40 participants, the activities included group work, discussions, seminars, and partner experience presentations, for a total of 30 training hours.

The Staff Week in a BIP format is at its second edition, and will be held again in 2025, with a different topic.

Sustainable Initiatives for a Changing world – SIC

Headed by Prof. Emanuele Forlani, Department of Political and Social Sciences (University of Pavia)

TAG: Innovative Pedagogical Approaches, Achievement of Sustainable Development Goals

The BIP was promoted by the Universidad de Loyola (Spain), as hosting HEi, with the cooperation of Instituto Politécnico de Viana Castelo (Portugal), University of Erfurt (Germany), University of Trento (Italy and the University of Pavia as Partners HEI.

Seven years after the launch of the 2030 Agenda, much remains to be done. We are in the decade of action to implement sustainable solutions to address the main global challenges: poverty, gender equality, economic inequality, and climate change. Educating for sustainable development

means developing an educational and research space in the University aimed at achieving competences that promote sustainable development. These competences on which the project was based were: Critical analysis, systemic reflection, collaborative decision-making, sense of responsibility towards present and future generations, international exchange of experiences and implementation of sustainable initiatives.

The project sought to raise awareness and train students in good practices of sustainable development from the multidisciplinary nature of the students through the methodology of Participatory Action Research (PAR). To this end, inter-university groups were created around the challenge of sustainability and climate change. These inter-university and interdisciplinary teams shared good practices that exist in their local environment to address climate change and sustainable development, visited, and learned from experiences about sustainability during face-to-face phase in Spain, and as a group they will propose innovative solutions to a problem that they have identified as a group.

The concept of sustainable development that will be worked on contains the three elements: social, environmental, and economic. The sessions worked on the interdependence of the three components as the key to sustainable development.

Prevention and resolution of disputes in international sales transactions

Headed by Prof. Giulia Rossolillo, Department of Law (University of Pavia)

TAG: Innovative Pedagogical Approaches; Inclusion of under-represented groups in international education

The BIP aimed to introduce students into the goals and different ways of international harmonization of private and commercial law (unification as well as approximation of domestic laws in view of cross-border civil and commercial cases between citizens and companies of different countries). As part of the broader area of privateinternational law, the technique applied to every cross-border civil or commercial matter will be illustrated.

Teaching Methods:

1. classical teaching for the required basic knowledge regarding international organizations and conventions in the field of private international law.
2. active analysis of the text of the underlying international convention (the “CISG”)
3. exercises to apply the techniques of private-international law in smaller hypothetical cross-border cases.
4. exercises to implement the acquired knowledge as to the CISG on smaller cases according to the relevant legal issues covered by the CISG.
5. applying what has been learned so far within a bigger hypothetical case that will be used for the moot court exercise at the end of the on-site session.
6. coaching toward the final moot court exercise.
7. final moot court.

Learning Outcomes:

1. Structural understanding of the different ways of unification as well as approximation of domestic laws in view of cross-border civil and commercial cases between citizens and companies of different countries.
2. Basic knowledge of the techniques used in private-international law.
3. Insight into the possibility to become a member of one’s university’s moot court team (for the VIS Moot Court on the CISG in Vienna).
4. Improved oral skills and presentation skills as a basis for broader advocacy skills.

4. Impact of BIPs in HEIs

BIPs make mobility more accessible to a broader range of students, including those with financial, personal, or professional constraints. By combining online and physical learning, they lower barriers to participation. BIPs encourage institutions to adopt innovative teaching methods, leveraging digital tools to create engaging and effective learning experiences and enhance the collaboration between higher education institutions, creating lasting partnerships that may extend beyond the BIP itself for the creating of other project proposals and activities.

One of the most important characteristics that marks and underlines the inclusive aspect of the BIP is that, notwithstanding the fact that the BIPs are eligible only if the partners are EU University, they are strongly interesting also for partner countries learners (both students, Professors and Staff). This is why almost all BIPs organized by University of Pavia have seen the participation of at least a partner country university that sent students and professors to follow and held lessons, representing one of the added values of the programs themselves.

The data from the University of Pavia's BIPs demonstrate a significant impact on student participation in global learning. Between 2020 and 2024, the university coordinated 31 BIPs, involving 248 international students which corresponds to 38% compared to incoming long-term mobility students.

These programs have also involved 12 departments within the university, reflecting the interdisciplinary nature of BIPs, and the 50% of which were organized by Departments that usually have low percentage of incoming and outgoing Erasmus+ exchanged. This aligns with the broader goals of Erasmus+ to democratize access to international learning experiences.

5. Challenges in implementing BIPs

While BIPs offer numerous benefits, their implementation is without full of challenges. Coordinating multiple institutions across different countries requires significant administrative effort, particularly when it comes to managing logistics, ensuring credit recognition, and maintaining consistent quality standards across virtual and physical components.

Coordination Across Institutions

BIPs require coordination between multiple HEIs across different countries, each with distinct administrative procedures, calendars, and academic regulations. Aligning the academic schedules and ensuring that all partners adhere to a unified timeline can be difficult, leading to delays in the implementation of the programme.

Institutional Commitment and Capacity

The successful implementation of BIPs requires strong institutional commitment from all participating HEIs. This includes a willingness to invest in infrastructure, staff training, and curriculum development. Institutions that lack the necessary administrative capacity or strategic focus on internationalization may struggle to deliver high-quality BIPs.

Accreditation, Quality assurance and Recognition

One of the critical challenges for BIPs is ensuring the recognition of credits earned through the programme across different institutions. Variations in national accreditation standards and university policies can make it difficult for students to transfer credits earned during a BIP to their home institutions. This issue is particularly acute in cases where BIPs are experimental or interdisciplinary in nature, as these programs may not fit neatly into existing accreditation frameworks.

To resolve challenges related to credit recognition, institutions should work towards standardizing accreditation processes for BIPs. Developing agreements between partner institutions regarding

credit transfer, as well as aligning BIP learning outcomes with existing national and international accreditation frameworks, can help ensure that students' academic achievements are recognized.

Despite these challenges, BIPs offer significant opportunities for growth within the internationalization strategies of higher education institutions. One of the most promising areas for development is the integration of microcredentials. By awarding microcredentials for specific skills acquired during the program, such as digital collaboration or project management, BIPs can provide students with tangible recognition that enhances their employability.

Moreover, BIPs can serve as a foundation for deeper collaboration between institutions. The virtual phase of a BIP, particularly when structured as a COIL project, allows institutions to build long-term partnerships that can extend beyond the scope of a single program.

These partnerships can lead to the co-development of curricula and research projects, further enhancing the internationalization goals of participating institutions.

Enhancing Coordination and Communication

Effective communication between partner institutions is essential for overcoming logistical challenges. So, it's essential, from the planning phase establishing clear governance structures and dedicated BIP coordinators can help streamline processes and ensure that all partners are aligned in their goals and timelines. Regular meetings, clear communication protocols, and shared digital platforms can also enhance coordination.

Mobility and Travel Constraints

Although BIPs are designed to reduce the burden of long-term mobility by incorporating virtual elements, the short-term physical mobility component still presents logistical challenges. These include securing visas for international participants, managing travel restrictions, and addressing accommodation concerns for students and staff during the physical mobility phase.

Funding and Resource Allocation

While BIPs are partially funded by Erasmus+ grants, insufficient funding often presents a challenge. HEIs must allocate significant resources to support both the virtual and physical components of the programme, which can be difficult for smaller institutions or those with limited international engagement budgets. Additionally, the allocation of internal staff resources to coordinate the logistical and academic aspects of BIPs can create financial strains.

Then, the hybrid nature of BIPs can require additional resources to support both the online and physical phases. Ensuring that all participating institutions have access to the necessary technological infrastructure is also critical, especially for universities in less digitally advanced regions.

Curriculum Design and Interdisciplinary Integration

One of the key benefits of BIPs is the opportunity for interdisciplinary learning. However, designing curricula that successfully integrate multiple disciplines while maintaining academic rigor can be challenging. Ensuring that all participating students, regardless of their academic backgrounds, can engage meaningfully with the content requires careful planning of learning outcomes, assessments, and instructional methods.

Aligning Learning Outcomes Across Institutions

BIPs often involve participants from multiple institutions, each with its own learning outcomes, assessment criteria, and teaching philosophies. Ensuring that the programme delivers consistent and measurable learning outcomes that satisfy all partner institutions can be a complex process. Misalignments in expectations between faculty members at different HEIs can hinder the overall learning experience.

Digital Literacy

The success of BIPs is contingent on the digital literacy of both students and faculty. Instructors must be proficient in using online learning platforms, delivering virtual lectures, and facilitating interactive online sessions. Similarly, students need to be comfortable navigating digital tools and engaging in virtual collaboration. The digital divide remains a significant obstacle.

Strengthening Digital Infrastructure and Training

To address technological barriers, institutions should invest in upgrading digital infrastructure and ensuring equitable access for all participants. Additionally, providing training in digital literacy for both students and staff is crucial for the successful implementation of virtual components. Online workshops, tutorials, and technical support services can enhance the digital capabilities of all participants.

6. Conclusion

Blended Intensive Programs represent a significant innovation in the field of international education, offering a flexible and inclusive model that integrates digital and physical learning. The case studies from the University of Pavia demonstrate the potential of BIPs to foster global learning, enhance interdisciplinary collaboration, and promote inclusivity in higher education.

Furthermore, BIPs are a great allied to enhance the University Internationalization. Thanks to the intensive programs they convince and enable even the most reticent students to explore the possibility to travel abroad for study, to enrich their academic and personal background.

They give students the chance to know a new country, a new culture and University that might become their choice to continue their studies and academic path for a longer period in the future.

As the higher education landscape continues to evolve, BIPs offer a promising way to expand access to international education and develop the skills needed for success in a globalized world. By addressing the challenges of implementation and exploring opportunities for further development, institutions can leverage BIPs to drive innovation and cooperation in international education.

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Making Learning and Thinking Visible from preprimary to lower secondary schools in Italy

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Abstract

This paper explores the methodologies and practices for Making Learning and Thinking Visible across educational stages from preprimary to lower secondary levels. The objective is to elucidate how teachers can implement strategies that reveal students' thought processes, foster deep understanding, and encourage reflective engagement with content. Visible Thinking (VT) (Ritchhart et al., 2011; Perkins et al., 2000; Tishman et al., 1995) is an approach to teaching thinking to learners that develops thinking dispositions, such as the inclination to be curious, open-minded, or planful, while also deepening their understanding of the topics they study. Making Learning Visible (MLV), instead, focuses on documenting educational practices (Krechevsky et al., 2013) to foster collaborative reflection and teachers' thinking, to support transformational as well as technical learning (Mezirow, 1995). In the preprimary and primary stages, emphasis is placed on play-based and inquiry-based learning environments with more simple Thinking Routines (TRs) (Mughini & Panzavolta, 2020; Ritchhart, Church & Morrison, 2011; Perkins et al., 2000) where children's natural curiosity and direct experience can be elicited. Techniques such as simplified core TRs and documentation panels are highlighted as effective means for capturing and reflecting on children's learning trajectories and thought processes. Transitioning to the primary and lower secondary levels, the focus shifts to more structured TRs for making thinking visible, including concept mapping, role-playing protocols, perspective taking and structured reasoning through sequences of TRs. These methods encourage students to articulate their understanding and reasoning, thereby fostering a classroom culture of open intellectual inquiry, self-assessment and collaborative, constructive peer feedback and group learning.

