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Special Issue
Artificial Intelligence and the paradigm shift of teachers' role

Guest Editors
Roger Azevedo, Giuseppe Città, Manuel Gentile, Dirk Ifenthaler

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Editorial. Artificial Intelligence and the paradigm shift of teachers' role

Editoriale. Intelligenza Artificiale e cambiamento di paradigma del ruolo degli insegnanti

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Technological 'evolution' has always influenced the world of education by providing new opportunities and challenges for teachers, school leaders, students, and families. Among the various technologies today, artificial intelligence (AI) is the one that attracts most of the interest. In fact, for the last two decades, the intertwining of AI and education has been the subject of intense study, so much so that research in this field has already contributed to providing the first evidence, in particular by demonstrating the ability of AI-based systems to meet the individual needs of students (Brusilovsky, 1996; Azevedo, 2002; Nye, 2015; Hemmler & Ifenthaler, 2022; Azevedo et al., 2022).

However, the 'new renaissance' that AI is experiencing, generated by innovations coming mainly from research in deep learning and generative AI, seems to outline scenarios that go far beyond the effect that new technologies typically have in the educational sector (Gentile et al., 2023a). In fact, recent advances in AI seem to have the power to reshape traditional educational paradigms (Ifenthaler et al., 2024), so much so that there is a discussion on how AI may influence the academic sector and future educational policies.

In this context, which forms a paradigm shift (Kuhn, 1970), teachers are certainly one of the key players involved and called upon to be actively involved in the change processes. After all, teachers have always been called upon to update their teaching practices by seeking to integrate new technologies rather than reject them. However, even in relation to the teacher's role, the changes introduced by AI signal a radical change.

The special issue, "*Artificial Intelligence and the paradigm shift of teachers' role*", aims to assess this dimension that recent AI advancements in education have produced. Through a meticulous peer-

review process, we selected five papers that contribute different points of view concerning the dimensions of change in the teacher's role (Gentile et al., 2023b).

With respect to the dimension of teachers' professional development, using the concept of transitional space, Iannella proposes an interpretation of generative artificial intelligence (GenAI) as an opportunity for growth for individuals and, in particular, for teachers' professional development. The author posits that the interaction with these systems materialises the transitional space as a playground where diverse realities coexist. This view calls upon teachers to be metacognitive practitioners, possessing complex knowledge that involves a dynamic relationship between technology, pedagogy, and the subject matter they teach.

However, the professional development strategies of teachers that policymakers will introduce have to consider the existing gap between urban and rural schools, seeking to ensure that the opportunity for change offered by the advent of AI does not contribute to widening this gap but rather is an opportunity for inclusion.

This is the theme of the contribution of Mangione and colleagues, who, in their study, present the results of a scoping review.

Raising teachers' awareness regarding the possible advantages and disadvantages of AI technologies requires an understanding of the underlying mechanisms. Therefore, a thorough examination of the definition of AI literacy is necessary.

Biagini and colleagues tackle this issue by showcasing the findings of a study that evaluates the AI literacy of doctoral students in a socio-educational setting, thereby representing the future generation of researchers and lecturers.

The study underscores the need for a more comprehensive approach to AI literacy, which includes a deeper understanding of its ethical, social, and economic implications, by analysing the cognitive, operational, critical, and ethical dimensions of AI in education.

Bosch and Kruger instead focus on how AI changes teacher-student interaction from a self-directed learning perspective. In their contribution, the authors explore the integration of chatbots as an open, dynamic, and customisable teaching resource in teaching and learning processes related to self-directed learning approaches. In this context, the authors suggest guidelines for integrating these technologies, considering the potential roles of both students and teachers.

Finally, Mastrogiacomi's contribution explores how the role of educators is transforming into that of facilitators of change who promote a use of technology capable of supporting and sharpening students' metacognitive skills. The author highlights how educators must work in collaboration with AI, redefining the boundaries of professional and personal training.

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The transitional space. Generative Artificial Intelligence as an opportunity for growth

Lo spazio transizionale. L'Intelligenza Artificiale Generativa come opportunità di crescita

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ABSTRACT This theoretical paper offers an interpretation of Generative Artificial Intelligence (GAI) as an opportunity for the personal growth of individuals and in particular for the professional development of teachers. It argues that GAI systems foster a metacognitive standpoint in human partners, implying that the latter necessarily draw on their own knowledge in the prompt formulation and output analysis phases. This evocative nature is joined by a transitional one: GAI systems are objects, phenomena that stand for the "external" knowledge, that of the corpus of training data, only indirectly, i.e., through standing for an "internal" knowledge, that of the human partner. Consequently, interaction with these systems represents a transitional space, a neutral playing field where internal and external realities coexist. It is a collaborative experience during which new ideas emerge, while others may evolve or take on a specific form. In order to create an active partnership with AI aimed at growth, it is emphasized that teachers are called to be metacognitive professionals who possess complex knowledge that provides for a dynamic relationship between technology, pedagogy and the content of the subject taught.

KEYWORDS Generative Artificial Intelligence (GAI); Metacognition; Transitional Space; Teachers' Professional Development; Technological Pedagogical Content Knowledge (TPACK).

SOMMARIO Il contributo propone una lettura dell'Intelligenza Artificiale (IA) Generativa come occasione di crescita per l'individuo e, in particolare, di sviluppo professionale per i docenti. Sostiene che tale tecnologia stimoli un atteggiamento metacognitivo da parte del partner umano, in quanto implica una riflessione sulla conoscenza nelle fasi di formulazione del prompt e di analisi del risultato generato. A questa natura evocativa, si aggiunge quella transizionale: i sistemi di IA Generativa sono oggetti, fenomeni, che significano una conoscenza esterna, ossia i dati di addestramento, indirettamente, cioè attraverso il significato di una conoscenza interna, quella del soggetto. Di conseguenza, l'interazione con tali sistemi rappresenta uno *spazio transizionale*, un'area neutra di gioco in cui realtà interna e realtà esterna coesistono. Si tratta di un'esperienza di collaborazione e interdipendenza durante la quale emergono nuove idee, mentre altre evolvono o assumono una forma specifica. Per poter attivare una partnership attiva con l'IA, tesa dunque alla crescita, si sottolinea infine come i docenti debbano essere professionisti metacognitivi in grado di mettere in gioco una conoscenza integrale, che contempli una relazione dinamica tra tecnologia, metodologia educativa e contenuto disciplinare.

PAROLE CHIAVE Intelligenza Artificiale (IA) Generativa; Metacognizione; Spazio Transizionale; Sviluppo Professionale dei Docenti; Technological Pedagogical Content Knowledge (TPACK).

1. Introduction

The educational world is currently experiencing a transformative shift fueled by technological advancements and by the evolution of teaching and learning methods. Over the past five years, this shift has been accelerated by the proliferation of Artificial Intelligence (AI) systems, which has prompted numerous policies that highlight the need for a conscious interaction with them in society.

Within the context of the United Nations 2030 Agenda for Sustainable Development, the *Beijing Consensus on Artificial Intelligence and Education* (UNESCO, 2019) recognizes the emergence of a requisite set of AI literacy skills for effective human-machine collaboration. It underscores AI's potential to innovate teaching and learning practices and address educational challenges. Concurrently, in the European context, the 2022 update of the *Digital Competence Framework for Citizens* considers it a priority to engage with AI confidently and safely. This means adopting a critical stance in order to identify the challenges, risks, and opportunities associated with AI, also within educational environments (Vuorikari, Kluzer, & Punie, 2022). Furthermore, the sixth action of the European Digital Education Action Plan (2021-2027), the *Ethical Guidelines on the Use of Artificial Intelligence and Data in Teaching and Learning for Educators* (European Commission, 2022), provides specific support to educators and school leaders for the ethical understanding and application of AI and data technologies, also clarifying common misconceptions about AI.

Throughout 2023, the widespread adoption of Generative Artificial Intelligence (GAI or GenAI) models, particularly OpenAI's GPT and Google's LaMDA, has led to the development of new publications aimed at exploring their use across all tiers of the educational spectrum. The UNESCO program document entitled *ChatGPT and Artificial Intelligence in Higher Education* examines the potential of tools such as ChatGPT at the highest levels of formal education (Sabzalieva & Valentini, 2023). This quick guide outlines ways to capitalize on these technologies not only to enhance teaching and learning outcomes but also to advance scholarly research, streamline administrative functions, and bolster community interaction. Moreover, it underscores the essential nature of tackling ethical issues such as academic integrity, the need for regulatory frameworks, privacy concerns, cognitive biases, and questions of gender and diversity, as well as accessibility and the impact of commercial interests. Among the outputs of the European Digital Education Hub (EDEH), a network of national advisory bodies on digital education, the third briefing report produced by the Squad on Artificial Intelligence in Education, *Use Scenarios & Practical Examples of AI in Education* (Cassidy et al., 2023), provides a detailed exploration of practical scenarios and examples of how AI, including GAI, can be used in teaching. Again, with reference to formal education, this report distinguishes between three categories of AI use: helping students to adopt a critical perspective on the use of AI in society (*teaching for AI*); imparting technical knowledge regarding AI's fundamentals (*teaching about AI*); and using AI systems to achieve teaching and learning goals, such as using them to enhance instructional design or to support learners while they study (*teaching with AI*). The UNESCO document entitled *Guidance for Generative AI in Education and Research* further deepens this topic, conducting a rigorous exploration into the essential steps and pivotal considerations necessary for a judicious governance of GAI within a framework that prioritizes human-centric values, striving to align the deployment of new technologies with educational goals and values (Miao & Holmes, 2023). This document examines the potential for integrating GAI technologies into the realms of curriculum design, teaching, learning and research activities, highlighting the aforementioned principles of ethical practice, safety, equity, and purposeful application. As of February 2024,

the *AI Competency Frameworks for Teachers and School Students* are being developed, expected to be published in September 2024 during the Digital Learning Week organized by UNESCO. These drafts confirm the vision offered in the guidelines, outlining a framework for teachers comprising five aspects: *Human-centered Mindset*; *Ethics of AI*; *AI Foundations and Applications*; *AI Pedagogy*; *AI for Professional Development* (UNESCO, 2024).

The attention paid to the application of GAI in the contexts of education and research concerns not only international institutions and organizations, but also the academic milieu. Universities are releasing documents aimed at ensuring that students, researchers, and staff are able to leverage the opportunities presented by GAI[1]. Although originally conceived in response to issues connected to academic integrity, they have been redirected to encourage the exploration of AI-based teaching, learning, and research methodologies, and support the development of new skills, setting a precedent for ethical, collaborative, and innovative educational approaches in the digital age. They also emphasize the critical need for a collaborative ethos within and between institutions, for example through the creation of interdisciplinary teams that blend computer science competence, pedagogical expertise, and subject-specific knowledge.

Abandoning gray literature and moving towards the area of scientific research, it is evident that during 2023 researchers undertook numerous experiments relating to the use of GAI in educational contexts, investigating ways it can be used to support or produce experiences of teaching and/or learning, identifying attitudes regarding the adoption of such emerging technologies and evaluating the benefits, risks, and challenges (Ansari, Ahmad & Bhutta, 2023; Bond et al., 2024; Fütterer et al., 2023; Grassini, 2023; İpek et al., 2023; Jeon & Lee, 2023; Su & Yang, 2023). The conversation on these issues has branched into those studies that were previously oriented towards the broader category of Conversational AI (CAI) and especially Intelligent Tutoring Systems (ITS) (Wollny et al., 2021).

The synthesis of perspectives presented across all the referenced documents, regarding both gray and white literature, appear to encourage a culture of innovation based on critical engagement with the personal and professional potential of GAI systems and on gaining tangible benefits from interaction with them while, at the same time, trying to avoid new facets of the digital divide.

This theoretical paper is underpinned by the above studies and aims to offer an interpretation of GAI as an opportunity for the personal growth of individuals and in particular for the professional development of teachers. It begins by proposing an analysis of the phases that constitute the interaction between the human partner and GAI systems, focusing on the metacognitive attitude that the latter inevitably invite one to adopt (see Section 2). Subsequently, it highlights GAI systems' transitional nature, evident in their interpretation as objects, phenomena that stand for the "external" knowledge (the training data) only indirectly, that is, through standing for the subject's "internal" knowledge. The interaction with GAI systems is thus analyzed as a transitional space, a creative interplay between the human partner and the algorithm that belongs simultaneously to the self and the outside world (see Section 3). Finally, reconnecting to the educational context outlined above, it investigates the knowledge required of teachers to support their professional development using GAI and proposes some reflections on the role that this technology can play in the growth of students (see Section 4).

[1] Noteworthy examples of universities that have pioneered such initiatives include the Italian universities of Siena and of Milan, the UK's Russell Group, the Federal Institute of Technology Zurich, the Aalto University of Helsinki, the University of Lugano, and the American universities of Berkeley, Harvard, and Stanford.

2. Interacting with GAI systems

GAI is a subcategory within the broader domain of AI, specifically within the Machine Learning (ML) branch. As such, GAI systems need to be "trained", that is, they need to process a large amount of data from which they "learn" how to simulate a typical human function (e.g. writing or drawing). After the training, they are able, upon request of a user, to generate new content – such as text, images, videos, 3D models, or music – that is coherent with, or similar to, the data provided during the training phase. Technically, GAI operates by employing multiple technologies, among which are Generative Adversarial Networks (GANs), Recurrent Neural Networks (RNNs), and transformer architectures like Generative Pre-Trained Transformers (GPT). The generated content, even when stemming from the same request, is always different because these technologies incorporate elements of randomness and variability. By leveraging stochastic processes, they can explore a vast gamma of potential outputs, selecting those that are most likely to be coherent and novel based on the learned data distribution.

2.1. Hallucinations and bias

As underscored in the literature referenced in Section 1, in the terms of use and technical reports of some of the most well-known services, GAI systems may in some situations generate inaccurate, misleading, untruthful, or non-sense content, often referred to as *hallucinations* (OpenAI, 2023). Furthermore, this content may reflect various societal biases, that is, distorted opinions that can be stereotypical and discriminatory, or exhibit views that may not be representative of the user's intent or are inappropriate for specific contexts. Hallucinations and bias are partly the result of the probabilistic nature of machine learning and partly due to the choice of data with which systems have been trained, with respect to which commercial services do not provide clear information about the reference sources[2]. In fact, this data could be incorrect, emphasize overrepresented points of view, contain stereotypes and prejudices (for instance, gender, cultural, racial, ideological biases, etc.) or present non-updated world knowledge and awareness of events (Ray, 2023). Thus, to benefit from GAI systems it is clear that users must first of all be informed about this issue of accuracy and reliability of the sources.

2.2. Prompts and outputs

Interaction with GAI systems can be divided into the following phases:

1. The human partner formulates and forwards to the system a *prompt*, i.e., an input, typically a request with specific instructions.
2. The GAI system processes and produces an *output* in the desired multimedia format (usually GAI systems are "specialized" in producing a certain type of output).
3. The human partner analyzes and interprets the output.

Some GAI systems only operate on single queries, while allowing the output to be redefined by establishing additional parameters, generally via a visual interface with buttons and choice options.

[2] A quick search on scientific databases such as Scopus is sufficient to identify a mass of these contributions from 2023 aimed precisely at assessing the trustworthiness of these systems. The author believes that the issue of accuracy and reliability will only be partially resolved by GAI systems that have limited and verified knowledge bases. Indeed, the randomness in the automatic generation process – along with the consequent risk of error – will persist, as it is an intrinsic characteristic of this technology. To definitively overcome doubts about quality, will it be necessary to ascribe *a priori* a trusted and respected authority – an *auctoritas* – to GAI systems?

Others incorporate conversational interfaces (these fall within the CAI category) that replicate human dialogue and therefore cyclically link prompts and output. In these cases, they make use of a local memory to remember previous exchanges, both in input and in output, allowing GAI systems to provide contextually relevant responses. Examples include services such as OpenAI's ChatGPT, Google Gemini (formerly Google Bard), and Microsoft Copilot.

Prompts must be formulated using clear, precise, and unambiguous language. The more structured the prompt, the more effective the output will be. It is thus a question of knowing the specific vocabulary of the cognitive domain being investigated and identifying a list of useful variables in order to obtain an appropriate result. Learning objectives, prerequisites, times, recipients, and settings are valid variables for formulating prompts in the context of teaching and learning. To formulate the prompt, it is possible to implement one or more communication strategies – the same ones that pertain to the "*pragmatic competence*" of oral and written communication. In linguistics, this competence "*underlies the ability to use (…)* [grammatical] *knowledge along with the conceptual system to achieve certain ends or purposes*" (Chomsky, 1980, p. 59), including "knowledge of conditions and manner of appropriate use [of language]" (ibid., p. 224).

The simplest *prompting strategies* are aimed at using the system as an executor, a tool for obtaining a specific output. It is therefore a matter of asking direct questions, equipped with the appropriate variables and possibly accompanied by examples, positive or negative, useful for directing the result. Or again, these are requests for revision and manipulation of contents, on the level of signified or signifier, which may include reformulation, paraphrase, reorganization, replacement, completion, expansion, or summary. It is clear that the prompt must also be structured according to the desired format, whether for example a text or an image.

Output analysis implies what is described in the previous paragraph, i.e., the need to verify the quality and conformity of the generated content. In the event of undesirable results, it is possible to ask to regenerate the content, in whole or in part, or progressively refine the prompt so as to make it more specific and suitable for achieving the objectives.

In the case of conversational interfaces, it is essential to put into practice prompting strategies capable of activating what will later be described as an *active partnership* with the machine, i.e., the valorization of the system's contribution to the construction of knowledge (see Section 3). For example, it is possible to ask for clarification on the output provided or activate a sort of self-criticism on the part of the system so that the system critically evaluates its own responses. Or again, guide the system in processing answers through sequences of logical steps typical of problem solving, ask it to generate prompts itself, or invite it to ask questions to reduce possible guesses regarding variables not explicitly declared. It should be underlined that the conversational context, i.e., the production of a local memory relating to the information exchanged, could lead the GAI system to offer results limited to a specific, partial experience of the world, or to align itself with the human user's perspective even when that perspective lacks objective correctness. This latter behavior, not dissimilar to *filter bubbles*[3], has been observed and described as *persona sycophancy* (Sun et al., 2024)[4].

[3] A situation where a search on the Internet produces mostly information that conform to and reinforce the user's own beliefs, due to the search algorithm and the keywords used.

[4] Sometimes it is the user who chooses to orient the conversation towards specific needs, providing the system with a list of useful information to frame his profile, for example professional.

2.3. The metacognitive attitude

Formulation of the prompt and output analysis are two activities that require not so much the *action* of *asking* and *analyzing*, but the *ability* to *know how to ask* and *how to analyze*. GAI systems continually connect the *human partner*, i.e., the interacting subject, with knowledge. More specifically, they force a reflection on knowledge and consequently, the assumption of a *metacognitive attitude*. The human partner can formulate an effective prompt only if he knows what he is asking (*signified*) and knows how to ask it (*signifier*), just as he can analyze the output only if he is able to decode it (*signifier*) and to evaluate its content (*signified*). Competence in the domain of knowledge pertaining to the field of inquiry is required, also in the form of the critical ability to appraise what is (still) not known.

3. The transitional space

In the previous section, emphasis was placed on how interaction with GAI systems impels the subject to adopt a metacognitive attitude, i.e., continuous comparison with his own knowledge. Why then should an individual who already knows and indeed, is even metacognitive, need such interaction? Furthermore, why should a human choose to turn to a technology that also produces content containing hallucinations and bias?

Here the author chooses to answer the first question starting from an image taken from psychoanalytic theory, that of *transitional space*. Donald Woods Winnicott (1953; 1958; 1971) used this term to refer to an intermediate, liminal area of experience to which both the internal reality of the subject and the external one, shared with others, contribute. This is a crucial area for the development of a sense of self, a space for imagination and play, thus of creativity, where fantasy and reality overlap. The transitional space is activated by the subject in childhood, starting from specific *objects* or *phenomena* that can be imbued with subjective meaning while still being recognized as part of external reality. Examples might be a bundle of wool, the corner of a blanket, a word, or a mannerism, which are never totally under the child's "magical control" (i.e., internal) nor totally out of his control, therefore external. "*The transitional object and transitional phenomena start each human being off with what will always be important for them, i.e., a neutral area of experience which will not be challenged*" (Winnicott, 1958, p. 239). Object relations, the problem of what is objectively perceived yet subjectively conceived, self or not-self, represents a lifelong human concern. Winnicott himself stated that the transitional space is also omnipresent in adults' everyday social lives, when some experiences appear simultaneously from within and from without: "*This intermediate area of experience* […] *throughout life is retained in the intense experiencing that belongs to the arts and to religion and to imaginative living*", and – not least – "*or creative scientific work*" (ivi, p. 249).

In her seminal work *The Second Self: Computers and the Human Spirit*, Sherry Turkle (1984) took up Winnicott's theories in her observation of human relationships with technology. Focusing on how people relate to computers and other digital devices, she supported the transitional nature of the latter, configuring them as *evocative objects*, i.e., capable of provoking self-reflection: "*I look at the computer in a different light, not in terms of its nature as an "analytical engine", but in terms of its 'second nature' as an evocative object, an object that fascinates, disturbs equanimity, and precipitates thought"* (ibid., p. 13). By projecting their thoughts, feelings, and human qualities onto machines, individuals transform these devices into tools through which they think about themselves, expression of a part of the self, *mirrors* of the mind. Digital devices allow one to objectify and observe from the outside many aspects of oneself that had always been perceived only from within.

A few years later, in *Life on the Screen: Identity in the Age of the Internet*, Turkle (1995) explored how cyberspace also has a transitional nature. Observing mediated interactions such as those occurring within Multi-User Dungeons (MUDs), she described how this virtual realm provides a *psychosocial moratorium* (Erikson, 1968), a safe environment, a sandbox for self-discovery in which individuals can experiment with their identities with minimal real-life consequences, supporting their own growth. She wrote "*virtual spaces may provide the safety for us to expose what we are missing so that we can begin to accept ourselves as we are. Virtuality need not be a prison. It can be the raft, the ladder, the transitional space, the moratorium, that is discarded after reaching greater freedom. We don't have to reject life on the screen, but we don't have to treat it as an alternative life either. We can use it as a space for growth*" (Turkle, 1995, p. 263).

GAI systems connect the subject with his own knowledge, stimulating the metacognitive attitude (see Section 2). From this perspective, they take on the role of mirrors of the self, of evocative objects. Moreover, their transitional nature lies in the fact that they stand for the "external" knowledge, that of the corpus of training data, only indirectly, i.e., through standing for an "internal" knowledge, that of the human partner. The creative interplay activated during content generation is a knowledge management process that belongs simultaneously to the self and to the outside world. The concept of author, whether human or algorithmic, loses value and fades away, giving centrality to collaboration and the co-construction of knowledge. The GAI system, in fact, can:

- concretize the ideas that the human partner possesses, thus becoming in part the intermediary and in part the author of their manifestation (e.g., the idea of a fantastic landscape that becomes the tangible image of a fantastic landscape);
- support reconfiguring or completing the human partner's ideas;
- allow the development of new ideas, i.e., not known to the human partner before the interaction.