Keywords: Making Learning Visible, Visible Thinking, Collaborative Research, Deep Learning, K-12 Education.

1. Introduction

This paragraph outlines the foundations of the research presented in this paper, providing both the cultural context and its connection to previous studies on MLTV activities in Italy.

1.1 Making Learning and Thinking Visible in Upper Secondary Schools (Phase 1)

"Making Learning and Thinking Visible" is an initiative resulting from the collaboration between the Harvard Graduate School of Education (Boston, MA) and Indire (the National Institute for Educational Documentation, Innovation and Research). The first phase of the project (2018-2021) involved three upper secondary schools from the "Avanguardie Educative" innovation movement (Laici, Mosa, Orlandini & Panzavolta, 2015), a network of innovative schools aiming at booting educational innovation in Italy.

The idea focuses on enhancing both subject-specific competencies and the development of different types of thinking: critical, creative, logical-mathematical, reflective, decision-making, and systemic (Panzavolta, Mosa, Laici, Guida & Cinganotto, 2018).

The MLTV idea draws on some key concepts: first, *documentation*, understood as the "practice of observing, recording, and sharing the process and product of learning through different media, with the goal of deepening learning itself2 (Krechevsky et al., 2013). Documentation, from this perspective, is the primary means of making learning visible to the individual, their class, and the broader educational community, covering three main areas: the Self, the others (i.e. other

teachers, educators and practitioners), and the community (Mosa & Panzavolta, 2019). It also serves as a way to innovate pedagogical research in schools, encouraging reflection, discussion, and exchange around it (Panzavolta, 2020).

The second construct is *group learning*, defined as “a group of people emotionally, intellectually, and aesthetically engaged in solving problems, creating products, and making sense. [A group] where each learns both independently and with and through others” (PZ & Reggio Children, 2001).

The third concept includes various *tools* (protocols, Thinking Routines, etc.) that make thinking visible and support the development of creative, deep, and divergent thinking. Thought is not just cognitive but dispositional, distributed, and can be made visible through specific practices (Ritchhart, 2015).

The theoretical framework of MLTV derives from the integration of two frameworks developed by Project Zero: "Visible Thinking" (Ritchhart, Church & Morrison, 2011; Ritchhart & Perkins, 2005, 2008) and "Making Learning Visible" (Krechevsky et al., 2013), and their adaptation and localization to the context of Italian high schools (Panzavolta & Mughini, 2020). Visible Thinking employs specific cognitive routines, the Thinking Routines (TRs), a kind of organizational structure to guide students' mental processes and encourage active elaboration.

The goal is precisely to make cognitive processes visible and to foster a culture of exploration and critical thinking in schools (Perkins & Blythe, 1994). TRs encourage students to actively engage with a topic, think beyond the facts they know, connect new knowledge with prior knowledge, shift perspectives, and build dispositions and attitudes. These tools originate from decades of research at Harvard in the broader field of cognitive sciences (Perkins, 1992; Perkins et al., 2000), aimed at investigating higher-order thinking skills and creating the conditions for a thinking classroom.

1.2 MLTV from Preprimary to Lower Secondary Schools (Phase 2)

In 2021, in response to a growing demand from teachers, the research group decided to expand the project by involving schools from preprimary to lower secondary education. Thus, the project "Making Learning and Thinking Visible from preprimary to lower secondary education" was born as an opportunity for schools to deepen some experiences they had carried out during the first phase. This second phase of the project involved four schools: IC "Borgaretto-Beinasco" in Beinasco (TO); IC "Beniamino Gigli" in Recanati (MC); IC "Claudio Puddu" in Prato (PO); IC "Govone" in Govone (CN). These schools were selected among the institutes that were able to guarantee continuity to the co-research project. An agreement has been signed between Indire and each single school. The project started in the 2022-2023 school year and lasted for two years. It concluded in July 2024 with the submission of an ex-post survey for teachers.

In continuity with the first phase of the project, this second phase focuses on *group learning*, students' *forms of thinking*, and the conceptual and organizational tools aimed at promoting teachers' reflexivity, primarily through *documentation*. To ensure the success of the experimentation, the working group of each school was composed of at least two teachers for each level of the first cycle of education (preschool, primary school, and lower secondary school), for a minimum of six teachers per school. A "contact" teacher had the role of coordinating their own working group and acting as a liaison between the whole school community and the researchers. In order to map the impact on the organization as a whole, the working group of each school also included the school principals.

Compared to the first phase of the project carried out in high schools, the co-research group's main challenges in this second phase were primarily two. The first was to observe how tools such as TRs could be used within teaching and learning processes with children aged 3 to 14. The use and potential adaptation of these tools for very young children in preschool, who are not yet able to write, appeared especially challenging.

The second point of interest relates to the format of the co-research process. Following the COVID-19 pandemic, it became common for schools to engage through webinars or videoconferencing. In this second phase of the project, an online research methodology with a

participatory approach (Gerber, Abrams, Curwood & Magnifico, 2017; Salmons, 2022) was introduced. This approach provided continuous support to teachers through a monthly online guidance process, along with the rigorous and consistent use of documentation.

The objectives of both the online guidance process and the project as a whole were:

- To reflect on and explore ways to enhance educational practices by sharing, discussing, and analyzing documentation of students' thinking and learning.
- To contribute to a collective understanding of how to create more effective learning environments in schools and classrooms.
- To develop sustainable and replicable structures, practices, and tools that can be shared across schools.

The project centered on key areas such as educational innovation, metacognition, school motivation (e.g., sense of self-efficacy), and inclusive teaching practices (e.g., personalization, individualization, and differentiation).

2. Materials and Methods

After presenting the overall project context, this section provides information on research methodology and tools.

2.1 Research Methodology

The research methodology is based on the collaborative research model (Desgagné, 1997; Magnoler, 2012), focusing on valuing teachers' thinking (Tochon, 2000; Damiano, 2006) and viewing the analysis of practices as a tool for teacher professionalization (Altet et al., 2006). This approach promotes recursive and interactive processes between theory and practice. Collaborative research involves consistent interaction between researchers and school stakeholders, with the researcher acting as an organizer, facilitator, and co-constructor of knowledge, guiding reflective practice and professional growth (Magnoler, 2012).

The macro research questions are as follows:

- “How can Indire create support systems to transfer Project Zero frameworks to more schools, particularly primary and lower secondary education?”
- “What connections can be made between MLTV frameworks and innovations in Italian education, such as primary school assessment reforms?”
- “Are adaptations needed when applying MLTV practices from upper secondary to lower secondary, primary and pre-primary schools? If so, what are they?”

The profile of teachers in this context is the one of “teacher-researcher”. Teacher-researchers in MLTV engage in a research process to explore questions related to making learning and thinking visible in their specific contexts.

This involves choosing a specific research question, collecting data by documenting the learning-teaching practice – particularly group learning – analyzing data collaboratively by a discussion-guided protocol, connecting with other research efforts to highlight learning and thinking and planning next steps for ongoing in-school inquiry.

The dimensions of analysis of the gathered material insist on three levels:

1. The professionalism of the teacher.
2. The classroom level.
3. The organizational level.

As for the professionalism of teachers, the areas of inquiry vary from “culture” (focussing on whether and how MLTV optimized and improved one’s teaching approach or modified the principles of one’s teaching approach; enriched one’s ability to analyze, describe, and address knowledge in relation to its teachability considering the different developmental stages), to “teaching” (focussing on the overall organization of teaching, strategies and specific techniques

used to facilitate learning, inclusion and formative assessment), to the “social and community” levels (focussing on how MLTV contributed to strengthening one’s collaboration with other teachers, influenced one’s involvement in other professional experiences, contributed to one’s community growth and improved one’s ability to build positive relationships with caregivers and other stakeholders); and finally to the “caring of the profession” area (focussing on whether and how MLTV fostered one’s need for professional development and increased the use of documentation as a tool for reflection).

As for the second level, the teaching-learning practice, the areas of inquiry vary from the “student self-regulated learning” area (focussing on whether and how MLTV promoted active knowledge production, autonomous learning and group learning), to the “system thinking” area (focussing on whether and how MLTV enhances students' ability to deepen understanding, explore phenomena from multiple viewpoints, observe details and complexities, critically reflect on perspective taking, connect one's own perspective to the broader human experience, etc.) to the “emotions in learning” area (focussing on whether and how MLTV allows the design of activities that enable students to experience and confront powerful emotions, pay attention to others’ emotions and reflect and act based on this understanding – such as helping peers – as well as face difficulties and cope with them) to the “creative thinking” and “metacognition” areas (focussing on whether and how MLTV stimulates students and expands their ability to think creatively, encouraging them to use a variety of languages and systems of representation, promotes feedback loops and motivates students to to strengthen their reflective attitude).

Finally, the third level, considering the whole school as a learning organization, operationalizes areas such as “school culture and vision” (focussing on whether and how MLTV connected to the school's culture and identity, integrated with the school's vision and objectives, influenced the way learning and teaching are understood, and promoted the growth of the teaching community in terms of practices, professional profiles, professional stance, attitudes, etc.), the “communication, relationships and knowledge sharing” area (focussing on whether and how MLTV promoted or intensified discussion practices on professional action, encouraged internal communication/relations between and among teachers, families, students and other stakeholders and encouraged shared planning); the “content design and curriculum” area (focussing on whether and how MLTV led to a radical revision of practices, transformed teaching and learning practices with respect to at least one of the dimensions of the Framework of the 8 Cultural Forces, institutionalized in the school’s Educational Offer Plan and contributed to the development of a vertical school curriculum).

One meta-level was also considered, that is the methodological approach itself (focussing on whether and how the MLTV co-research approach has been useful, the periodic meetings demanding, the protocol effective, the use of documentation worthwhile etc).

2.2 Overview of the Research Tools

To implement the project, the research group developed and used a set of data collection tools organized around three phases: ex-ante, in-progress, and ex-post, as shown in Table 1.

Table 1 - General overview of the research strategy and tools.