This last case, certainly the most interesting, occurs only where the subject manages to establish an active and continuous partnership with the GAI system through dialogue. The conversational context can support the progressive development of the knowledge initially put into play by the subject, which is shaped by the responses generated from time to time by the GAI system, which in turn are however the result of the encounter with the inputs previously provided by the subject.

Interaction with GAI systems represents a transitional space, a liminal area of creativity and possibility that is neither internal nor external to the subject. In this space, individual knowledge hybridizes with the information offered by the machine in a dynamic process, providing the metacognitive subject with an opportunity for intellectual growth. In the event that the latter engages his social identity (and thus a competence relating to a specific expertise, pertaining to the working sphere), a professional development is implemented. This experimental laboratory takes place when the subject actually has a desire to gain and produce new knowledge, that is, when he is driven by a *sense of curiosity*. This sense of curiosity is based on the metacognitive attitude and represents the awareness of an internal limit and at the same time the will to explore and transcend this limit. Individuals who choose to interact with a GAI system "*know that they do not know*", as Socrates puts it.

Interaction with GAI systems is part of an unprecedented communicative landscape. For the first time, interlocutors (i.e., a human and an algorithm) do not interpret knowledge "*in the same way*". However, despite the algorithm intrinsic inability to assimilate or "understand" the informational content it is tasked to manipulate or generate in a human way, the purpose of the communicative exchange is always achieved since the significance of the generated information is cognizable and relevant to the human partner (Esposito, 2022). But why turn to a GAI system, a technology, an interlocu-

tor who doesn't "understand" in order to grow? Especially if, as previously mentioned (see Section 2), the content generated can be a carrier of hallucinations and bias?

To answer this second question, it is interesting to recover the construct of the Zone of Proximal Development (ZPD) developed by Lev Semënovič Vygotskij (1978). The ZPD represents the distance between the child's actual developmental level, determined by autonomous problem-solving, and the potential developmental level, achievable through problem-solving under adult guidance or in collaboration with more capable peers. In this area, which has been assimilated by some to the transitional space (Naranjo Orozco, 2021; Parola, 2023), the adult or the more capable peers are described as the More Knowledgeable Other (MKO), that is, figures who provide the structure to support the child in achieving new competencies. Stojanov (2023) observed how GAI systems, in that specific case ChatGPT, may serve a function similar to that of Vygotsky's MKO since they possess an expansive range of multidisciplinary data to which they have been exposed during training. However, given the susceptibility of these systems to hallucinations and biases, the scholar recommends using them with caution to scaffold knowledge. Here it therefore seems more useful to describe a GAI system as a More Experienced Other (MEO) or a More Informed Other (MIO), a kind of traveler who has had the opportunity to visit many places and who, when questioned, begins his narrative. This definition perhaps better highlights the breadth of the system's exposure to various data rather than actual competence.

It is therefore assumed that the choice to relate to the GAI as MEO (or a MIO) is a self-education choice intentionally made by the subject who, being metacognitive and therefore aware of his own relationship with knowledge, wants to attribute an educational value to technology. This value could indeed reside in the possibility of a critical comparison with the system-generated information, but also in the aspect of unpredictability, i.e., in the fact that the systems produce different content from time to time and consequently keep one's sense of curiosity active potentially indefinitely.

4. What knowledge for the teacher?

Considering the figure of the teacher and reflecting upon the teaching process, three main areas of professional practice can benefit from interaction with a GAI system. These correspond to the *preactive, interactive*, and *postactive* teaching task domains, i.e., the cyclical phases of *analysis* and *design*, *implementation* (also known as *execution*), and *evaluation* (Jackson, 1966, 1968; Clark & Peterson, 1986).

Examining preactive tasks, GAI systems can support teachers in creating tools for analyzing educational needs, in shaping a course structure (*macro design*), or in detailing lesson plans and specific interventions (*micro design*). For instance, they can assist them in identifying teaching methods or frameworks, formulating syllabi and learning goals, developing evaluation strategies, and readjusting their planning to align with established pedagogical approaches or objectives.

GAI systems can facilitate the creation of material, whether in digital format or for print reproduction, that can be used during the interactive stage of teaching. This can encompass the production of textual or visual materials to be presented during a lesson, such as discussion prompts or images, storyboards for video lessons, scripts for podcasts, or other content that meets specific criteria (for instance, for individuals with special educational needs). GAI systems can also simulate dialogue with professional figures or historical characters, to be managed in the classroom together with the students (Iannella, 2020; Iannella et al., 2021). In addition, they can support the assessment of learning by designing authentic tasks and evaluation rubrics, establishing protocols to foster metacognitive attitudes, and generating objective tests and exam questions.

Moving to postactive tasks, GAI systems can correct, evaluate, and grade student work according to specific guidelines, or provide feedback aimed at encouraging specific behaviors. They can also help produce tools that assist teachers in reflecting on their own actions and on students' results in order to improve teaching and support continuous professional development.

Despite the specificities of each task domain, it seems clear that within the context of teaching, a prompt and/or an output cannot fail to contain at least two pieces of information: one relating to the content, i.e., knowledge (for example that of a specific discipline), and one relating to pedagogy, i.e., the aspects that situate and make possible the transfer and acquisition of that knowledge (for example the learning objectives, the architecture of instruction, the strategies…)[5]. To these *content-related* and *pedagogical* dimensions, a third is always added, the *technological*. The latter refers not only to the tools (analogue or digital) to be used to facilitate specific pedagogical practices in a specific discipline (for example an evaluation rubric or a clicker), but especially to the circumstance that is examined here, i.e., the fact that the teacher is using a technology for a teaching purpose, the GAI system. A prompt like "*Generate a checklist to explore first-year university students' attitudes towards Mathematics*" contains and interrelates these three dimensions (Mathematics, attitude, checklist) and is obviously activated in the third (interaction with GAI).

From this perspective, an active partnership with GAI systems on the part of the teacher assumes, or rather requires, his integral training, such as that proposed by models that work on these three aspects, among which the Technological Pedagogical Content Knowledge (TPACK) framework (Koehler & Mishra, 2005). TPACK refers to knowledge regarding the complex relationships between technology, pedagogy, and content that enable teachers to develop appropriate and context-specific teaching strategies. To experience and benefit from the transitional space, teachers should be metacognitive professionals trained both in the uniqueness and in the interrelationships of these three dimensions.

Mishra, Warr and Islam (2023) observed that the advent of GAI raises questions about the relevance and the value of the TPACK framework. They argue for the importance of a fourth kind of knowledge, called Contextual Knowledge (XK), which pertains to the awareness of broader systemic factors that can empower or constrain GAI systems' use, such as state-level policies or standards. Teachers must not only understand how GAI works and its impact on teaching practices but also how it is creating a new ecosystem and, consequently, is changing individuals and society.

4.1. The relationship between GAI systems and students

What has been illustrated so far pertains to the area of teachers' professional development and therefore to that *teaching with AI* proposed by the EDEH's Squad on Artificial Intelligence in Education (see Section 1), which consists in the use of technology to achieve teaching and learning objectives.

It is crucial to acknowledge that teachers typically assume a dual role during an educational event. In fact, the latter is both content-related and relational (Iannella & Pagani, 2022; Sensevy & Mercier, 2007). The content-related dimension involves the knowledge building role, while the relational one aims to foster a supportive learning environment and establish meaningful connections with students. Within this vision, the concept of *hidden curriculum* (Jackson, 1968; Snyder, 1970) becomes relevant. This refers to the unspoken or implicit rules, behaviors, stereotypes, and values learned in edu-

[5] Jeon & Lee (2023) observed the centrality of pedagogical knowledge in the interaction between the teacher and GAI systems.

cational settings, outside the formal curriculum. Considering the impact of technology in education, this socialization phenomenon can also include transmission of ideas of resistance to or acceptance of innovation, not always in a critical form. Hence, the conscious and discerning use of GAI systems in the teaching process may implicitly cultivate in students a mindset attuned to seizing the opportunities presented by AI, with benefits in social, personal, and future professional scenarios.

AI literacy can be further supported by explicitly teaching the risks and opportunities of AI, an action that falls within what the EDEH's Squad on Artificial Intelligence in Education defines as *teaching for AI*. This practice presumes a Heideggerian responsibility to the students since it lays the groundwork for building their own independent judgments concerning technology. In accordance with what was stated in the previous paragraphs, *teaching for AI* would thus also mean bringing students closer to adopting the same metacognitive attitude adopted by the teacher.

Aware of his own knowledge and of the errors and biases of a relationship with the sources of knowledge that is not always transparent, the student must pay attention to how he declares his knowledge to the system (*formulation of the prompt*) and must critically observe the results generated (*output analysis*). It is as if he deals not so much with a tutor but rather with himself or with a companion who has chosen to study everything (see Section 3). In the interaction with GAI, if the teacher finds a transitional space for growth as a professional, and therefore of a competence that pertains to a specific domain of expertise, the metacognitive student, a subject in progress, finds his transitional space for growth as a knowledge manager, i.e., as a continuous learner.

5. Conclusions

AI is reconfiguring the ways in which knowledge is managed. As it becomes increasingly integrated into various aspects of daily life, it is imperative to identify how humans can steer it towards active and fruitful use. From this perspective, the literature that evaluates its use in educational contexts is underlining how critical engagement, attentive to the benefits, risks and challenges can support teaching and learning practices and lead to innovative research.

This theoretical paper argues that interaction with GAI systems can offer the individual an opportunity for growth, provided that the latter starts from an adequate amount of awareness and competence in the domain of knowledge pertaining to the inquiry. Indeed, during the interaction, GAI systems force the human partner to reflect continuously and critically on his own knowledge. It is not simply a matter of asking and analyzing, but of knowing how to ask and how to analyze. From this perspective, GAI systems can be interpreted as evocative objects (Turkle, 1984). Acting as mirrors of the subject's knowledge, they provoke self-reflection. Therefore, they require (and, at the same time foster) a metacognitive approach.

The evocative nature of GAI systems refers to a transitional dimension (Winnicott, 1953; 1958; 1971) too. GAI systems are transitional objects or phenomena as they stand for the "external" knowledge, that of the corpus of training data, only indirectly, i.e., through standing for an "internal" knowledge, that of the human partner. The creative interplay activated during content generation is a knowledge management process that belongs simultaneously to the self and to the outside world. GAI systems can concretize, reconfigure, or complete the ideas of the human partner and, especially during the conversation, stimulate new ones. In this situation the concept of the author, whether human or technological, fades in value, giving instead central roles to collaboration, co-construction of knowledge and partnership. GAI systems synthesize the data they are trained with and always create new

information with the interacting subject, in a situation of interdependence. From this interdependence the metacognitive subject can draw something new – a product, an idea, a solution, a process, a skill, an attitude – and can grow. Thus, interaction with GAI systems constitutes a transitional space, a liminal area of experience neither under the complete "magical" control of the subject nor totally outside his control. Those who choose to interact possess the strength of their own knowledge and a sense of curiosity that urges them to go beyond their limits. They see in a technology that presents a rich "experience" and outlines a *ludus* through its unpredictability, the possibility of creative action.

GAI systems offer professional development opportunities for teachers, but only if they are metacognitive professionals able to bring into play an integrated knowledge encompassing technology, pedagogy, and disciplinary content during the interaction. These three dimensions, the same as the TPACK Model, are in fact always present in the prompt and/or in the output, as they represent the essential conditions for fulfilling a teaching purpose.