	Impact on the classroom level	*Impact on the professionalism of the teacher*	*Impact on the organizational level*
Ex-ante	Teachers’ pre-survey		
In-progress	Monthly online meeting “Fishbowl”		-
	In-progress teachers’ survey		
	On-site visits in school		
Ex-post	Teachers’ post-survey		
	-	In-depth interviews with school principals	

1. *Teachers' pre-survey* - Regarding ex-ante research tools, to establish a starting point for the project a *Teachers' pre-survey* was developed. This questionnaire was administered to teachers in May 2022 and the responses were provided in an aggregated form for each school, with a total of 4 respondents. The results were shared during the project's kick-off meeting in June 2022 to collectively evaluate the strengths, challenges, and future potential of the experiment. Due to the initial conditions (small sample size, diverse experiences, and significant individual differences), the questionnaire followed a distinctly qualitative approach. Its goal was to capture the evolution of the experiences over time and highlight aspects that the experimenters found particularly noteworthy.
2. *Monthly online meetings using the "Fishbowl" protocol* - Regarding the tools used during the research-in-progress, the co-research strategy involved mutual ongoing support from researchers and teacher-researchers in the classroom implementation of thinking routines. This was achieved through monthly two-hour online meetings, aimed at facilitating in-depth discussions on teaching and learning practices using the "Fishbowl" protocol (Miller & Benz, 2008), a technique specifically developed for encouraging peer collaboration. A second key element of this process was the documentation activity carried out by the teachers during their classroom work with students. During the online meetings, moderated by the researchers, teachers took turns sharing the documentary materials they had gathered, guided by the research question formulated by their school. Rather than simply describing the practice, each teacher was asked to identify a specific focus of analysis to present as a point of interest for their colleagues. To achieve this, they were required to select and make explicit the observable and shareable elements that could spark an in-depth professional discussion. In this way, the documentation of practices became a method of data collection by the teacher-researchers, based on a convenience sampling strategy determined by the teachers themselves. The meetings served as opportunities to present and share this data. The analysis of the documentation was conducted collaboratively during the online sessions, with triangulated interpretation involving the researchers, the documenting teachers, and other teachers participating in the experimentation. This approach, consistent with collaborative research methods, fostered the development of a productive community of practice (Schön, 1987; Wenger, 2006). Throughout the two-year project, sixteen online meetings were held, each lasting two hours—eight per year, one per month. All meetings were recorded and transcribed, producing a total of 16 transcripts that can be subjected to thematic analysis.
3. *On-site visits in schools using a shared observational protocol* - In addition to the remote discussion activities, the research group conducted onsite visits at the four schools. During these visits, researchers used an *observational protocol* shared by all team members to document teachers' work in the classroom, eventually producing observation reports on the activities. For each school, researchers observed and documented three distinct classroom activities, one for each school level (pre-primary, primary, and secondary education). A total of twelve classroom activity observation reports were generated that will be analyzed using thematic analysis methodologies.
4. *In-progress teachers' survey* - This questionnaire was administered to teachers in June 2023, with responses provided in an aggregated form for each school, totaling 4 respondents. The results were shared during the final meeting of the first year of the project, held in June 2023. The questionnaire aimed to assess the outcomes of the first year of experimentation and facilitate a collective discussion on the strengths, challenges, and future potential of the project. To achieve this, a distinctly qualitative approach was used.
5. *Teachers' post-survey* - Regarding ex-post research tools a *Teachers' post-survey* was developed. Unlike the previous surveys, since the research group had already collected a large amount of descriptive material, this survey was distinctly synthetic and quantitative in nature. Questionnaires were administered to all teachers participating in the project to assess potential impacts on three key areas: "The classroom level", "The professionalism of the teacher" and "The organizational level". The analysis of *Teachers' post-survey*

results, administered in July 2024, is underway. It will also be useful in guiding potential developments of the project (Phase 3).

6. *Interviews with school principals* - To investigate the impact of the experimentation on the schools, a set of questions was developed for the principals. Four in-depth interviews were conducted, and the resulting materials will be analyzed using deductive thematic analysis methods.

3. Results

It is still too early to provide a comprehensive report on the ongoing data analysis. However, the first step in the process involved analyzing the *Teachers' Pre-survey* (May 2022) and the *In-progress Teachers' Survey* (June 2023). The nature of these two research tools was distinctly descriptive and qualitative and here we will present the findings in an aggregated form. Three researchers identified the relevant themes that emerged in each survey, assigned labels to each theme, grouped them into macro-categories, discussed and interpreted the results, and evaluated the findings. The categories that emerged and will be discussed here are as follows: 'Motivation to experiment MLTV,' 'Use of Thinking Routines,' 'Use of Documentation,' 'Corrective measures,' and 'Challenges.'

- *Motivation to experiment MLTV* - Regarding the motivations that sparked preprimary to lower secondary schools' interest in the MLTV methodology, it is worth highlighting that these schools and teachers are particularly focused on the quality of their work. They have developed a reflective attitude, oriented toward continuous research and the use of tools that support their professionalism. It is with this mindset that, in all the cases analyzed, the schools embraced experimentation, hoping that it could provide effective tools to tackle the ambitious challenges each school had uniquely set for itself: strengthening students' problem-solving skills, developing listening abilities, enhancing motivation to study, and fostering reflective and creative thinking. All of these are complex and mature challenges that portray teachers committed to placing the student at the center of the educational process rather than the content.
- *Use of Thinking Routines* - During the first year of experimentation, schools naturally focused on TRs that supported key processes such as listening, broadening perspectives, fostering creativity and inclusivity, promoting student agency and voice, enhancing metacognitive thinking, and encouraging self-correction and the use of mistakes as learning opportunities. According to teachers, TRs were highly effective for several reasons. First, their flexibility allowed them to be adapted to different content and learning contexts. They facilitated collective observation (of images, stories, experiences), encouraging students to share personal insights with the group, thus contributing to the creation of shared knowledge. TRs also stimulated students to activate prior knowledge and formulate questions, which expanded the group's collective understanding: "What do I know about this topic?", "What do I now know after my classmates shared their knowledge with me?", "What else do I want to discover about the topic?". This process encouraged students to reflect on their existing knowledge and interests and collaborate in negotiating questions with their peers: "What do I ask?" "What do you ask?". Furthermore, TRs helped students adopt multiple perspectives, deepening their understanding of topics and encouraging them to consider opposing viewpoints. This led to more meaningful learning by engaging emotional connections and making the complexity of reality more apparent. Teachers noted that empathizing with characters through TRs encouraged students to pay closer attention to what they learned. The routine nature of TRs also played a significant role, helping students develop habitual behaviors, which reduced cognitive load and systematically built skills such as observation, argumentation, and evidence-based reasoning. This consistency allowed students to internalize key processes, like asking coherent questions and providing structured responses, which teachers could then evaluate. Ultimately, teachers observed heightened

student enthusiasm, collaboration, and engagement, particularly among those who were typically less involved, reflecting the overall effectiveness of TRs in the classroom.

- *Use of documentation* - The questionnaires highlight documentation as a key strategic activity in the experiments. In many cases, students are responsible for gathering their own work and materials from the routines, which reduces the teacher's workload and makes the process more sustainable. Teachers may also supplement with additional methods, such as video or audio recordings or scanning student work. Regardless of format—whether textual, video, photographic, audio, or drawings—the primary aim of documentation is to make students' metacognitive thinking visible. This visibility allows teachers to observe and engage with students' cognitive processes, fostering reflection and metacognitive awareness. In class, the use of these materials (e.g., photos of work and transcripts of group discussions) helps to make individual knowledge explicit, facilitates sharing within groups, and promotes broader knowledge-sharing across the class. Teachers noted that dedicating time to documenting and discussing these materials, such as recording debates to stimulate future lessons, significantly enhances teaching effectiveness. For example, the *Ladder of Feedback* protocol was used to document teacher discussions, providing a reflective tool for evaluating their own practices. Overall, documentation serves as a valuable tool for both student reflection and teacher self-evaluation, helping identify strengths and areas for improvement.
- *Corrective measures* - Adjustments were made to the timing of activities, and teacher intervention was needed in the early stages to guide students who were struggling. Once supported, these students were able to continue independently. Minor simplifications were also made to the TRs requirements. In preschool, often TRs were conducted during circle time, with a focus on encouraging individual verbalizations. This allowed children to express their thoughts or learning without external influence. In one TR the families of 5-year-old children were involved, asking the children to describe a classmate. Later, the TR focused on their own family. Additionally, the *Compass Points* TR was used with the families of 3-year-olds during the orientation meeting, providing parents with guidance through the *Suggestions* point. In primary school, prompt questions were sometimes needed to elicit students' ideas. Many times, instead of generating questions as required by the routine, students tend to offer solutions. As a result, teacher intervention is often necessary in order to redirect them towards formulating questions.
- *Challenges* - Some challenges emerged during the experimentation process. In almost all cases, these challenges were surprisingly consistent in pointing to difficulties related to time management. These issues manifested in various ways: managing time within a single routine ("tasks are too long!"), the pace and frequency of routines within the learning process ("frequently applying routines in math teaching seems like an impossible mission"), and the extended time required for student-centered teaching compared to content-centered, lecture-based instruction ("the school often doesn’t allow for this type of planning easily: it feels like we are doing less teaching and taking time away from content"). Additionally, the time required for both the documentation process and for deep reflection on teaching practices proved demanding for teachers. Balancing routine classroom activities with the added task of collecting and analyzing documentation put significant pressure on time management. Secondly, adapting the TRs to different age groups and learning contexts was occasionally difficult, especially when working with very young children. Some teachers noted that while TRs offer flexibility, ensuring that they were effectively tailored to each student's learning style and needs required considerable effort and thoughtful planning. However, the effort required decreased as teacher and students became more familiar with this type of work. In this regard, the concept of routine is very important: “As structures, thinking routines are designed as scaffolds for thinking. They give us as learners a framework for our thinking [...] however, their real power comes in their use as cognitive strategies that become patterns of behavior for students” (Ritchhart, 2015 pp.193-194).

In summary, despite the unique characteristics of each school, the four schools involved in the research project shared common positive outcomes across various educational levels. Notably, the use of MLTV protocols and Thinking Routines proved transformative for teachers, shifting their role from merely teaching content to fostering deeper understanding: as Hobbs states, “Understanding (as distinct from knowledge or skills) is about being able to perform various tasks, such as making predictions about what would happen if [...]. Generating predictions and making inferences demonstrate understanding and, at the same time, advance it by applying it to new situations.” (Hobbs, 2007 p.7).

4. Conclusions

In conclusion, five key themes emerged. As for motivation to experiment with MLTV, teachers embraced MLTV to improve student skills such as problem-solving, listening, perspective taking and creative thinking. They focused on putting students at the center of learning. TRs were effective in fostering high-level thinking skills. They encouraged student reflection, engagement, and adoption of multiple perspectives. Teachers observed that TRs created more meaningful learning experiences. Documentation, though demanding, was essential for capturing student thinking and enhancing collaborative reflection. It was also a tool for teacher self-evaluation and helped make learning visible in various forms. As for corrective measures, teachers made adjustments to the timing and complexity of TRs, especially when dealing with small children in preprimary contexts. Additional support was needed for younger students or those struggling with the routines. Teachers faced time management difficulties in applying TRs and documenting progress. The added demand on time for student-centered learning was significant, especially in adapting routines for different age groups.

Despite these challenges, MLTV and TRs had a transformative impact, shifting the focus from teaching content to fostering deeper student understanding.

During the third phase of the project (school year 2024-25), the Indire-school research group intends to meet in person in order to collaboratively plan the next phase. One direction, in the spirit of Avanguardie Educative (AE), is to organize the workflow as MLTV Mentor Schools. The 4 comprehensive schools involved in the second phase, as well as the 3 upper secondary schools involved in the first phase of piloting, will play the role of AE Mentor Schools. Their tasks are: informant about the MLTV idea, presenting lesson plans and learning examples, organizing seminars and workshops, providing feedback and hosting visiting sessions. During the visit, some structured activities should be organized, such as in-classroom observation, peer planning, documentation discussion and so on.

The role of Mentor school is strongly needed within an educational system where innovation does not spread homogeneously. One of the challenges in propagating innovation is scalability and systematization in schools (meso level) and across the country (macro level). While it is often the case that educational innovation can proliferate at the micro level (from one teacher to another), systemic change at the meso and macro levels is much more problematic (OECD, 2015; Guida, Mosa & Panzavolta, 2019).