These pages aim to encourage a willingness to contemplate the use of GAI systems through an interdisciplinary lens, weaving together insights from psychology, sociology, computer science, and pedagogy. The proposed reflection, at present theoretical, lays the foundations for future analysis and experimentation.

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Revitalizing education in rural and small schools: The role of AI in teachers' professional development

Rinnovare l'educazione nelle scuole rurali e piccole: Il ruolo dell'AI nello sviluppo professionale degli insegnanti

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ABSTRACT The article explores the intersection of artificial intelligence (AI) and the professional development of teachers, with a focus on small and rural schools. Following a scoping review conducted by the research group, the focus is placed on the analysis of three studies, each pertaining to three subtopics within the theme "AI and teacher professional development" that emerged from the mapping: the use of intelligent environments for teacher training, teachers' perceptions of AI solutions to support their practice, and the development of intelligent agents to assist teaching. The research emphasizes the importance of teacher training in addressing the challenges posed by AI to bridge the gap between urban and rural schools. This opens to future scenarios that will be explored through interviews with national and international experts and a Delphi Study, aimed at identifying opportunities for small schools and developing guidelines to achieve convergence on potential interventions in non-standard educational contexts.

KEYWORDS AIEd; Artificial Intelligence; Rural Schools; Small Schools; Teachers' Professional Development.

SOMMARIO L'articolo esplora la connessione tra intelligenza artificiale (AI) e sviluppo professionale degli insegnanti, concentrandosi sul contesto delle scuole di piccole dimensioni e rurali. A seguito di una scoping review condotta dal gruppo di ricerca, l'attenzione è posta sull'analisi di tre studi, afferenti a tre sottotemi del topic "AI e sviluppo professionale dei docenti" emersi dalla mappatura realizzata: l'uso di ambienti intelligenti per la formazione degli insegnanti, la percezione degli insegnanti sull'uso dell'AI nella loro pratica, lo sviluppo di agenti intelligenti per supportare l'insegnamento. La ricerca enfatizza l'importanza della formazione degli insegnanti per affrontare le sfide poste dall'AI per colmare il divario tra scuole urbane e rurali e apre a futuri scenari che verranno esplorati attraverso interviste con esperti nazionali e internazionali e uno Delphi Study al fine di identificare opportunità per le scuole di piccole dimensioni e sviluppare linee guida per raggiungere una convergenza sui possibili interventi nel contesto educativo non standard.

PAROLE CHIAVE AIEd; Intelligenza Artificiale; Scuole Rurali; Scuole di Piccole Dimensioni; Sviluppo Professionale degli Insegnanti.

1. Artificial intelligence and professional development of teachers

Educational research focuses on the theme of artificial intelligence (AI) as a disruptive technology for education, capable of rethinking teaching and learning processes, supporting activities of personalization, democratic access to resources, creation of immersive, inclusive and adaptive environments (Panciroli & Rivoltella, 2023; Panciroli & Macauda, 2021). Studies show how AI in education (AIEd-Artificial Intelligence in Education) can offer teachers new possibilities for design and managing teaching, but also new challenges related to the need to acquire specific skills, to address ethical and social issues connected to the use of AI and to maintain an active and critical role in the educational process (Ahmed & Ganapathy, 2021; Baker & Smith, 2019; Hinojo-Lucena et al. 2019; Kuleto et al., 2021; Liu et al., 2022; Mijwil et al., 2022; Pedró et al., 2019; Razia et al., 2022).

A recent systematic review (Celik et al., 2022), provides an overview on the use of AI applications by teachers, focusing on the processes of planning, implementation, and evaluation. It also addresses the challenges in the use of artificial intelligence by teachers, such as the inapplicability of AI system in a generalized manner to various contexts, the lack of technological knowledge on the use of AI, or the absence of interest for AI, often fear of upsetting their own way of doing school. In particular, with attention to AI for the professional development of teachers, research has reasoned in terms of impact of AI in the educational context with reference to teaching practices and skills of teachers (Al-Zyoud, 2020; EU, 2023).

In May 2023, UNESCO hosted a ministerial roundtable on generative AI and education, in which more than 40 Ministries of Education shared their insights and concerns about the growing influence of generative AI in education. This meeting reiterated the need for proactive engagement on the new horizons for education that generative AI can offer starting from a Competency Framework for Teachers (AI CFT) characterized by 18 competencies, distributed over 6 dimensions (Human-centred Mindset, Ethics of AI, Foundation AI knowledge, AI skills, AI pedagogy) along levels of progression (Understand, Apply and Create). The absence to date of institutional policies or formal guidelines on the use of generative AI applications requires intervening on the competencies required by teachers in order to build support and development paths that cannot exacerbate systemic inequalities and give rise to new forms of discrimination and non-equity of educational offer with attention to the most fragile and remote territories.

2. Teacher training and use of technology in small schools

The international literature highlights, on the one hand, the advantages that the use of technology can bring to small schools, and, on the other hand, the main criticalities related to the use of technology in small schools, which often find themselves in a condition of not only geographical but also cultural isolation.

Among the advantages that technologies can bring to small schools, besides of course being able to access resources of all kinds available online, are: being able to connect classrooms with other realities (Hargreaves, 2009; Laferrière et al., 2011), facilitating the inclusion process in educational contexts that are new to pupils (Hannum et al., 2009) and widening the choice of extracurricular activities accessible to students (Hawkes et al., 2002). However, despite the considerable benefits they can bring to small schools, before the lockdown following the COVID-19 pandemic, technologies were not so widespread, even where their use could have ensured a real leap forward. Observations conducted from

2014 to the beginning of the pandemic had shown that in Italy, even in the most innovative contexts of small schools where technologies were present and used daily, they were extremely tied to the single discipline and the specific subject, which was often the subject of one or more impromptu lessons by the teacher (Pieri & Repetto, 2019). With the lockdown, technologies entered all schools and homes of school-age children but were used in a decidedly heterogeneous manner by different schools, and by different teachers even within the same school (Füller & Spiewak, 2020).

There is, for example, a widespread lack of a more interdisciplinary and continuous vision of didactics and of a leading theme. These are essential elements in a project-based or competence-based teaching that guides and gives coherence to the teaching activities proposed and implemented by teachers. And in several cases, technologies have been, and are still being, used to remotely deliver frontal lessons designed for face-to-face teaching (Lucisano, 2020).

As far as critical issues are concerned, with reference to possible barriers to the use of technology in primary and secondary education, there are still few studies that specifically investigate the situation in small schools (Fargas-Malet & Bagley, 2022; Pieri, 2022). Among the main critical issues related to the relationship between technology and small schools that emerged from the literature review are the absence or shortage of technology hardware and software (Francom, 2016; Kale & Goh, 2014; Rundel & Salemink, 2021), limited bandwidth (Handal et al., 2018; Rundel & Salemink, 2021), the absence of personnel dedicated to the maintenance of computer equipment, hardware and software, and to the resolution of any technical problems, and last but by no means least (Wang et al., 2019), the lack of skills on the part of teachers both in the use of technology in general and in the use of technology for teaching purposes (Azano et al., 2019).

With regard specifically to the lack of skills on the part of teachers both in the use of technology per se and in the use of technology for teaching purposes, although access to an adequate and well-maintained technological infrastructure is a conditio sine qua non for the introduction, and use, of technology in the teaching of small schools, other less tangible factors are also very important. These include, for example, the possibility to train, and support teachers in developing the awareness and ability to rethink technology according to the specific pedagogical needs of their students and develop educational pathways that connect school and everyday life (Azano et al., 2019).

One study (Goodpaster et al., 2012) shows that innovation in teaching practices (think, for example, of the spread of technology-supported active methodologies that put the pupil at the centre of their own learning process) may be more difficult in more remote areas due to the effects related to isolation, which entail little opportunity to compare and collaborate with other teachers and to take refresher courses. Globally, the digital divide between schools has become extremely evident since March 2020 (Rundel & Salemink, 2021) when the COVID-19 pandemic led to the temporary closure of schools in most parts of the world. Most countries, in order to cope with school closures, resorted to online schooling that allowed students and teachers to carry on with school activities. This posed a high risk of exclusion for those with insufficient Internet connectivity or digital devices (Ferraro et al., 2020; Kaden, 2020). While some schools already had online platforms available, teachers and pupils partly already accustomed to using them and technologies and network connection already present in students' homes, in other cases schools did not have online platforms available, teachers and pupils accustomed, and sometimes able, to use them and technologies present in students' homes. In some cases, teachers merely sent material to students via e-mail (Füller & Spiewak, 2020).

What happened during the lockdown demonstrates once again how important it is to bridge digital inequalities in school and beyond school. While some small schools are refractory to the adop-

tion of technology in educational activities, others accept and even encourage the use of technology in school (Howley et al., 2011; Kormos, 2018). As Mangione and Cannella (2021) mention, ministerial programmes, which usually tend to focus either on how to obtain technology or how to use it, can play a very important role in overcoming the digital divide (Howley et al., 2011). For example, in the United States, there are federal and state ad hoc grants to improve small schools' access to technology. For example, there are government programmes such as E-Rate, designed to promote Internet access, which offer some benefits to small schools but require them to independently manage the provision of hardware and software and teacher training (Park et al., 2007). In Italy, the National Operational Programmes (PON) for schools "*Per la Scuola-competenze e ambienti per l'apprendimento*" and "*Gestione degli Interventi sull'Edilizia Scolastica*" represent a preferential observation point for intercepting and selecting new ideas and proposals for small schools (Mangione et al., 2017a; Mangione et al., 2017b). Typically, programmes designed to increase the use of technology involve mentoring (Duncan & Stock, 2010) or training (Sundeen & Sundeen, 2013). Both mentoring and training are aimed at helping teachers improve their relationship with technology.

3. AI and teacher professional development in rural schools: Areas of research and relevant studies

To explore the potential use of AI in the context of small and rural schools, an initial exploratory study was conducted through a scoping review (Mangione, Pieri, & De Santis, 2023). The main research question was, 'What does international literature say about AI and rural education?' and the secondary question was, 'What are the main areas of AI application in the rural educational context?'. For this research, citation databases such as WoS and Scopus, along with the more general tool Google Scholar, were utilized. The keywords employed included "artificial intelligence", "machine learning", "deep learning", "artificial education" and "rural education", "rural school", "small school". Inclusion criteria comprised openly accessible works in English published from 2010 onwards. A total of 45 references were identified, of which 19 were deemed relevant after removing duplicates and assessing abstracts for relevance. The analysis of these contributions led to their categorization based on recurring themes of investigation:

- AI to revitalize teaching-learning processes and bridge the gap between urban and rural schools (11 references);
- AI and professional development of teachers (4 references);
- AI for the development of predictive models regarding students' interests and success (2 references);
- AI for service management and risk prediction (2 references).

In this study, we aimed to provide a critical analysis of three articles included in the overarching theme of "*AI and professional development of teachers*", considering this field fundamental for small and isolated schools:

1) *Educational Equity in the Age of Artificial Intelligence - Taking the Construction of Rural Teachers as an Example* (Yao, 2020);
2) *Exploring Teachers' Perceptions of Artificial Intelligence as a Tool to Support their Practice in Estonian K-12 Education* (Chounta, Bardone, Raudsep, & Pedaste, 2022);
3) *Why Not Robot Teachers: Artificial Intelligence for Addressing Teacher Shortage* (Edwards & Cheok, 2018).

These three articles were chosen because they address the theme of teachers' professional development from three different perspectives.

3.1. Intelligent environments for rural teacher training

The training of rural school teachers in the "*age of artificial intelligence*" is a strategic action to promote educational system equity and modernize education, but it faces some significant challenges. This is the starting point of Yao's reflection in the article *Educational Equity in the Age of Artificial Intelligence - Taking the Construction of Rural Teachers as an Example* (2020). His considerations are closely related to the Chinese educational system but with attention to specific differences, they can also provide important insights for other school realities located in "*places left behind*" to overcome the limitations that occur in remoteness situations (Mangione & Cannella, 2021).

In these contexts, where the absence of colleagues to exchange innovative ideas and the distance from central educational hubs or training sites constitutes a major limitation for the professional development of teachers, the development of AI-supported online environments may represent a possibility to overcome the "*information island*" and impact teacher training.

In recent years in China, with the *Development Plan for the New Generation of Artificial Intelligence* (2017) and the subsequent *Education Informatization 2.0 Action Plan* (2018), there has been a deep integration between information technology and education that has promoted Internet access in schools, teacher training in digital skills and improved digital educational resources (Yan & Yang, 2021). Despite these plans and despite the *Support Plan for Rural Teachers* (2015) issued by the Ministry of Education there is still a large gap between urban and rural schools (Zhang, 2015; Li et al., 2020; Jian, 2020).

The main problems identified by Yao for the "construction" of rural teachers are:

- (a) the unequal allocation of resources between urban and rural schools;
- (b) the shortage of teachers in rural areas and the difficulty in recruiting them;
- (c) the irrationality of the curricular structure (the lack of specialized teachers in certain subjects often forces other teachers to cover these subjects with a heavier workload and inadequate professional skills);
- (d) the low professional quality of rural teachers due to their educational background and lack of computer literacy.

The question is how AI supported technology can provide an opportunity to address these issues. Setting aside the problem of resource allocation, we focus on the other points.

To address the limited educational resources in rural schools, some local school administrators encourage or require urban teachers to teach in rural schools for a semester or a year with favorable conditions. Teacher mobility only occurs from the city to rural schools, and often, the relocation is driven by personal interest and for a short period. Unidirectional teacher mobility cannot solve the problem of teacher shortages in rural areas and does not promote the training of rural teaching staff.

For this reason, Yao (2020) argues that it is necessary to promote a two-way flow of teachers, allowing teachers from rural areas to visit schools in other regions, such as counties, cities, and provinces, to exchange experiences and learn from other teachers.

Technology can play a key role in this process, for example, by creating a provincially supported communication platform powered by artificial intelligence. Each teacher would have a profile with personal information and data files on this platform. Moreover, all schools in the province could use this platform to reserve schools for teacher exchanges. After a period of teacher exchange, the involved schools would evaluate the teachers' performance and acknowledge their contributions. This exchange and evaluation process would help teachers reflect on their experiences and receive feedback on their

practice. It's a system aimed at promoting the sharing of knowledge and experiences among teachers from different areas and enhancing overall teaching quality. As for the issue of the shortage of teachers in certain subjects and the development of an incomplete curriculum, it can be addressed by establishing collaborations between universities and rural schools, allowing students majoring in the lacking subjects to teach through an online platform. This approach would alleviate pressure on rural teachers, enhance teaching quality, stimulate students' interest, and improve learning opportunities. Moreover, it would provide colleges and universities with the opportunity to enhance the professional level of their students and create a significant connection between various areas of education. Ultimately, to improve the professional quality of rural teachers, it is suggested to fully utilize AI-supported information technology to establish cross-school and cross-sector teacher training. This approach would enable one-on-one targeted training among teachers, transcending geographical limitations. On the one hand, school connections would benefit both sides to mutually enhance one another and support the development of an online, digital, personalized educational system. Through the use of technology as an AI-enanched learning platform, training between two schools becomes more specific. Trainer teachers can tailor the training according to the specific needs of the rural schools involved. At the same time, it's possible to establish specialized teams of trainers that facilitate ongoing, long-term collaboration between the two schools. This approach not only overcomes the barriers of time and space but also ensures high-quality training to promote the professional development of rural teachers. The use of intelligent platforms would enhance the assessment and management process of teacher training effectiveness, enabling two-way evaluations and continuous assessments. The intelligent platform based on big data and cloud computing can provide users with real-time, precise, flexible, and open sharing services, significantly improving the quality of educational resource sharing services and offering effective solutions to disparities in high-quality teaching resources between urban and rural areas (Jiang, 2021). Overall, as the article suggests, AI-supported technology could play a key role in enhancing the efficiency, effectiveness, and equity of the teacher exchange process and in promoting the sharing of knowledge and experiences among teachers. For example, the development of AI-supported learning environments and communication platforms could provide a personalized interface to allow teachers to easily communicate with each other and with the schools involved in the exchange. An intelligent matching algorithm could analyze teachers' profiles, their skills, experiences, and preferences to match them for teaching exchanges, facilitating networking. AI could analyze data collected during teacher exchanges to identify patterns and trends in teacher performance and student outcomes. These analyses could provide valuable insights to improve the exchange process and identify best practices, promoting a transformative approach in teacher education (Kusmawan, 2023). AI-based virtual assistance could provide support and resources to teachers during the exchange process, such as offering advice on how to handle certain teaching situations or providing additional teaching materials.

3.2. Teachers' perceptions of Artificial Intelligence as a tool to support their practice

The goal of this study, realised by Chounta et al. (2022) in Estonia, was to explore teachers' perceptions about AI as a tool to support teaching. The integration of AI solutions in school settings has been recognised as useful for solving multiple problems, such as supporting automatic or semi-automatic assessment of student performance and tracking their progress (Heffernan & Heffernan, 2014; Luckin 2017), giving students scaffolding and personalized recommendations (Albacete et al. 2019; Tarus et al. 2018). In particular, the research questions underlying this study were two:

1) How do K-12 teachers perceive AI as a tool to support teaching and what are their expectations?
2) What are the perceived challenges that K-12 teachers face regarding their work practices?

To answer these questions, the authors involved 140 Estonian K-12 teachers in a survey. Regarding the sample, 37% of the teachers involved in the survey had more than 20 years of professional experience, 28% between 10 and 20 years, 17.5% between 5 and 10 years, and 17.5% less than 5 years. 98% of the participants stated that they routinely use learning software and applications in their teaching practice.

The survey consisted of three parts, each focusing on a specific aspect. The three parts are described below.

1) Teachers' perceptions, attitudes, and familiarity with AI (5 questions). The first two questions aimed to investigate teachers' personal knowledge of AI. The first item asked participants to rate their knowledge about AI using a 6-point Likert scale. The second item provided participants with five statements about AI and asked them to indicate which statements were true. The third item aimed to understand teachers' familiarity with AI. The last two items were aimed at investigating teachers' perceptions of the use of AI in education.
2) Teachers' perceived challenges in the classroom (1 question). The authors, considering the potential of using AI to equip teachers with 'superpowers', in line with Holstein et al. (2017), asked teachers to name up to three superpowers that would help them do their jobs better.
3) Teachers' job profiles and contexts (4 questions). The authors asked about participants' professional profiles, practices, and work contexts. The authors asked the participants what kind of learning technologies they used to support their practice, which areas of their work could potentially be supported by AI and whether they would like to know what kind of technologies are behind the tools they use. In addition, the authors asked participants how long they have been working as teachers.

The results of this survey suggested that teachers perceived themselves as having limited knowledge about AI and how it could support them in practice. Most of the participants stated that they have either a limited (47%) or fair knowledge (35%) regarding AI. About 4% of the teachers responded that they never heard of AI before, and 8% that they are not sure what it is. Only 6% of the participants stated that they know a lot about artificial intelligence. On the other hand, when asked about AI's fundamental concepts, most teachers provided on average 60% correctly.

However, participants demonstrated a positive attitude towards the use of AI in education. Regarding the positive aspects of using AI in education, participants believe that AI could help them to be more creative in their practices, to group the student population according to their level of knowledge, and to organise teaching materials in terms of levels of difficulty. About the critical issues related to the use of AI at school, participants emphasised their concerns about the effort they would have to put into learning how to use AI technologies appropriately and the potential trust issues that could arise from the use of AI. Participants also expressed concerns about the sidelining of the human factor and the effectiveness of AI for tasks requiring human intelligence and empathy.

The survey shows that teachers would like to possess superpowers that would make them able to clone themselves and read the thoughts of their students. Teachers would also like to be able to assess not only the knowledge but also the emotional state of their students. Furthermore, teachers stated that they would appreciate a superpower that would enable them to speak multiple foreign languages fluently. These results are in line with those obtained by Holstein and colleagues (2017).

Based on these findings, the authors identified the six challenges that teachers face: effectiveness, efficiency, rapport, course planning, personal attributes and personal skills. When designing AI-

enhanced solutions to support teachers, it is crucial to understand and consider not only the benefits but also the risks that artificial intelligence could pose to education. For example, one approach to support teachers' effectiveness and efficiency could be to provide them with AI models that automatically predict or evaluate student performance. However, it is crucial to keep in mind that the results of such models depend on the existing data they are trained on. For example, a predictive model trained on a gender unbalanced dataset will be more effective for the majority gender and less effective for the minority gender. This algorithmic bias may therefore support unfair and discriminatory policies for certain groups based on gender and underrepresented student populations in general.

To support teachers in planning courses, artificial intelligence could be used, for instance, to provide recommendations on teaching materials and projects. In this case, one potential risk of this practice concerns the transparency of recommendation systems and the quality of recommendations (Sinha & Swearingen, 2002). Another potential risk that the authors see in this use of artificial intelligence concerns the ethical and accountability aspects related to the role of teachers. One concern is that by over-prescribing automated solutions to teachers, there is a danger of undermining and diminishing the role of teachers.

In terms of relationship support, teachers have been asked to learn more about their students' thoughts and attitudes, for example to read their minds. An artificial intelligence system that provides teachers with real-time assessments or indications of students' cognitive and affective state could undoubtedly be a step in this direction. However, this may entail both ethical and privacy risks.

Finally, teachers stated that some of the problems they face are related to a lack of certain skills such as, for example, knowledge of foreign languages. The authors envisage that AI can support teachers by offering, for example, language translation services for teaching materials, but promoting teachers' dependence on Artificial Intelligence may entail risks in terms of liability if the results of AI are, for example, incorrect.

One implication of this work is undoubtedly the need to consider teachers' professional development, as in fact the International Teaching and Learning Survey (TALIS) points out, most teachers would like to improve their skills in the use of ICT for teaching (OECD 2019). Moreover, most teachers often participate in professional development activities. Chounta et al. (2022) point out that this highlights the need to rethink and shape the competences that teachers should acquire in the technology-rich classrooms that have been trying to be built in recent years. Chounta et al. (2022) point out that although AI is currently a hotly debated topic in both science and public opinion, further contextualized and conceptualized discussions with teachers are needed to develop AI-enhanced tools that will find a place in the classroom (Chounta, 2019; Verbert et al., 2020). As the survey results suggest, it is crucial to communicate to teachers the purpose, expected benefits and potential pitfalls of the new technology in order to support its integration into the school context. Above all, it is important to communicate how technology meets teachers' needs and does not hinder or prevent what teachers perceive as important. Finally, as Bridle (2018) points out, there is a danger in the mindless implementation of new technologies, and AI, that uncritically reproduce the mistakes of the past. Considering AI as the solution to all educational problems could have detrimental effects, for example, on the ethical level. As Bridle (2018) noted, establishing cooperation between humans and technology could prove to be a much more powerful strategy than total and uncritical reliance on computation alone.