In their work on the dissemination of innovation, Murray, Caulier-Grice, and Mulgan (2006) outline a framework with six stages that describe how innovations progress from inception to systemic change. These stages are “prompts”, the moment when an organization recognizes the need or opportunity for innovation, “proposals”, the moment when it generates ideas or solutions, drawing on others’ experience, “prototyping”, when ideas are tested and refined, “sustaining”, the phase when the tested idea are described into a sustainable model, “diffusion”, the phase when the innovation is spread more broadly and, finally, “systemic change”, when the innovation is embedded into the larger system, resulting in transformative change.

The complexity of the fifth and sixth stages, diffusion and systemic change, is significant because they involve the transition of an innovation from a localized or small-scale context (e.g., a single school or organization) to broader societal or systemic adoption. It requires altering the underlying structures, cultures, and power dynamics of established systems. Systemic change often faces

resistance from entrenched interests and requires significant coordination across multiple levels of governance and institutions. It demands not only the acceptance of new practices but also shifts in mindset, organizational culture, and sometimes even legislation.

Harris (2008) highlights these stages as particularly complex because they go beyond technical implementation and touch on broader socio-political and cultural dimensions. Systemic change, in particular, often requires changes in policy, infrastructure, and deeply held cultural beliefs, which are much more difficult to achieve than simply spreading a new tool or practice. Therefore, while innovations may succeed at a micro level, they often struggle to achieve the same level of success when scaled to the meso (institutional) or macro (national or systemic) levels.

This is the challenge that Avanguardie Educative is currently facing, especially at a time when the Ministry of Education, through the Training of School Personnel for the Digital Transition measures (D.M. 66/2023), is supporting a rapid digital transformation. The cultural approach of Avanguardie Educative, particularly through MLTV, could provide essential support for this broader systemic change.

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School networks and types of mentoring networking. Analysis and validation of enabling factors

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Abstract

Despite the recognized value of networked school mentoring, this practice is still not widely adopted due to challenges and obstacles that limit its collaborative effectiveness (Armstrong et al., 2021; Rossi et al., 2022). In 2021, EUN, in collaboration with various Ministries of Education (MOE) and INDIRE, launched the international project "Mentoring for School Improvement (MenSI)" to study and experiment with different forms of mentoring across more than 120 schools, including those in peripheral areas, with the goal of improving professional development and educational innovation. In Italy, INDIRE involved the innovation networks of "Small Schools" and "Educational Vanguards," creating four regional clusters composed of mentor and mentee schools, involving 22 institutions and over 100 participating teachers (Rossi et al., 2022; Panzavolta et al., 2022).The analysis of the "enabling factors" for mentoring was conducted on multiple levels, considering both individual schools and school clusters, first at the international level and then validated nationally. This scientific contribution presents the factors that emerged from the international survey, based on data from a variety of sources (surveys, interviews, observations, and cluster diaries), and then validates these factors through exploratory research involving all the Italian schools participating in the project. This investigation allowed for a redefinition of the priority scale of factors and highlighted significant differences between schools of different levels and regional contexts, helping to identify the conditions that make certain factors critical to the success of school mentoring.

Keywords: Network Ecosystem**,** Mentoring Networking; Mentoring Enabling Factors.

1. Introduction to Network School Ecosystems and value of mentoring networking

In recent decades, the emergence of network ecosystems has played a crucial role in rethinking the ways of fostering innovation and transforming educational systems. The OECD (2015) has promoted the idea that educational networks, based on a collaborative model, represent a unique opportunity to improve the quality of education on a systemic level. Network ecosystems are organizations that promote continuous mutual learning between schools, based on the sharing of knowledge, experiences, and resources. In these contexts, schools are no longer isolated entities, but interconnected parts of a broader system, better equipped to address contemporary educational challenges, such as digitalization, inclusion, and pedagogical innovation (OECD, 2015; Schleicher, 2018; Mangione et al., 2024). International literature has highlighted how the network model, in contrast to the traditional hierarchical model, fosters greater autonomy and responsibility among local actors (Fullan, 2014; OECD, 2019). In this context, school networks, organized around common goals and aimed at exchanging effective practices, can act as catalysts for large-scale change. The effectiveness of educational networks in promoting innovation lies in their ability to break down traditional barriers between schools, creating spaces for experimentation and shared reflection that transcend institutional and territorial boundaries (Kolleck, 2015; Hargreaves & Fullan, 2015). Within network ecosystems, mentoring networking emerges as a powerful tool for professional support and development. This model, based on collaboration between mentor and mentee schools, extends the traditional concept of teacher mentoring, recognizing the added value of transferring knowledge and skills at an organizational level. In particular, mentoring between schools promotes the sharing of experiences on how to implement innovative practices and manage institutional change, with positive impacts on both pedagogy and school governance (Armstrong et al., 2020). Empirical evidence shows that school-

toschool mentoring can act as a driver for educational innovation, not only through the transfer of technological and methodological skills but also by supporting the transformation of organizational practices. A recent study by Hudson (2013) emphasizes how professional dialogue within educational networks provides mentee schools with the opportunity to explore new teaching approaches, address common challenges, and adapt best practices to their own context. This type of collaboration helps reduce barriers that often hinder educational improvement, such as resistance to change or lack of adequate resources (Armstrong et al., 2020). A diachronic reflection on the evolution of educational networks shows that such approaches have been progressively adopted in many international school systems. In the 1990s, the importance of closer collaboration between schools was recognized as a way to address the growing challenges of globalization and the diversification of educational needs (Hopkins, 2001). In Europe, several countries have developed school networks with the aim of improving educational quality through inter-institutional partnerships, as demonstrated by projects promoted by the European Commission (European Commission, Eurydice, 2018). These early approaches inspired subsequent national interventions, such as the British initiative on Teaching School Alliances, which promoted systematic collaboration between schools to disseminate innovative practices (Muijs, 2010). Today, numerous school networks are supported by Ministries of Education or Research Centers to facilitate professional growth and educational improvement processes. In Europe, for example:

- School networks have been established to overcome problems of remoteness and isolation (e.g., the e-Island system in Croatia).
- Thematic networks exist, such as Hungary's Eco School and Talent Point.
- Generalist networks have been created to address political challenges related to improvement and innovation, such as Hungary's Basic School Network (Oktatási Hivatal Bázisintézménye) or the MakerSpace Network in the Czech Republic (Rossi et al., 2022).

Studies that have delved into conceptual approaches related to educational networks over the years (Huber et al., 2014; Kolleck, 2015) have guided INDIRE in promoting collaborations between schools as spaces for reflection on practices and for didactic and organizational innovation (Mangione & Cannella, 2018). In Italy, INDIRE has taken a leading role in promoting educational networks through projects such as Avanguardie Educative and the Piccole Scuole movement, which aim to connect schools of different types and sizes, particularly in peripheral and rural areas, to support innovation and the improvement of education quality (Rossi et al., 2022).At the core of the networking process is the concept of mutuality and reciprocity (European Commission, 2018), which gives rise to horizontal mentoring (Rossi et al., 2022). These networks have helped build a model of shared innovation, based on collective reflection and the exchange of pedagogical practices between educational institutions (Mughini, 2022; Mangione et al., 2024). Moreover, the value of school networks has been further strengthened through the adoption of tools such as Continuous Professional Development (CPD), which enables continuous professional training tailored to the real needs of teachers and school leaders (Cannella & Laghigna, 2023).The Mentoring for School Improvement (MenSI) project, funded by the European Union, has supported and explored the transformative potential of mentoring networking to enhance digital skills in schools (Rossi et al., 2022). INDIRE participated in the project by involving schools from the Innovation Networks (Avanguardie Educative and Piccole Scuole), creating 4 clusters (2 for each network) in specific territories (Emilia-Romagna, Sicily, Campania, and Puglia). The schools involved experimented with a cluster approach, where groups of mentor schools, recognized for their expertise in specific areas, supported other schools in the innovation process. The adoption of systematic monitoring and reflection tools, such as the Deming Cycle (Plan, Do, Check, Act), contributed to improving the effectiveness of the mentoring process, identifying enabling factors and best practices at an international level, and facilitating the adaptation of these models to the Italian context (Panzavolta et al., 2023).Mentoring networking has supported educational innovation and has been a significant professional development opportunity for the teachers and school leaders involved. Participation in school mentoring networks has led to continuous reflection on educational practices and has facilitated the building of professional learning communities. Involvement in collaborative activities, such as workshops, pedagogical

ateliers, and job shadowing sessions, enables participants to acquire new skills and develop a more reflective and strategic approach to their professional practice (Mangione & Cannella, 2018; Cannella & Laghigna, 2023). Furthermore, innovative school networks now present themselves as spaces for experimentation and the dissemination of didactic innovations, making the transformation process more sustainable and widespread. Mentor schools contribute to creating a culture of innovation and continuous improvement, which is reflected not only in teaching but also in school governance. The network approach, therefore, not only improves individual competencies but also strengthens the systemic capacity of schools to tackle future educational challenges (Hargreaves & Fullan, 2015; OECD, 2019).

2. Models and tools for School-to-School Mentoring

Peer review methods have long been recognized as essential tools for fostering professional growth and improving educational practices through collaborative reflection and feedback. In the context of school-to-school mentoring, these methods play a crucial role in supporting the exchange of knowledge, enhancing instructional quality, and promoting a culture of continuous learning. According to Hargreaves & Fullan (2015), peer review mechanisms enable educators to engage in mutual evaluation and learning, which not only strengthens individual competencies but also contributes to broader institutional development. This collaborative model is central to effective school-to-school mentoring, where mentor and mentee schools work together to reflect on their practices, share innovative strategies, and co-develop solutions to common challenges (Muijs & Harris, 2003).

Peer review approaches, such as classroom observations, collaborative teaching, and reflective dialogue, provide structured opportunities for schools to engage in meaningful professional discussions and critically assess their teaching and leadership practices. These methods align with the concept of learning organizations outlined by Senge (2006), where continuous learning is embedded into the fabric of the institution, supported by mechanisms that encourage feedback, inquiry, and adaptation. Research suggests that school systems that adopt peer review methods in their mentoring processes experience increased teacher agency, improved instructional practices, and a more cohesive school culture (Katz & Earl, 2010).

In school-to-school mentoring, several peer review strategies have been widely studied and applied to support professional development and institutional innovation. Below, we present some of the most effective tools, grounded in the literature, that facilitate this collaborative process:

- *School Visits:* School visits are a foundational component of peer review in mentoring contexts, allowing educators to observe firsthand how practices and innovations are implemented in a different school environment (Armstrong et al., 2020). These visits provide mentee schools with the opportunity to reflect on their own practices, draw inspiration from successful implementations, and engage in discussions with mentor schools about contextual adaptation. Research by Chapman et al. (2009) emphasizes the importance of these visits in promoting cross-school learning, particularly in systems seeking to scale innovations across multiple schools.
- *Instructional Rounds*: Modeled after the medical field, instructional rounds involve a group of educators visiting classrooms to observe specific teaching practices, followed by debriefing sessions to discuss observations and potential improvements (City et al., 2009). This peer review method has been shown to foster a deep level of reflection and collective problemsolving around instructional practices. Leana (2011) notes that instructional rounds encourage a culture of inquiry, where teachers collaboratively explore effective pedagogies and refine their instructional approaches based on peer feedback.
- *Job Shadowing:* Job shadowing allows educators from mentee schools to spend extended periods within mentor schools, observing daily teaching and leadership practices. This immersive experience is valuable for contextual learning and professional development, as it provides mentees with real-time insights into the functioning of successful schools (Hopkins, 2001). Through job shadowing, mentees can witness

leadership decision-making processes, instructional methods, and strategies for managing school-wide change, enabling them to reflect on how such practices could be adapted within their own contexts.

- *Team Teaching:* Team teaching, where mentor and mentee educators collaborate in planning and delivering lessons, has been recognized as an effective peer review strategy (Kelchtermans, 2019). This method facilitates hands-on collaboration, allowing teachers to experiment with new techniques while receiving immediate feedback from their peers. According to Friend & Cook (2013), team teaching enhances instructional practices by combining diverse perspectives and expertise, fostering professional growth through real-time collaboration and co-reflection.
- *Learning Walks:* Learning walks are short, focused visits to classrooms, during which educators observe specific teaching strategies or classroom management techniques. Stoll et al. (2006) highlight that learning walks enable teachers to engage in targeted observation, followed by reflective dialogue aimed at improving their own teaching practices. These walks are often structured around particular themes, such as student engagement or formative assessment, providing mentee schools with concrete examples of best practices in action.
- *Semi-Structured Interviews*: Semi-structured interviews serve as a peer review tool in which mentor and mentee school staff engage in guided conversations about pedagogical practices, leadership strategies, and school-wide innovations. As noted by Kvale (1996), these interviews offer a flexible yet focused way to gather insights into how mentor schools approach key educational challenges. Through this reflective dialogue, mentee schools can better understand the principles behind successful practices and consider how to adapt these approaches to their own settings.
- *Video-Based Observations:* Video-based observations, where teaching practices are recorded and analyzed, offer another effective peer review tool in mentoring contexts. As Tripp & Rich (2012) argue, video allows for a detailed and iterative review of teaching episodes, enabling both mentors and mentees to analyze teaching techniques in depth. This strategy also promotes reflective practice, as educators can revisit specific moments in the classroom and engage in detailed discussions about instructional choices, classroom management, and student engagement.

Each of these strategies provides structured opportunities for reflective practice, collaborative learning, and professional growth, making them invaluable tools for school-to-school mentoring. By incorporating peer review methods into mentoring networks, schools can create a culture of continuous improvement, where educators learn from each other and jointly develop solutions to the complex challenges of teaching and learning (Hargreaves & Fullan, 2015). These tools not only enhance individual teacher development but also contribute to the broader goal of systemic educational innovation, as schools work together to elevate teaching standards and improve student outcomes.

3. What factors can be considered Enablers of Mentoring Networking?

Mentoring networking, that is, mentoring between schools organized into networks, represents an emerging area of research in the educational context, but it remains characterized by conceptual and practical gaps. A diachronic review of the literature highlights the importance of certain “enabling factors” that contribute to the sustainability and effectiveness of these mentoring models. However, there is also a lack of empirical studies that systematically validate these factors and investigate their applicability in various contexts. Among the main recognized enablers, leadership plays a crucial role. Harris (2008) thoroughly explored the concept of collaborative leadership within school networks, emphasizing how an effective coordination system that involves all participating schools is essential to ensure the success of mentoring networking. Specifically, Harris points out that distributed leadership allows schools to share responsibilities and resources, creating an environment where all institutions can actively

contribute to mutual improvement. Similarly, Leithwood et al. (2006) stress the importance of distributed leadership in encouraging the participation of all schools in the network in mentoring processes, particularly those that may be less inclined to engage in mentoring activities due to limited resources or expertise. However, while these studies provide important insights, gaps remain in understanding how this distributed leadership can be applied in school systems characterized by significant inequalities in terms of resources and capabilities. Muijs et al. (2011) highlight the difficulty of implementing shared leadership in educational networks where some schools, especially less experienced ones, struggle to take initiatives due to a lack of confidence or institutional support. Another key enabling factor relates to relational aspects, such as trust and communication between participating schools. The development of reciprocal trust relationships has been analyzed by Stoll et al. (2006), who indicate that a strong sense of peer collaboration fosters an environment open to the exchange of practices and innovative ideas. According to Daly (2010), trust is one of the main pillars of effective educational networks, as it allows schools to overcome the fear of appearing vulnerable, openly sharing difficulties, and benefiting from each other's experiences. However, building these relationships requires time and commitment, as highlighted by Bryk and Schneider (2002), who emphasize that trust is an incremental process developed through repeated and positive interactions. Even here, there remains limited understanding of how school networks that start with low levels of trust can build strong and sustainable relationships. Studies like those by Kelchtermans (2019) show that initial lack of trust can often hinder the success of mentoring networks, but few studies have examined how to overcome this challenge systematically. The dimension of cultural context is another aspect that has been overlooked in current literature. Fullan (2001) and Chapman et al. (2009) point out that a pre-existing culture of collaboration is a fundamental enabling factor for the success of educational networks. However, there are few studies that systematically explore how to build this culture in contexts where it is absent. In particular, there is a lack of longitudinal studies that analyze how a collaborative culture can be developed over time through targeted interventions or specific educational policies. This gap is particularly relevant in more isolated school contexts or those with a long tradition of autonomous and competitive work. Moreover, there are insufficient indications of how mentoring networks can adapt to the cultural specificities of different regions or countries. School networks function differently depending on political, economic, and social contexts, but most studies tend to overlook these variables, focusing instead on universal models that may not be applicable in all situations. Another often neglected aspect is the role of technology as an enabling factor. Few studies explore how digital tools can be used to support mentoring between schools in a network. With the expansion of digital platforms and online learning tools, one might expect greater use of such technologies to facilitate communication and collaboration between schools, especially in geographically dispersed contexts. However, as Daly (2010) observes, most educational networks do not fully exploit the potential of technology to create effective and continuous connections among participants. Despite increasing research on the use of digital technologies in schools, their specific application in school mentoring networks remains an underexplored area. This represents a missed opportunity, as integrating digital tools could reduce some of the logistical and relational barriers that currently limit the effectiveness of mentoring networking. Lastly, the long-term sustainability of mentoring networks is another area where studies are limited. While many studies focus on the initial stages of building networks, few examine how these networks can be maintained over time and what mechanisms are necessary to ensure continuity in mentoring. Leithwood et al. (2020) note that many school networks disband once initial funding or support is exhausted, suggesting that the lack of sustainability strategies represents a significant challenge for mentoring networking. Furthermore, Hudson (2013) emphasizes that there is still little understanding of how resource and capacity disparities between schools can negatively affect mentoring, especially in less developed contexts. Without adequate attention to sustainability, there is a risk that these networks become temporary initiatives, unable to produce a lasting impact on educational practices and professional development.

Despite the insights offered by the literature regarding the dimensions that can be considered enablers of a successful mentoring process between schools, one of the main issues is the lack of large-scale empirical research that explores enabling factors in diverse educational contexts.

Most existing studies focus on isolated cases of success, often in countries or regions with relatively developed resources and a pre-existing culture of collaboration. While Leithwood et al. (2006) and Harris (2008) underscore the importance of distributed leadership, there are few analyses that examine how this form of leadership can be implemented in school systems characterized by a scarcity of resources or fragmented governance. Specifically, there is a limited understanding of how schools with less collaboration experience or fewer resources can develop effective leadership capacities to manage mentoring networks. Muijs et al. (2011) point out that less experienced or under-resourced schools may face greater difficulties in playing an active role in mentoring, but there is little research offering practical tools to address this challenge. Another evident gap concerns monitoring and self-evaluation tools for enabling factors within mentoring networks. Although some authors have emphasized the importance of building trust and positive relationships among networked schools (Stoll et al., 2006; Bryk & Schneider, 2002), there are few operational tools that allow for the monitoring of the growth of these relationships and intervention in cases of conflict or communication breakdown. Hudson (2013), for instance, highlights how trust is a key element for the sustainability of mentoring networks, but there is little empirical evidence on what strategies can be adopted to create trust where it is lacking or to reflect on the absence of this dimension and repair deteriorated or easily breakable relationships within a school network. The lack of these tools is a critical issue, as it prevents schools and network coordinators from identifying and addressing relational problems that could compromise the success of mentoring in a timely manner. While the literature and school documents offer a theoretical basis on the enabling factors of mentoring networking, critical gaps remain that need to be filled through broader and more in-depth research. In particular, there is a need for more systematic studies on how these factors can be activated and sustained in different cultural, institutional, and resource contexts. Otherwise, the risk is that mentoring models between schools remain confined to privileged realities, leaving behind those that could benefit most from such collaborative practices.

At the European level, within the Mensi Project, the set of “enabling factors” for mentoring was obtained through an analysis of data on different levels of action within the target school ecosystem: the individual school level and the cluster level of schools (Mangione et al, 2024). Starting from the international context, the factors that contributed to the effectiveness and success of a mentoring-based approach to digital school improvement were revisited and validated through an exploratory survey involving all the schools in the Italian clusters involved. The study, which was confirmatory in nature, aimed to validate, at the Italian level, the key factors, called “enablers,” that contribute to the effectiveness and success of a mentoring process among schools.

4. Methodologies and instruments

Starting from the international context, the factors that contributed to the effectiveness and success of a mentoring-based approach for digital improvement in schools have been revisited and validated through an exploratory survey involving all the schools in the participating Italian clusters. The confirmatory study (Trinchero, 2002) aims to validate, at the Italian level, the key factors, called “enablers”, that contribute to the effectiveness and success of a mentoring process between networked schools: the goal is to determine whether, in the Italian context, some factors are more decisive than in the international context and whether there are substantial differences within the different school levels, between Mentor and Mentee schools, and/or due to the specificities of the various contexts.

The main objective of the “Mentoring ICT Survey” questionnaire is to collect empirical data on participants’ perceptions and experiences regarding mentoring in schools. Specifically, the questionnaire aims to gather information on the priority scale of factors considered key to the development of their cluster and institution. The questionnaire is structured into several sections that allow for the collection of detailed information on participants, schools, and the mentoring processes adopted. The first section of the questionnaire collects basic information on participants and the institutions where they work. This data helps contextualize the responses,

analyze differences between various roles and types of schools, and better understand the institutional context in which each participant operates, as well as correlate the data with specific school characteristics. The questionnaire then investigates the application of the Deming cycle (Plan-Do-Check-Act) (Deming, W. Edwards, 1986) in schools with the aim of assessing its adoption and effectiveness as a tool for continuous improvement. The next section is divided into two parts, each of which explores the enablers of mentoring at the cluster and individual school levels. Participants must rank ten enablers in order of priority, using a scale from 1 to 10, where 1 represents the highest priority and 10 the lowest. This part of the questionnaire provides a detailed overview of the participants' perceived priorities for successful mentoring, both at the network and institution levels. In this section, participants have the opportunity to suggest an alternative enabler they consider important for mentoring and indicate its relative importance compared to the already listed enablers. Additionally, they are asked to indicate which of the existing enablers they would eliminate to make room for the new suggested enabler. The final section of the questionnaire asks participants if they are willing to continue with research and further investigation activities.

As for the questionnaire, it was administered to 158 teachers and 18 principals in total. Among the 81 respondents, 16 were from mentor schools and 65 from mentee schools. Of the respondents, 53.1% belonged to secondary schools and 46.9% to primary schools; 13.6% belonged to the Emilia-Romagna cluster, 33.3% to the Sicily cluster; 24.7% to the Campania cluster; and finally, 28.4% to the Puglia, Lazio, and Sardinia cluster.