3.3. Artificial intelligence to overcome the "teacher shortage" in small schools

The shortage of teachers in small schools and rural schools is currently considered a global problem (UNESCO, 2015) that jeopardizes access to primary education for children living in the most peripheral and marginal areas. In the face of the shortage of teachers in rural areas, the challenges in recruiting teachers and the consequent impact that the difficulty in retaining teachers in the most isolated territories will have on the global economy, there are now numerous studies that explore the teacher retention strategies adopted or adoptable by schools (Ingersoll et al., 2018; Mitchell et al., 2022) including for example strategies related to well-being, or strategies that look at the hiring of international teachers or strategies aimed at integrating the teaching team with professionals able to enter and stay in class and guarantee a continuity of teaching at risk. The issue of teacher shortage becomes an area of study and attention (Qian et al., 2020; Sindelar et al., 2018) of pedagogical research that looks at non-standard educational contexts such as small schools (Cannella et al., 2020; Mangione & Cannella, 2021) so much so that today we wonder about the use of AIED and the opportunity to invest in "*educational agents in pedagogical roles*" to overcome the problem and guarantee universal primary education by 2030 in remote areas. The debate now exploded at an international level on the ability of mechanical agents to play the role of teachers (Chin et al., 2011; Mitchell et al., 2022;) and studies on conversational agents based on dialogue and intelligent tutoring systems (ITS) share an idea of future linked to "*robotic instructors*" and the importance of going beyond "*routine skills*" and investing in pedagogical agents with "*relational and emotional skills*". The ability to work on "*educational proximity*" requires pedagogical agents to take into account spatial factors in social relations to promote effective learning. Scholars Bosede Edwards and Cheok (2018) wanting to answer the question "*can we build a robot that can act as a teacher in remote areas?*" hypothesize the development of pedagogical agents based on the three domains of learning: cognitive (teaching delivery, pedagogy and learning content), psychomotor (movement system) and emotional (sensory system). In line with what has been said, they also identify the "skills" that an independent robot teacher must possess:

- show those characteristics expected from a social agent (agency and social presence);
- act by being able to choose the appropriate pedagogy strategy;
- manage and engage in social interaction in class. Studies on the effectiveness of physically embodied agents compared to those based on screen or animated (Dahl & Kamel Boulos, 2013; Di Tore et al., 2013) push scholars to opt for a physical robot, like the one produced by VStone Company (Osaka, Japan) able to intervene on the affective dimension. Sota, as the prototype of the pedagogical agent developed is called, can connect to devices enabled to electronic sensors creating the so-called IoT network (Internet-of-Things). It is portable and small enough to be moved even by small children and can be placed on a table or desk. It can engage in a conversation and can be programmed to perform assessments based on data and allow their visualization on a connected screen exploiting it with classroom response systems (CRS) and collaborative learning environments or able to foster open and networked educational processes.

The independent robot responds to an educational paradigm that values social and peer learning (Capuano et al., 2013; Michinov et al., 2015) and group discussion (Mangione et al., 2012). A good teacher must be a good communicator and able to show a good level of agency and social presence (Straub, 2016) translatable into: embodiment (physical presence) with attention to the ability to engage other agents and manage their attention (Di Tore et al., 2013), verbal and non-verbal skills and recognition of others, ability to observe the rules of social communication (turn-taking, greetings, form

of address, etc., leave-taking) ability to simulate social roles related to the context and use of social memory (Straub, 2016). A pedagogical agent must be able to support motivation and manage feedback and operate in a collaborative environment (Biswas et al., 2005). In the design of Edwards and Cheok (2018) a system is hypothesized that can record the identities of the students at the beginning of the class sessions and store them in a database accessible by the teacher robot. This acquisition system uses a CRS connected to an evaluation system. The evaluative teaching sessions are based on the visualization of a question or stimulus by the class and the student or groups of students are called to reason using the CRS that connects the answers with the identity of each student provided at the beginning of the session. This is followed by a peer discussion session. The ability to recognize and respect the basic rules of social interaction is evidenced in turn-taking enabled by silence perceived through the absence of voices of students in class. This allows the robot teacher to "know" when to proceed with the lesson or discussion. By coordinating body movements with facial expressions, non-verbal communication is simulated, including body language, which is a significant concept in human-human interaction. The robot-teacher closes the lesson with a summary, greets and dismisses the class. The doubts expressed by the scientific community, mainly regarding the demands for social interaction and affective communication skills in mechanical agents, could be addressed with AI. In the future, robots could potentially function not only as classroom assistants or study companions for students, but also as independent agents capable of maintaining social and affective relationships and managing classroom spaces. This could be especially useful in hybrid learning environments, where both remote and in-person schooling are combined due to environmental difficulties that prevent teachers and students from reaching schools (Mangione & Cannella, 2021; Mangione et al., 2023).

The use of AI to address the "*teacher shortage*" in small schools also aligns with one of the four OECD Scenarios for the Future of Schooling constructed within a timeframe of approximately 20 years, up to 2040. In Scenario 1, "Schooling extended", the need for "*a more marked division of tasks and greater diversification of professional profiles in schools has emerged*" is highlighted (Fuster, & Burns, 2020). If, as suggested in this future scenario, "*an emphasis on digital tools impacts traditional teaching, and many tasks for educators in the classroom may become restricted to 'contingency management'*", then it is possible to consider pedagogical support agents where "*a reduced but distinct, well-trained teaching corps remains in charge of designing learning content and activities, which may then be implemented and monitored by educational robots along with other staff employed under diverse working arrangements (voluntary/paid, part-time/full-time, face-to-face or online), or directly by educational software*" (Fuster, & Burns, 2020). Development must also consider adapting professional development and career structures to the new scenarios. It is crucial for the management of professional satisfaction that educators perceive alignment between their professional development and the tasks they are asked to perform. The development must also consider adapting professional development and career structures to the new scenarios of AI, taking into account the conditions of professional satisfaction that educators perceive, seeking to define a use of pedagogical agents capable of promoting professional growth among teachers in small schools and their more optimal allocation.

4. Conclusions and research's perspective

The topic of AI and the professional development of rural teachers is a rapidly growing area of study, with solutions aimed at improving the quality of educational resource sharing and peer collaboration. For instance, this is achieved through the development of intelligent platforms based on big

data and cloud computing, which facilitate access to information, foster cooperation between urban and rural teachers, develop networks among schools, and implement training and mentoring programs for teachers. On the other hand, there are scenarios where AI is used to enhance and improve the teaching-learning process through the use of intelligent agents that support individuals in their learning activities. This solution aims to address the critical issue of teacher shortages, particularly urgent in developing economies, where the lack of teachers can jeopardize access to universal primary education for all. In this context, it is also necessary to examine teachers' perceptions of AI as a tool that could have a positive impact on their professional practice and the ethical skills, they should develop to use this technology responsibly. The core of the research focuses on the importance of AI for continuous training and professional development as key levers to address different challenges. Based on the mapping carried out and the in-depth analysis of AI for the professional development of teachers for better management of small schools, the research aims to broaden the investigation by offering additional sources of information, perspectives, meanings, and applicability. Participatory interviews with national and international experts are planned with the aim of identifying opportunities for small schools and defining the challenges that can guide future studies in the field of educational research. These experts, selected for their knowledge of the small school context, will be asked to answer key questions that emerged from the scoping review. The goal is to identify opportunities for small schools and define the challenges that can guide future studies in the field of educational research. Subsequently, to synthesize the guidelines emerging from the research, experts will be engaged in a Delphi Study (Green, 2014). This iterative process will facilitate consensus on the areas of AI intervention in the non-standard educational context. Later, by connecting the stimulus questions to the dimensions that emerged from the scoping review and the challenges emerged from Delphi study, it will be possible to prepare a confirmatory study on large numbers. A questionnaire survey tool will be prepared and shared with all teachers and managers who join the National Network of Small Schools. The survey will allow us to validate the dimensions and interventions that AI would allow for small schools and at the same time identify others, intercepting where possible also the first implementation scenarios or detect the *anticipatory practices* AI based (Miller, 2018).

5. Author contributions

Giuseppina Rita Jose Mangione (INDIRE) is the author of paragraphs 1, 3.3, 4; Michelle Pieri (University of Trieste) is the author of paragraphs 2, 3.2; Francesca De Santis (INDIRE) is the author of paragraphs 3, 3.1.

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Less knowledge, more trust? Exploring potentially uncritical attitudes towards AI in higher education

Minor conoscenza, maggiore fiducia? Una esplorazione degli atteggiamenti potenzialmente acritici verso l'IA nell'istruzione universitaria

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ABSTRACT Artificial intelligence (AI) has the potential to transform various aspects of our lives, but its development has been accompanied by several social and ethical concerns. To comprehend the implications and underlying mechanisms, it is essential to acquire a broad understanding of its benefits and drawbacks. To this purpose, AI literacy is a fundamental driver for more aware attitudes towards AI development and implications. However, AI literacy research is still in its infancy. To contribute to advances in the sector, this paper presents the results of a study aimed at assessing students' AI literacy in the context of higher education, focusing on doctoral students. A survey on AI literacy was performed in four dimensions: cognitive, operational, critical and ethical. The results show that while participants had little AI knowledge, they were overconfident of the technology's capabilities. The study highlights the need for a more comprehensive approach to AI literacy that encompasses a deeper understanding of its ethical, social and economic implications.

KEYWORDS Artificial Intelligence in Education; Artificial Intelligence Literacy; Education; Ethics.

SOMMARIO L'intelligenza artificiale (IA) ha il potenziale per trasformare vari aspetti delle nostre vite, ma il suo sviluppo è stato accompagnato da numerose preoccupazioni sociali ed etiche. Per comprendere le implicazioni e i meccanismi sottostanti, è essenziale acquisire una comprensione ampia dei suoi benefici e svantaggi. A questo scopo, l'alfabetizzazione all'IA è un fattore fondamentale per promuovere atteggiamenti più consapevoli verso lo sviluppo dell'IA e delle sue implicazioni. Tuttavia, la ricerca sulla literacy all'IA è ancora agli esordi. Per contribuire ai progressi del settore, questo articolo presenta i risultati di uno studio volto a valutare l'alfabetizzazione all'IA degli studenti nel contesto dell'istruzione universitaria, concentrandosi su dei dottorandi. L'indagine sulla loro literacy all'IA è stata condotta su quattro dimensioni: cognitiva, operativa, critica ed etica. I risultati mostrano che, sebbene i partecipanti avessero poca conoscenza dell'IA, erano eccessivamente fiduciosi nelle capacità della tecnologia. Lo studio evidenzia la necessità di un approccio più completo all'alfabetizzazione all'IA, che includa una comprensione più profonda delle sue implicazioni etiche, sociali ed economiche.

PAROLE CHIAVE Intelligenza Artificiale nell'Educazione; Alfabetizzazione all'IA; Istruzione; Etica.

1. Introduction

In an era where technology's influence is hardly deniable, Artificial Intelligence (AI) stands at the forefront, shaping multiple sectors from business to the arts and, notably, education (Casal-Otero et al., 2023; Laupichler et al., 2023; Liu et al., 2023; JRC & OECD, 2021; UNESCO, 2021; Zawacki-Richter et al., 2019). Our daily interactions - from adjusting settings on smart home devices to seeking help from virtual assistants like Siri and Google - highlight AI's ubiquitous presence in modern life. This widespread incorporation of AI amplifies the urgency for a comprehensive understanding, leading to a pressing call for robust AI literacy across the population (Kong et al., 2023 to cultivate a broad awareness and comprehension of both AI's potential benefits and drawbacks (Gašević, Siemens, & Sadiq, 2023; Selwyn, 2022; Perrotta & Selwyn., 2020).

However, despite the growing consensus on the significance of AI literacy, research in this domain is still in its infancy, the exact definition of AI literacy remains elusive, and there is a notable gap in the development of coherent strategies for promoting and evaluating it (Cuomo et al., 2022; Kong & Zhang, 2021. At its core, AI literacy is believed to champion ethical use, ensure adaptability in an ever-evolving technological landscape, and address societal inequalities (Selwyn, 2023; Wilton et al., 2022). Such a foundation supports a community in making informed decisions, especially in the face of AI's societal and ethical implications (Floridi et al, 2021, UNESCO, 2019; UNICEF, 2021; Zhang et al., 2022). Research has consistently highlighted the necessity of introducing AI literacy from the early stages of education (Long & Magerko, 2020; Su & Zhong, 2022). Countries worldwide have started weaving AI concepts into primary and secondary education, preparing younger generations for the challenges and opportunities of the future (Williams et al., 2019). However, when focusing on higher education, particularly among doctoral students, research is even scarcer (Hazell et al, 2020; Gouseti, 2017). Doctoral students are a niche representing the next generation of researchers and professors. Given this position in academia, doctoral students' perceptions can provide invaluable insights into the understanding and potential integration of AI literacy into academic curricula. This paper seeks to bridge this knowledge gap by presenting the results of a survey that delves into doctoral students' perceptions of AI literacy. By doing so, we aim to contribute substantially to the ongoing discourse on how best to navigate a future deeply interwoven with AI, ensuring that the next generation of scholars and leaders are adequately prepared. To assess the level of self-perceived literacy, in this study, we administered a previously validated questionnaire (Biagini et al, 2023) to a sample of 66 Italian PhD students from different programmes, mainly but not exclusively, in the field of educational sciences. The AI literacy perception was assessed by measuring their knowledge and understanding of the topic across four dimensions: the cognitive, operational, critical and ethical dimensions. These are regarded as the key dimensions in many AI Literacy frameworks (Cuomo et al., 2022; Ng et al., 2021). The questionnaire includes both close-ended and open-ended questions, allowing a comprehensive analysis of participants' understanding of AI aimed at providing valuable insights into the current level of AI literacy among students.

2. Background

2.1. AI Literacy Frameworks and definitions

Even though there is still no consensus on a definitive description of AI literacy, various attempts have been made to frame it within the broader context of digital literacy. The diverse range of defini-

tions, such as Kandlhofer and colleague's (2016) emphasis on grasping basic AI techniques and applications, showcases the foundational aspects of AI literacy. Authors like Druga et al. (2019 & 2022) and Wong et al. (2020) highlighted the importance of AI literacy's ethical aspects and awareness of its societal influence. Long & Magerko (2020) defined AI literacy as a range of skills that enable critical evaluation and productive collaboration with AI technologies. Liu & Xie (2021) expanded AI literacy to include digital literacy and computational thinking. Kim et al. (2021) emphasised knowledge, skill and attitude, while Kong & Zhang (2021) and Cetindamar et al. (2022) discussed AI literacy in the context of career readiness. Yi (2021) discussed AI literacy's cultural and subjective dimensions, implying that AI literacy is more than a set of technical abilities but also includes the ability to navigate and modify one's life amid AI's transformations. Deuze & Beckett (2022) and Hermann (2022) examined AI literacy's applicability and influence from normative and practical perspectives. Laupichler et al. (2023) and Wang, Rau and Yuan (2022) emphasised informed AI use and implications for decision-making. Finally, Weber and colleagues (Weber, Pinski & Baum, 2023) provided a comprehensive view, encompassing data and algorithm literacy as key components.

Our earlier research led to the development of a framework described by Cuomo and colleagues (2022), which consists of four essential dimensions that, combined, cover the entire range of AI literacy skills mentioned above. To be more specific, the framework is made up of:

- a Knowledge-related Dimension: this encompasses the understanding of fundamental AI concepts, focusing on basic skills and attitudes that do not require preliminary technological knowledge (Ng et al., 2021). It includes understanding AI types, machine learning principles, and various AI applications such as artificial vision and voice recognition.
- an Operational Dimension: focused on applying AI concepts in various contexts (Druga et al., 2019; Lee et al., 2021); it emphasises the ability to solve problems using existing AI tools and develop simple applications that incorporate AI modules to enhance analytical and critical thinking (Kim et al., 2021).
- a Critical Dimension: highlighting AI's potential to engage students in cognitive, creative, and critical discernment activities (Su & Zhong, 2022); it underscores the importance of effective communication and collaboration with AI technologies and critical evaluation of their impact on society.
- an Ethical Dimension: concerning the responsible and conscious use of AI technologies, this dimension stresses the balanced view of delicate ethical issues raised by AI, such as the delegation of personal decisions to a machine [e.g., job placement or therapeutic pathways], and emphasises the growing attention towards "AI Ethics", encompassing transparency, fairness, responsibility, privacy and security.

These factors work together to create a multifaceted perspective to investigate, evaluate and develop AI literacy. They stress the importance of going beyond only consuming AI passively to a more active and responsible knowledge, providing a comprehensive, integrative method to addressing AI literacy.

2.2. Assessment tools

The central focus of our approach to measuring this specific construct lies in the development of a comprehensive framework. This framework is essential to address the multiple components and their interconnections that are fundamental to understanding AI. Such a framework is necessary due to the complexity and multifaceted nature of AI literacy. Several efforts have been made to develop tools to measure different aspects of AI literacy. These tools mostly focus on some components of AI literacy (e.g.,

Table 1. Summary of the AI literacy questionnaires reviewed.

Tool name	Author	Questionnaire purpose	Questionnaire Target	Validation process EFA=explorative factor analysis; CFA=confirmative factor analysis AVE=Average Variance Extraction	No. of items
Assessment of non-experts' AI literacy	(Laupichler et al., 2023)	Support the development of a scale for the assessment of AI literacy.	Non-experts	Content validation but no factor loadings	38 items
Critical AI literacy scale (CAILS)	Biagini et al., 2023	Evaluate critical skills in AI use, covering knowledge, operation, criticism, and ethics.	Non-experts, Academics	Complete validation, EFA, CFA, AVE and Reliability)	40 items
Artificial intelligence literacy (AILS scale)	(B. Wang et al., 2022)	Assess the self-reported competence of users in using AI	AI Users (Expert and non-expert)	Complete validation (EFA, CFA, Reliability)	12 items
AI anxiety (AIAS scale)	(Y.-Y. Wang & Wang, 2022)	Measure AI anxiety	Citizens (Expert and non-expert)	Complete validation (EFA, CFA, Reliability)	21 items
Attitude Towards Artificial Intelligence (ATAI scale)	(Sindermann et al., 2021)	Trust in and Usage of Several Specific AI Products	Citizens (Expert and non-expert)	Complete validation (EFA, CFA, Reliability)	5 items
General Attitudes towards Artificial Intelligence (GAAIS scale)	(Schepman & Rodway, 2020)	Inform legislators and organisations developing AI about their acceptance by the end users	Citizens (Expert and non-expert)	Complete validation (EFA, CFA, Reliability)	20 items

affective factors or collaborative variables), while neglecting its intricate nature (Laupichler et al., 2023). Examples that demonstrate this tendency include the "Attitudes Towards Artificial Intelligence Scale" (Sindermann et al., 2021), the "General Attitudes Towards Artificial Intelligence Scale" (Schepman & Rodway, 2023), and the "Artificial Intelligence Anxiety Scale" (Wang & Wang, 2022). In order to address this constraint, based on the comprehensive framework for AI literacy created by Cuomo et al. (2022), we developed a questionnaire that includes items from preexisting assessment tools as well as new or modified ones. Moreover, to choose elements that may be altered to assess AI literacy as a result, we also looked at validated questionnaires on comparable themes, including technical competence or digital literacy. An all-encompassing technique for assessing AI literacy could offer valuable insights into the efficacy of educational interventions. This widely applicable scale could serve as a significant tool for researchers and educators to test and improve AI literacy in many contexts. Table 1 shows the tools reviewed.

3. Method

3.1. Research questions

The variability in AI education methods and objectives stems from the diverse target demographics, each presenting unique learning needs and challenges. Interestingly, a preliminary scan of the academic

landscape on this topic uncovers two predominant categories of publications. One delves into the practical aspects of AI education, detailing course designs and evaluations for non-experts (Long & Magerko, 2020, Lin et al., 2021; Shih et al., 2021), while the other ventures into the theoretical aspects, exploring definitions and the relationship between AI literacy and other literacies (Kandlhofer et al., 2016; Wienrich & Carolus, 2021). Both research strands, with their distinctive focuses, are essential for a complete grasp of AI literacy. Thus, this research aims to investigate the doctoral students' AI literacy perceptions by measuring their knowledge and understanding of the topic across the cognitive, operational, critical and ethical dimensions. The research questions (RQ) addressed in this study are as follows:

RQ1. *What are the levels of self-perceived awareness of doctoral students regarding the dimensions of AI literacy?*
RQ2. *Are there differences in the perceived trustworthiness of AI in relation to the knowledge reported by the students?*

3.2. Survey and measures

To address the research questions, a validated questionnaire (Biagini et al, 2023) was administered. The questionnaire scale consists of 10 items on AI ethics, 10 on AI critical assessment, 12 on AI applications, and 8 focused on AI knowledge and explores the opinions and perceptions of respondents regarding AI literacy in the context of education. Its aim is to understand the varying degrees of importance assigned to different education-related opportunities and challenges associated with AI. The survey gathered responses from multiple participants varying across different questions. The survey covered a range of topics, beginning with general questions that gather demographic information about the respondents, including their gender, age, educational background, years of professional experience, and their propensity towards technology. Given the questionnaire's focus on AI in education, it included questions specifically tailored to the respondents' involvement in the education sector. Thus, a few items explored whether they work in education, the location of their workplace, and the number of years they have been working in the field. This information helped contextualise their responses and identify any potential correlations between AI literacy and professional experience in education. To comprehensively evaluate AI literacy, the questionnaire is further divided into four sections aligned with the theoretical framework (Cuomo et al, 2022). Respondents could answer according to a 5-value Likert scale from the minimum level 1 ("None at all") to the maximum level 5 ("A great deal") of agreement with the proposed statement. The first section delves into the respondents' knowledge of AI, assessing their understanding of core concepts and principles related to artificial intelligence. The second section examines the respondents' application abilities in AI. It aims to assess their practical skills in applying AI techniques or utilising AI tools effectively. The third section focuses on their critical evaluation of AI. It seeks to measure the respondents' capacity to critically evaluate AI technologies, including their potential benefits, limitations and implications. Lastly, a fourth section addresses the ethical considerations associated with AI. This section aims to determine the respondents' awareness of ethical issues related to AI and their ability to evaluate and navigate ethical dilemmas that arise in the context of AI.

3.3. Data analysis: the participants

To understand the demographics of the target students and their academic experiences, we collected some broad information about their profile. This article presents a convenience sample consisting of 66 Italian PhD students from a socio-educational background, aiming to investigate vari-

Table 2. Sample characteristics.