5. Quantitative data analysis

The collected data were analyzed using descriptive statistics techniques. The percentages reported represent the sum of the preferences indicated by participants as their first, second, and third choices for each enabling factor, providing a clear picture of the priorities and perceptions regarding the success of mentoring. At the cluster level, data from the international survey revealed that the most important factors are a common theme, achievable goals, and access to resources. In the Italian context, school mentoring has taken on a distinctive form, guided by three main enabling factors (Figure 1): comparison of practices (15.8%), willingness to learn from others (15.4%), and active learning (12.9%). These factors were identified as essential for the success of mentoring networks, reflecting the cultural and pedagogical specificities of the Italian education system. In Italy, the comparison of practices allows schools to share experiences and methodologies, offering opportunities to learn from both similar and different contexts. The willingness to learn from others is rooted in a collaborative culture that values the contribution of each member of the educational community. Active teacher participation in mentoring activities is crucial to promoting direct involvement in innovative practices, fostering the adoption of new teaching methodologies through practical and interactive experiences. These enabling factors not only support the success of school-to-school mentoring but also help create a more equitable education system where innovations can spread and adapt to the specific needs of different schools.

At the individual institution level, the main enabling factors emerging from the international survey were leadership, shared vision, and a school-wide agreed policy. In the Italian context (Figure 2), however, greater emphasis was placed on continuous professional development (34.1%) and peer learning (26.7%). The focus is on the importance of providing teachers with constant opportunities for training and growth, supported by mentor schools through development toolkits and dedicated resources. Furthermore, interactions among teachers promote the transfer of knowledge and skills, fostering a supportive environment for mutual assistance.

The data analysis at the cluster level shows that while there are some common enabling factors between the first and second cycles, such as practice comparison and achievable goals, there are also significant differences. In the first cycle, there is a greater emphasis on active learning (15.8%) and the willingness to learn from others (15.8%). In the second cycle, more priority is

given to access to the knowledge base (9.1%), resource sharing (10.6%), and recognizing and valuing individual participants (8.3%).

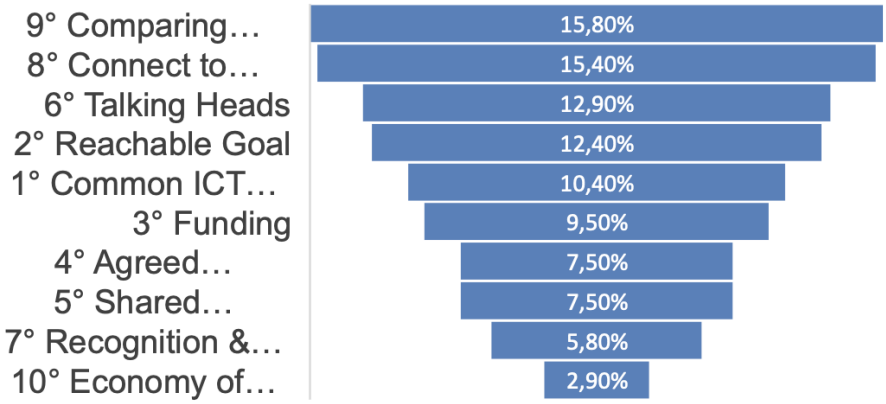


Figure 1 - Cluster Level: Enabling Factors in the Italian Context.

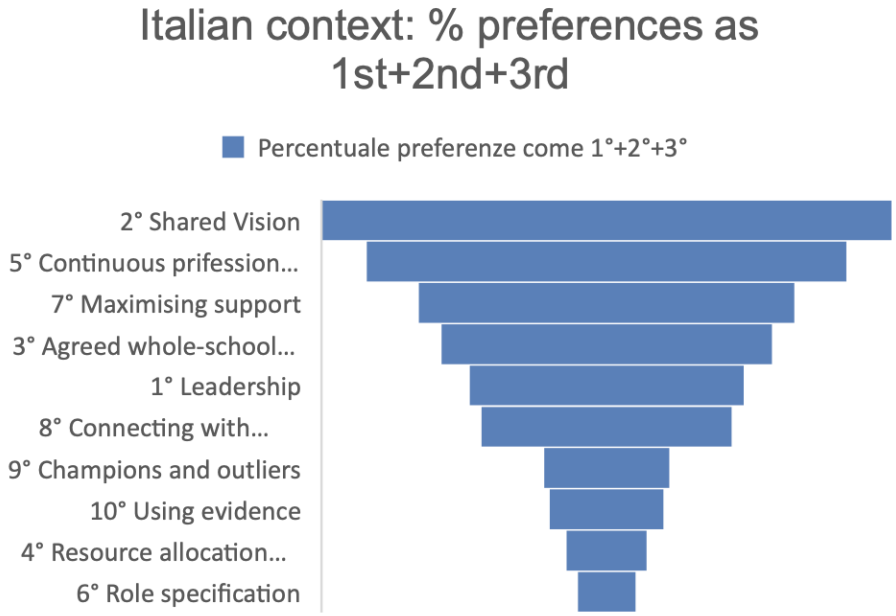


Figure 2 - Institution Level: Enabling factors in the Italian context.

At the institutional level, while shared vision and leadership are key factors in both cycles, peer learning is more valued in secondary schools (9.9%), whereas community engagement is more important in the first cycle (4.6%). Additionally, secondary schools place more emphasis on identifying digital talents (3.4%) and using evidence to inform teaching practices (3.1%), reflecting a stronger focus on innovation and data-driven research. The analysis of the enabling factors for mentoring at the cluster level reveals key differences between mentor and mentee schools. Both categories recognize the importance of practice comparison and the willingness to learn from others, but mentor schools place more emphasis on active learning (14.6%) and resource sharing (10.4%). Mentee schools, on the other hand, prioritize achievable goals (13.5%) and agreed-upon protocols (8.3%). These differences suggest that while mentor schools tend to adopt a more collaborative and dynamic approach, mentee schools require more defined structures and clear objectives to support their improvement journey.At the institutional level, mentee schools place greater importance on shared vision, continuous professional development, and leadership compared to mentor schools. This suggests that mentee schools may need clearer guidance and structured support to effectively implement mentoring activities. Mentor schools, however, give more importance to peer learning and agreed-upon school policies, reflecting a more

collaborative and structured approach. Both categories acknowledge the importance of community connections, with greater emphasis from mentee schools. These differences indicate that mentee schools focus more on building a shared vision and developing leadership skills, while mentor schools prioritize optimizing collaborative and structured practices.

6. Open-Ended responses analysis

To gain a deeper understanding of the enabling factors within the context of mentoring networking between mentor and mentee schools, a qualitative analysis was conducted on the open-ended responses provided by participants in a national survey. The questions focused on the factors considered crucial both at the cluster level (Q20) and at the school level (Q26). The analysis of openended responses allows us to go beyond quantitative data, offering a detailed look at the perceptions, experiences, and motivations of the teachers involved. The analysis was carried out using a thematic approach. The responses were read and coded based on recurring themes that reflect the key concepts expressed by the participants. Among the emerging themes, we identified factors related to resource sharing, the definition of common and achievable goals, the willingness to learn from others, and the use of agreed-upon protocols. These factors were highlighted as key enablers for the success of the mentoring process. The most significant quotes from mentor and mentee school teachers were collected to provide concrete examples of the dynamics experienced within the clusters. These quotes help to deepen the understanding of collaborative practices, and the conditions deemed essential for creating an environment of learning and professional improvement.

From the analysis of open-ended responses on the *enabling factors at the cluster level*, several interesting reflections emerged on key themes that facilitated the success of mentoring between schools. One of the most frequently mentioned themes is resource and best practice sharing. Participants emphasized how the comparison between mentor and mentee schools made learning more active and meaningful, allowing for concrete and shared experimentation of teaching practices. "*The comparison of best practices between mentor and mentee schools was very productive and made learning active and meaningful. There was sharing among schools, and the common theme was developed and achieved by all"* (teacher - mentor school). This process not only led to the acquisition of new methodologies but also to continuous professional enrichment, as highlighted by some teachers who defined this exchange as a "community of practices". Another crucial factor is the definition of a common theme and the pursuit of achievable goals. Many teachers stressed how the clarity of objectives encouraged greater motivation and concreteness in learning. This focus on a shared objective contributed to strengthening group dynamics, allowing for more effective collaboration between the participating schools. "*It is necessary to share a common theme and pursue an achievable goal to be concrete in learning"* (teacher – mentee school). The willingness to learn from others emerged as a prerequisite for the success of the cluster. Several teachers reiterated that without this openness, it would have been difficult to establish true collaborative dialogue and promote professional improvement. "*The willingness and comparison with others were very important for the development of the common project"* (teacher – mentor school). The comparison of practices also played a fundamental role, allowing teachers to reflect on their own methods and make concrete changes in their daily practice. Another interesting aspect is the importance of emotional and relational collaboration for active learning within the clusters. Some teachers noted how working together allowed them to grasp the emotional dynamics present in the daily life of the school, strengthening interpersonal relationships and facilitating reflection on active learning processes. "*Active learning was the priority factor in the cluster as it was necessary to be open to learning and experimenting with the teaching practices proposed by the mentor school"* (teacher – mentee school). Finally, several participants raised the importance of agreed-upon protocols. "*The use of agreed-upon protocols makes the requests and objectives clear, avoiding dispersion across too many fronts"* (teacher – mentee school). The use of protocols provided a clear structure for group work, making it easier to define steps, phases, and expected results. This avoided dispersion, allowing efforts to focus on welldefined and recognizable interventions.

The analysis of open-ended responses on *the enabling factors at the school level* highlighted several key themes, including leadership, shared vision, continuous professional development, and peer learning — elements considered crucial for the success of mentoring within educational institutions. In particular, leadership is seen as a determining factor for ensuring coherence and coordination in school activities. Leadership emerges as a fundamental factor for the success of mentoring within schools. Teachers repeatedly emphasized the importance of having a leader with a clear vision and motivational skills, capable of guiding the institution toward innovation and digitalization. The presence of shared leadership, which promotes dialogue and cooperation among all team members, was seen as essential for creating a dynamic and inclusive learning environment. "*Good leadership allows for faster and more effective organization of work, and similarly, the sharing of vision and an agreed-upon policy for the entire school promotes coherent development of the path"* (teacher – mentee school).

Another significant theme is the need for a shared vision between teachers and leaders, considered crucial for aligning the efforts of the entire institution. Sharing a common vision not only facilitates the achievement of educational objectives but also ensures coherence in the actions taken. According to participants, a shared vision helps avoid fragmentation and promotes the dissemination of best practices. "*A shared vision and agreement on objectives create a useful fabric for the professional development of the entire institution, which remains over time and can be disseminated among the various teachers"* (teacher – mentee school). Continuous professional development was another factor considered essential for constantly improving teachers' skills and adapting to changes in the educational context. Mentoring played a significant role in this process, allowing participants to acquire new teaching methodologies through peer learning and promoting innovation in daily practice. "*Peer learning has allowed us to get to know each other better as colleagues and to work together towards a common goal"* (teacher – mentor school). The direct comparison with colleagues allowed teachers to develop new skills and reflect on their practices, fostering an exchange of ideas and methodologies. As one participant emphasized, "*Peer learning has allowed us to get to know each other better as colleagues and to work together towards a common goal"* (teacher – mentee school*)* highlighting the value of collaboration in professional improvement.

7. Reflection on the survey analysis results and the differences between cluster-level and schoollevel mentoring

The reflection on the results of the qualitative responses, both at the cluster level and at the individual school level, provides an interesting snapshot of the functioning and effectiveness of mentoring networking in the educational context. The differences between the two levels of mentoring — cluster and school — highlight distinct dynamics, while maintaining some points of convergence. At the cluster level, mentoring seems to benefit from a broader and inter-institutional dimension, where resource sharing, collaboration between schools, and the comparison of different practices are key enabling factors. Participants often emphasized how the presence of a common theme and shared objectives promotes dialogue and cohesion between different schools. Active learning, access to shared resources, and the willingness to learn from others emerge as essential components that have enabled schools to experiment with new teaching methodologies in a collaborative manner. In this context, cluster-level mentoring appears particularly useful in breaking down institutional isolation and creating opportunities for mutual exchange. However, the larger dimension of the cluster requires careful management of interschool relationships and the definition of agreed-upon protocols to avoid dispersion and maintain a common vision. At the school level, mentoring takes on a more internal dimension, focused on the individual and organizational growth of school staff. The qualitative responses show that leadership and shared vision are central to promoting coherence in actions and ensuring that innovative practices are adopted by the entire teaching body. At this level, the role of continuous professional development and peer learning becomes more prominent, considered indispensable for the constant improvement of skills and teaching practices. School-level mentoring, therefore, tends to focus on building an internal collaborative culture and the

systematic dissemination of best practices, often through the creation of informal networks among teachers and shared training moments

A key difference between cluster-level and school-level mentoring lies in the scale of interaction and the management of complexity. At the cluster level, mentoring requires broader coordination between different institutions, often with varying resources and contexts, while at the school level, the focus narrows to harmonizing practices within the same educational community. Peer comparison and resource sharing are important in both contexts, but at the school level, these processes take on a more structured and long-term form, while at the cluster level, they may be episodic or limited to specific projects. While there are similarities between cluster-level and school-level mentoring—such as the centrality of collaboration and the sharing of resources and best practices—the differences in scale and strategic focus determine distinct dynamics. At the cluster level, mentoring aims to strengthen the bond between schools and promote a culture of shared innovation through inter-institutional dialogue. At the school level, however, mentoring focuses more on building a cohesive educational community, oriented toward continuous professional growth and the systematic adoption of innovative teaching practices. Both levels are essential for promoting quality education, but they require different management approaches and strategies to maximize their impact.

8. Conclusions and research perspectives

The results of the national survey revealed significant differences between the Italian and international contexts. In Italy, the enabling factors were more oriented towards practice comparison, a willingness to learn from others, and active learning (Stoll & Louis, 2007), fostering greater interaction and mutual participation in the collaboration and sharing of practices. In contrast, the international context placed more emphasis on structural elements such as defining achievable goals, access to resources, leadership, and well-defined school policies. These differences reflect varying educational cultures, pedagogical approaches, and specific needs of school contexts. The discrepancies underscore the necessity to adapt mentoring policies and educational strategies to the specifics of the local context. In Italy, the emphasis on practice comparison and active learning reflects an educational tradition that values collaboration and experience sharing, suggesting that mentoring initiatives should be designed to enhance and strengthen these characteristics. Both contexts recognize the importance of a shared vision within the school; however, while the international level emphasizes leadership and school policies, Italy prioritizes continuous professional development and peer learning (Lieberman & Miller, 2001), indicating a more collaborative approach focused on internal professional improvement (Shank, 2017). Schools must be able to adapt mentoring strategies to their specific needs, goals, and available resources. This requires school leadership capable of recognizing the peculiarities of their context and promoting an open, collaborative learning environment. The emerging data highlights that there is no universal approach to educational success. Schools need to identify the most relevant enabling factors for their specific environment, adopting customized strategies that respond to their conditions and needs (Hargreaves, 2021). The results obtained provide valuable insights for designing more effective educational policies and mentoring practices that are adaptable to local specifics. However, the study has some limitations. The sample size, while representative, could be expanded to include a larger number of schools and diverse contexts. Furthermore, additional research could explore in more depth the long-term impact of school-to-school mentoring on educational practices. Future research should continue to investigate these dynamics to ensure that school mentoring can fully realize its potential for educational improvement and innovation.

In light of these findings, the future research perspectives of INDIRE focus on two main directions: the development and validation of a mentoring toolkit to propose to innovation networks, and the international validation of the enabling factors for mentoring. The first initiative aims to support the systematic development of professional growth for school actors through the sharing of mentoring models, operational guidelines, and training materials and self-reflection regarding enabling factors and the situation of the specific school or cluster. The second initiative involves

the international validation of a framework on the factors that facilitate the success of mentoring, involving all schools in the Mensi Community from different countries. This process entails collaborative research with international schools, cultural adaptation of enabling factors, and impact assessment through comparative studies and longitudinal evaluations. These actions represent fundamental steps to ensure the sustainability and adaptability of mentoring practices in innovation networks. Through the development of specific tools and the validation of enabling factors in international contexts, it will be possible to promote continuous improvement of educational practices and student outcomes.

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Clustering and emerging mentoring models

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Abstract

Mentoring in schools is used both as an effective teaching/learning strategy between teacher and learner (Bird, 2001) and for the support of novice teachers (Mullen & Klimaitis, 2021; Lyons et al., 2019). More rarely it has been used in the context of school communities supporting each other, as in the case of mentoring experienced by the schools involved in the MenSI (Mentoring for School Improvement) project. The European Schoolnet consortium coordinated the project which involved 120 schools from six countries [Belgium/Flanders, Croatia, Czech Republic, Hungary, Italy, Portugal]. The main objective of the project was to promote digital innovation in schools using ICT but also, at the institutional level the involvement of small schools and schools located in marginal contexts with disadvantaged students, and to explore and analyze the effectiveness and sustainability of mentoring approaches. This contribution intends to describe the mentoring models that emerged during the experimentation among the Italian schools. After the end of the project funded by Horizon the project was extended for one more year due to the effectiveness emerged by the evidence and by the teachers' and school leaders' voices.

Keywords: Mentoring, Disadvantaged Students, Digital Innovation, ICT, Marginal Context.

1. Introduction

The expectations society has of schools are manifold and increasingly high; schools are of crucial importance in the formation of tomorrow's citizens and represent a pivotal institution for the future of society, with a complex and multifaceted role. It must be capable of preparing young people for the world of work but also of forming ethical and aware citizens, ready to face global challenges with responsibility and humanity. School is no longer seen only as a place where notions are transmitted, but as a fundamental institution for the integral development of the person, capable of preparing students to face continuous challenges. In a globalized world dominated by technology, society demands that schools promote digital skills, critical thinking, creativity and the ability to solve complex problems. In addition to this, it is called upon to promote social values such as solidarity, respect for others, cultural diversity and inclusion. In a context where social inequalities are increasingly evident, the educational institution should be an agent of social mobility (Maccabelli, 2010) capable of offering everyone, regardless of background, the same opportunities for success. Teachers are faced with an important task, and it is essential that they be supported in order to best fulfill their profession.

While a great deal has been invested in the training of school personnel to support professional growth, a crucial element for the smooth functioning of the educational system, it appears essential to activate processes that accompany the teacher in the design, testing and evaluation of new teaching methods. This involves activating processes that support change and foster exchange among colleagues. One of the most effective ways to foster this professional growth is mentoring, a coaching practice in which a more experienced teacher guides and supports a less experienced, or struggling, colleague not only from a technical point of view, but also in terms of motivation and personal development. The mentoring process is based on trust between colleagues, constructive discussion, and offers mutual benefits: the mentor strengthens his or her leadership and reflective skills, while the "mentee" teacher gains new skills, approaches, and confidence. Mentoring can be a valuable approach to support all those teachers who wish to innovate teaching but lack the courage to do so due to fear or difficulty by providing an environment for discussion, learning, and professional growth. In an educational context where

change and innovation have become imperative, many teachers face new and complex challenges, such as integrating technology, inclusive teaching, and promoting soft skills. Mentoring provides them with practical and emotional support (Roberts, 2000) to deal with these changes effectively.

Mentoring allows for constant dialogue and personalized discussion with an experienced mentor; teachers can receive specific advice and guidance, addressing their individual needs. This form of mentoring allows them to explore new teaching approaches, such as the use of digital tools, active methodologies, or differentiation of teaching, with guidance. Mentoring encourages sharing and reflection on practices among colleagues, thus avoiding professional isolation, which can often hinder the adoption of innovative practices. This confrontation allows for discussion of ideas, experimentation with new methodologies, and facing possible difficulties with greater awareness (Zachary, 2005). For those who wish to innovate, it is essential to have the opportunity to exchange views with a colleague (Cohen, 2003) who has already faced similar challenges, promoting professional development based on ongoing dialogue. Mentoring can have the function of supporting the initiation of a new experimentation; a mentor can encourage calculated risk-taking, supporting the teacher in the innovation journey, monitoring results and making adjustments as the work progresses. This kind of support decreases the anxiety associated with change and stimulates steady growth (Schön, 2008). Mentoring for instructional innovation can involve the introduction of new technologies or techniques, but also a broader rethinking of the teacher's role and practices. An experienced mentor can help the teacher critically reflect on his or her own approach, encouraging him or her to promote teaching that is more student-centered, flexible, and inclusive. Innovation is not just a matter of tools, but of mindset, and mentoring fosters precisely the development of an attitude open to change by allowing some of the most challenging tasks that modern schooling requires to be addressed effectively. A teacher supported by a mentor also has the opportunity to develop greater critical awareness about his or her own practices, understanding strengths and areas for improvement (Orland et al., 2010).

Mentoring in schools is generally used both as an effective teaching/learning strategy between teacher and learner (Bird et al., 2015) and for supporting novice teachers (Mullen & Klimaitis, 2021; Lyons et al., 2019). More rarely, it has been used in the context of school communities supporting each other, as in the case of mentoring experienced by the schools involved in the MENSI (Mentoring for School Improvement) project [Horizon Mensi https://cordis.europa.eu/project/id/101004633]. This approach not only contributes to the improvement of each teacher's professional development, but also implies a revision of the organizational model, with the aim of increasing and sharing the in-school know-how of knowledge and skills that are developed as a result of confrontation and peer work.

The project aimed at qualitative research of models, both theoretical and practical, of mentoring and analysis of widespread policies to accompany schools in the use of ICT. The partners employed their school networks for a bottom-up dissemination of innovation through mentoring between schools that served as hubs in the MenSI project.

2. Materials and methods

Mentoring is considered in the current literature to be one of the most effective practices for facilitating learning and takes the form of a process in which a more experienced individual or groups of individuals (mentor) guide and support the less experienced (mentee) by facilitating the development of personal skills, knowledge and abilities (Randolph & Johnson, 2008; Herrera et al., 2000; Black et al, 2010). This process takes place through interaction, the exchange of ideas and the shared use of materials and resources useful for new learning. In recent years, the practice of mentoring in education has spread at various levels: mentoring between students, between teachers and students, between teachers and finally between schools. According to Allen & Eby (2007) mentoring represents a unique relationship between two individuals characterised by mutual learning. The main objective is to provide support and guidance that foster the acquisition of knowledge and skills. In the field of education, schools and teachers are

confronted with numerous changes, which pose complex challenges and require continuous adaptations, and *topdown* training together with the numerous commitments they face does not allow them to respond adequately to the demands posed by school objectives. In this context, mentoring becomes a key tool for both individual and collective professional growth. A crucial factor characterising mentoring concerns the professional relationship that is established between mentor and mentee, based on mutual trust and respect. Turgut & Taşçı (2024) distinguish between mentoring at the macro level, which contributes to the growth of the educational system, and mentoring at the micro level, which promotes the reduction of dropout rates and increases the educational success of students. The micro level in addition to including mentoring between teacher and student (Kutsyuruba et al., 2019; Butler et al., 2012) is a very effective practice in the relationship between teachers, such as that which occurs between experienced and novice teachers (Lindqvist et al., 2024; Aderibigbe et al., 2018) which in addition to contributing to professional development, promotes trust reinforces a sense of belonging and improves work well-being (Abetang, 2020). At the macro level, mentoring between schools represents a practice between schools that is less widespread and certainly more difficult to implement. It implies the creation of networks of schools that are willing to share their internal know-how to support other institutions in achieving objectives, which can be defined and adapted from time to time. An example of how this collaboration can be beneficial concerns certain issues that may be of common interest among schools such as, for instance, addressing the problem of early school leaving or improving student learning performance through the use of effective and targeted strategies (McMeekin et al., 2003; Admiraal, 2021). This approach, which involves a considerable number of schools through the networks that are created, has the potential to generate significant impact at a systemic level, even withstanding teacher turnover or changes in school leadership. However, it is important to recognise that the articulation of activities required to effectively implement such networks may be complex. For this reason, it is crucial to consider two main aspects: the content aspect and the organisational aspect. The first aspect is crucial because it identifies the core issues that need to be addressed, recognises the competences within the school that can be shared and, at the same time, identifies the critical issues that might emerge along the way. This in-depth content analysis makes it possible to focus on the most relevant objectives and to plan the strategies needed to address the challenges (Hairon et al., 2020; Schenk et al., 2020).

On the other hand, the organizational aspect requires a strategic guide (Mullen et al., 2021) that acts as a director and facilitator of the process, creating the optimal conditions for teachers and managers from different schools to collaborate effectively. Such guidance must include tools and practices that promote communication and the sharing of resources, thus enabling barriers that may hinder cooperation to be overcome. Only through careful and targeted coordination, taking into account all the above-mentioned aspects, it will be possible to maximize the benefits of mentoring between schools. This approach not only fosters improved educational practices, but also contributes to the overall development and growth of the educational system, creating a richer and more stimulating environment for students and teachers.

2.1 Research Methods and process

The Mensi project was primarily based on qualitative investigations of models of mentoring theory and practice and a policy analysis of school-wide mentoring approaches.

The sample was chosen according to criteria shared with the project member countries in such a way as to coalesce around the pathway schools with a similar profile both in terms of the use of technologies and in terms of experiences of accompanying experimentation in the use of teaching methodologies.

Based on the school criteria specified by the consortium, the partners have organized the school selection process independently in the 6 MenSI pilot countries (BE, CZ, HR, HU, IT, PT). This has resulted in a total of 24 mentor schools and 96 mentee schools which will work in clusters, each composed of 1 mentor school working with 4 mentee schools. Each country has 4 clusters. The sample of schools taking part in the project was selected from among the schools in the Indire networks (Avanguardie Educative and Piccole Scuole) through a national call for applications in

which internationally agreed selection criteria were indicated. The profile of the sample school had to respond to five Indicators (Categories) taken from the SELFIE (Leadership and school capacity for digital innovation; Teacher; Students; Collaboration, partnerships and networking; Digital Resources/Infrastructure) broken down into five criteria for each indicator that made it possible to identify schools with a robust experience of the use of technologies at systemic didactic level and mentoring skills both inside and outside the school.

From this ideal profiling, four schools were identified as 'Mentor Schools' or Advance schools capable of transferring and scaling up digital technology-related innovation in school. At the level of individual teachers, networking and peer-to-peer mentoring - an experienced teacher guiding and supporting a less experienced one - are effective mechanisms for professional development. However, at the whole-school level, these approaches are less widespread despite evidence of effectiveness.

2.2 Emerging mentoring models

School-to-school mentoring entails holistic, active collaboration between two or more establishments for specific purposes, such as professional development, to overcome isolation or overall organizational improvement. Such mentoring often takes place through school networks but there can be large differences in outcomes, depending on factors such as whether participation is voluntary or compulsory, instigated externally or internally, or recognised and supported by education authorities.

A literary review, conducted within the MenSI (Mentoring for School Improvement) project, funded by the EU Horizon 2020 programme, identified three models of mentoring (CUREE, 2005; Camberwell, 2016; Armstrong, Brown, Chapman, 2020; Panzavolta, Cannella, 2024). The first model is of the top-down type and involves support from central institutions, such as Ministries of Education or national actors; these models are characterized by a common scientific and technological architecture, provision of tools, guidance and strategies for both Mentors and Mentees and a reduced level of autonomy. The second model is of the bottom-up type and is a different and opposite structure to the previous one: Mentor and Mentee schools self-determine their mentoring process, the level of autonomy of the subjects is very high and the tools and strategies are based on experience, rather than on shared scientific knowledge or scientifically validated tools, which is the strong point of the first model. The third model is of the mixed type and integrates the two perspectives (mixed approach).

It is therefore important to understand better how 'top-down' and 'bottom-up' approaches work and to explore different incentives and rewards that can motivate schools to become engaged in whole-school peer learning.

The Horizon Mensi project involved 6 participating countries (Italy, Portugal, Croatia, Hungary, Czech Republic, Belgium), 24 schools, totalling 120, organized in 4 national clusters, and were selected by public tender. The clusters consisted of one Mentor school and 4 Mentee schools. The criteria for selecting the Mentor and Mentee schools were defined at European level, identifying both the themes of expertise needed and the characteristics of the actors involved. The Italian schools were grouped according to the criteria of belonging to 4 Clusters. (Cluster 1 Emilia Romagna, Cluster 2 Sicily, Cluster 3 Campania, Cluster 4 Puglia, Lazio and Sardinia). Each Cluster was characterized by one main theme on which the research action carried out in the following months was focused.

The topics on which mentoring processes have been activated, in Italy, are part of the proposals of two networks Avanguardie Educative and Small and rural school network. MLTV - Making Thinking and Learning Visible (Mughini & Panzavolta, 2020), Digital Educational Content (Anichini, 2020), were the mentoring focus of the two secondary schools. The practices of digital use in the classroom (Rivoltella, 2022) and Outdoor education (Giunti, Orlandini & Panzavolta, 2022) have been the focus of the lower secondary and primary schools involved. The two lower secondary schools selected for the mentoring process emphasized the importance of the involvement of the School Leader as part of the process ensuring an overall vision and as a driver of change capable of analyzing the processes initiated for improvement and facilitation of formal and informal

exchange. In the Bobbio school, the vision was elaborated by the staff who determined the institute's planning (plan) then shared it with the school board. In Giovanni XXIII Mentor School, the School leader pointed out the importance of identifying Mentor teachers who can analyze training needs and encourage colleagues in sustainable activities, considering their proximal development and creating conditions for professional growth that are challenging and stimulating.The schools indicated what tools were needed to plan and monitor the mentoring process. In secondary schools, Mentor schools focalized their support process activities in using ICT in the curriculum and/or school pedagogy. The schools highlighted the importance of sharing resources and the readiness to learn from others. According to ISIS Europa, the cluster becomes a 'producer' of collective knowledge, reflections and professional practices that become resources. ISISS Majorana reports on the sharing and exchange of resources, the use of apps and dedicated platforms but also videos, collaborative lessons, use of augmented reality, storytelling, hyperdocs and shared templates.

To scale up the innovation in the school a large number of participants must be involved. To produce a systemic change, it is necessary to arrive at a cyclic cascading process over time that fosters the growth of the school community. It is necessary for the teachers involved to be open to exchange, to benchmarking, learning from the experience of others, picking up the strengths of the best colleagues to adapt them to their own reality, seeking inspiration for one's own work and learning from the mistakes of others, trying to avoid them. These elements are valid between colleagues from the same school but also within the exchange between schools. The visiting of schools is fundamental, as it allows one to enhance one's own experiences and nurture other school visions. The tools for planning, initiating and testing the mentoring process turn out to be a fundamental part of the process.

2.3 The Training of the mentee schoolteachers

The Moodle platform was fundamental for carrying out the activities as it provided all the technical means necessary for group work carried out remotely. The users were registered and grouped according to the criteria of belonging to 4 clusters.

The activities of the 4 clusters were set up following the planning of the 4 phases of the Deming Cycle (Plan-Do-Check-Act) and were independently timetabled, setting up the events-meetings at agreed times and intervals based on the needs of the members of each cluster, under the guidance of the Mentor School. For each phase, a Cluster-specific Webex meeting was scheduled.. These activities were also enriched with moments of asynchronous communication.

The key role of the videoconferencing connection should be emphasized. The meetings, in fact, were all video-recorded by exploiting the integrated functions, and were made available online in the platform so that users could deepen or review the most significant moments. For each phase, a Cluster-specific meeting was scheduled, in which users were able to address the topics proposed by the Mentor School teachers, and start the work to be done to complete the assigned task and in view of the next phase. These activities were also enriched with moments of asynchronous communication via the Forum application, sharing and exchange of teaching materials in the repository folders, from which the various files made available could be easily downloaded, and in some cases, finally, with in-person visiting events.

3. Results

With regard to the research in the European context, the Brunel University team, in collaboration with Indire, found confirmation of the elements that define a good mentoring process in the literature (Harris, 2008, 2018; Kools & Stoll, 2016; Hobson & Malderez, 2013) such as strong leadership; the creation of a sense of shared ownership and responsibility; the prospect of professional growth; clarity in roles and planning of actions to be taken; the presence of a climate of trust and communication (Hobson & Malderez, 2013); and satisfactory digital maturity. The mentoring architecture differed from country to country: Belgium employed regional clusters per educational level, Croatia created clusters based on geographical proximity and Hungary

designated hub schools per county to spread the impact of the project. Italy focused on a constructivist model, giving agency to Mentor actors (Panzavolta, Garner & Nencioni, 2022), while Portugal exploited effective communication between national coordinators and school leaders.

A first result has to do with the importance of the mentoring structure, which provides the framework of meaning within which the processes take place. According to the Mentee schools, the architecture and tools suggested and collaboratively produced by Indire and Mentor schools were essential to improve their approach to innovation thanks to the Italian approach. The documentation proposed to support the mentoring and feedback process has been made more incisive in the absence of face-to-face interaction due to Covid-19. Face-to-face meetings have been organized only at the end of the project and for this reason they were very few.

4. Conclusion

The evidence collected at the end of the two-years project funded with Horizon allowed the research team to identify two main aspects. Firstly teachers' collaboration increased in terms of exchanging teaching resources and sharing good practices in a systematic way. This approach had an impact on the scaling up of digital innovation. The second aspect that evidence highlighted is the fact that digital innovation can be a driver of change if it is not an isolated event but requires a systemic approach that comes from the bottom, and involves all the school community. The effectiveness of the project activities led the research group to ask for an extension of MenSi main activities supporting it with internal funding to collect evidence about the enabling factors for an effective team in mentoring. Finally, Indire carried on one more year of research activities focusing on three main dimensions: professional development (Moolenaar, Daly & Sleegers, 2010); collaboration and sharing (Chapman & Fullan, 2007; Harris, 2008; Muijs et al., 2011); teaching methodologies and digital use (Earp & Bocconi, 2017). Sustainability remain the real challenge.

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