Characteristic	Items	%	Frequency
Gender	Male	31.82	21
	Female	63.64	42
	Prefer not to say	4.55	3
Age	18-24 years	5.3	3
	25-34 years	38.6	22
	35-44 years	24.6	14
	45-54 years	24.6	14
	55-65 years	5.3	3
Geographic Provenance	Tuscany	66.67	44
	Lombardy	13.64	9
	Puglia	7.58	5
	Sicily	6.06	4
	Liguria	3.03	2
	Piedmont	1.52	1
	Emilia-Romagna	1.52	1
School level of employment (if already working)	University	15.8	9
	Elementary School	14.0	8
	High School	14.0	8
Highest degree or level of education completed	University Degree	42.1	29
	Master's Degree	43.9	30
	Doctorate	7.0	5
Professional experience (in years):	Less than 5 Years	17.5	10
	5 to 10 Years	12.3	7
	10 to 20 Years	7.0	4
	More than 20 Years	7.0	4

ous factors influencing their academic experiences. The sample included 21 males (31.82%), 42 females (63.64%), and 3 participants preferring not to disclose their gender (4.55%). Age-wise, the largest group fell within the 25-34 years range, making up 38.6% of the sample with 22 respondents. Geographically, the sample was predominantly from Tuscany (66.7%, 44 respondents) and Lombardy (13.6%, 9 respondents). The highest level of education completed varied, with 29 holding a university degree (42.1%) and 30 possessing a master's degree (43.9%). Additionally, 5 respondents had completed a doctorate (therefore, attending a second doctorate), making up 7.0% of the sample. Among the respondents who already work in education (n=25), professional experience in teaching varied, with 10 participants reporting less than 5 years of experience (17.5%). Table 2 displays the sample details.

4. Results

4.1. What are the levels of self-perceived awareness of doctoral students regarding the dimensions of AI literacy? (RQ1)

4.1.1. Knowledge dimension: AI Literacy and Theoretical Foundations

In this study, while we administered the comprehensive survey encompassing all 40 items across the four dimensions of AI literacy, we report results for only 25 items that are relevant for

Table 3. AI – Knowledge perception.

Sub-Dimensions	None at all	A little	A moderate amount	A lot	A great deal	Mean	SD
Know and understand AI definitions and theoretical foundations (Knowledge-related dimension)	2 (3.8%)	13 (25%)	17 (32.7%)	15 (28.8%)	5 (9.6%)	3.15	1.03
Know and understand AI basic mathematical functions behind the algorithms (Knowledge-related dimension)	20 (38.5%)	13 (25%)	13 (25.0%)	4 (7.7%)	2 (3.8%)	2.13	1.13
Use and apply AI knowledge, concepts and applications (Operational dimension)	9 (17.3%)	22 (42.3%)	11 (21.2%)	7 (13.5%)	3 (5.8%)	2.48	1.10
Evaluate, appraise, and critically assess AI applications (Critical dimension)	14 (26.9%)	11 (21.2%)	16 (30.8%)	8 (15.4%)	3 (5.8%)	2.52	1.20
Create AI, design and build AI applications (Operational dimension)	30 (57.7%)	10 (19.2%)	5 (9.6%)	2 (3.8%)	5 (9.6%)	1.88	1.30
Understanding ethical issues related to AI such as fairness, accountability, transparency, safety (Ethical dimension)	3 (5.8%)	13 (25%)	12 (23.1%)	10 (19.2%)	14 (26.9%)	3.37	1.27

the research questions addressed. To gauge the participants' knowledge of AI principles, they were asked to assess their perceptions of the various AI framework sub-dimensions (e.g., "*When it comes to Artificial Intelligence (AI), I feel my knowledge on … would be: 1/None at all, 2/A little, 3/A moderate amount, 4/A lot, 5/A great deal", where the sentence was differently completed according to the framework dimension considered, e.g., "Evaluation, appraisal and critical assessment of AI applications*") (Cuomo et al., 2022). Understanding the definitions and theoretical foundations of AI is relatively well-distributed among the respondents. A majority, 67%, claim to have at least a moderate understanding, but a significant 33% feel they grasp AI concepts from none to a very little extent. Furthermore, when delving into the basic mathematical functions underpinning AI algorithms, the respondents feel considerably less confident. A significant 38.5% admit they have no understanding at all, and another 20% state they have only a little knowledge. The percentage of those who believe they know a lot, or a great deal drops to 11.5%, when compared to the previous answer. In terms of applying AI knowledge and concepts, the results lean more toward the basic side, with 59.6% having either no or just a little experience. The advanced end of the spectrum remains narrow, with only 19.3% feeling they can use or apply AI knowledge to a considerable extent. Evaluating, appraising and critically assessing AI applications shows a moderate distribution, with 30.8% having a moderate amount of confidence in their capabilities. A combined 25% believe they can evaluate AI applications extensively, while 26.9% have no experience. The ability to create, design and build AI applications shows a distinct trend: a clear majority, 57.7%, admit that they have no experience at all. Combining this with the 19.2% with minimal experience, it's evident that hands-on AI development remains specialised, though 9.6% claim a high degree of proficiency. Finally, ethical issues related to AI show an interesting distribution. While only 5.8% have no understanding of it, a noteworthy 26.9% feel they understand these issues to a great extent. The results hint at a heightened awareness or interest in AI ethics among the group, with 45.1% claiming to understand these issues a lot or a great deal. Table 3 summarises the results.

4.1.2. Operational dimension: Perceptions of AI Task Performances

The results suggest a mixed perception regarding the acceptance of AI performing various tasks (Table 4). Emergency services garner significant confidence with 64% of participants leaning towards AI support, either probably or definitely. Educational sectors also witnessed a strong inclination with 72% leaning towards a positive stance. When it comes to more intricate procedures like performing surgeries, the acceptance decreases with 50% probably or definitely endorsing it. News reporting emerges as a divisive field, with nearly half (48%) of the participants remaining neutral. The most significant confidence is observed in AI's potential for medical and scientific research with a commanding 66% probably or definitely advocating its role. However, emotional support showcased the most pronounced scepticism. A staggering 46% of respondents probably or definitely would not rely on AI for emotional sustenance. Assisting in surgical procedures fared better than performing them, with 64% leaning towards positive support.

Table 4. Allowing AI Performance.

Dimensions	Definitely not	Probably not	Might or might not	Probably yes	Definitely yes	Mean	SD
Supporting emergency services	1 (2%)	4 (8%)	13 (26%)	18 (36%)	14 (28%)	3.8	1.00
School / educational support	1 (2%)	4 (8%)	9 (18%)	23 (46%)	13 (26%)	3.86	0.96
Performing surgical procedures	1 (2%)	5 (10%)	19 (38%)	16 (32%)	9 (18%)	3.54	0.96
News reporting	3 (6%)	2 (4%)	24 (48%)	12 (24%)	9 (18%)	3.44	1.02
Medical/scientific research	1 (2%)	3 (6%)	13 (26%)	25 (50%)	8 (16%)	3.72	0.87
Emotional support	12 (24%)	11 (22%)	13 (26%)	9 (18%)	5 (10%)	2.68	1.29
Assisting surgical procedures	2 (4%)	2 (4%)	14 (28%)	19 (38%)	13 (26%)	3.78	1.01

4.1.3. Critical dimension: Analysing AI's Risks and Benefits

The excitement surrounding AI is palpable with 64.59% of respondents feeling that AI is exciting either a lot or a great deal. This enthusiasm likely stems from AI's potential to revolutionise industries, improve efficiency and solve the complex problems facing society. However, alongside this optimism, apprehensions also surface. When asked whether AI is considered dangerous, a notable 43.75% of participants believe it is to a moderate extent, and an additional 20.83% believe it is a lot, totalling 64.58%. Reflecting on the error rates of AI systems, a majority of 52.08% feel that AI systems make many errors to a moderate extent, and an additional 25% believe it's a little, totalling 77.08%. Regarding AI's performance compared to humans, opinions are varied, with the highest, 43.75%, believing that AI can perform better than humans. On the topic of AI replacing humans in routine jobs, a significant 35.42% believe this would be a lot better, and an additional 27.08% believe it to a moderate extent. This adds up to 62.5%, a considerable majority recognising AI's potential to efficiently handle routine tasks. In the economic context, a significant 41.67% think that AI can provide a lot of new economic opportunities, with an additional 29.17% believing it to a moderate extent, totalling 70.84%. Lastly, when considering the broader societal benefit from AI, a plurality of 45.83% feel that much of society will benefit moderately from a future filled with AI. Table 5 summarises the results.

Table 5. Perception toward AI.

Dimensions	None at all	A little	A moderate amount	A lot	A great deal	Mean	SD
AI is exciting	3 (6.25%)	4 (8.33%)	10 (20.83%)	17 (35.42%)	14 (29.17%)	3.80	1.11
I think AI is dangerous	7 (14.58%)	9 (18.75%)	21 (43.75%)	10 (20.83%)	1 (2.08%)	2.80	1.00
I think AI systems make many errors	3 (6.25%)	12 (25%)	25 (52.08%)	6 (12.5%)	2 (4.17%)	2,87	0.86
AI systems can perform better than humans	5 (10.42%)	13 (27.08%)	21 (43.75%)	6 (12.5%)	3 (6.25%)	2.80	1.00
An AI agent would be better than an employee in many routine jobs	4 (8.33%)	11 (22.92%)	13 (27.08%)	17 (35.42%)	3 (6.25%)	3.13	1.07
AI can provide new economic opportunities	4 (8.33%)	7 (14.58%)	14 (29.17%)	20 (41.67%)	3 (6.25%)	3.28	1.03
Much of society will benefit from a future full of AI	4 (8.33%)	10 (20.83%)	22 (45.83%)	8 (16.67%)	4 (8.33%)	3.00	1.01

4.1.4. Ethical dimension: Perceptions of AI's Ethical impacts

When asked about the future impact of AI (Table 6) the results show that regarding personal and individual privacy, about 60.41% of respondents express concerns that AI will negatively impact this area. For equity and fairness, 41.67% of respondents feel that AI's impact will leave this aspect about the same, with an additional 25% expressing a belief in potential improvements. Concerning workforce and labour displacement, optimism emerges as 41.67% believe AI will make the situation somewhat better. When considering relevant risks, 72.91% feel the situation will remain the same or improve with AI. Lastly, focusing on cybersecurity, a combined 47.92% of respondents harbour concerns that AI will make matters worse.

Table 6. Future impact of AI.

Dimensions	Much worse	Somewhat worse	About the same	Somewhat better	Much better	Mean	SD
Personal/individual privacy	7 (14.58%)	22 (45.83%)	12 (25%)	5 (10.42%)	2 (4.17%)	2.46	1.00
Equity and fairness	4 (8.33%)	12 (25%)	20 (41.67%)	11 (22.92%)	1 (2.08%)	2.89	0.92
Workforce/labour displacement	7 (14.58%)	8 (16.67%)	12 (25%)	20 (41.67%)	1 (2.08%)	3.04	1.11
Relevant risks	6 (12.5%)	5 (10.42%)	16 (33.33%)	19 (39.58%)	2 (4.17%)	3.17	1.06
Cybersecurity	6 (12.5%)	17 (35.42%)	8 (16.67%)	14 (29.17%)	3 (6.25%)	2.83	1.16

4.1.5. Corollary: Nuanced understanding of the AIL dimensions from a pedagogical perspective

The survey responses reveal a mix of positive and cautious attitudes toward the integration of AI in teaching (Table 7). To aid accuracy in teaching, a combined 66.67% of respondents either somewhat or strongly agree that AI could help teachers be more accurate. However, apprehension is apparent regarding the learning curve associated with AI tools. A total of 66.67% (43.75% somewhat agree and 22.92% strongly agree) acknowledge that a substantial effort would be necessary to learn how to effectively use AI in teaching. In terms of pedagogical tasks like reviewing homework, a significant 64.58% believe that AI could help save time. Despite these positives, scepticism and concerns persist. A combined 53.33% of respondents express distrust in AI's ability to execute tasks without errors. Job

security fears are also notable, with 37.5% of respondents expressing concerns that AI could take someone's job. When considering lesson planning, a substantial 56.25% feel that AI could aid in time saving, again highlighting AI's potential efficiency contributions in various teaching aspects. Similarly, for content and material sourcing, a 66.67% of respondents see AI as a time-saving tool. Despite these perceived advantages, a considerable 43.75% of respondents either somewhat or strongly believe that teaching fundamentally requires human involvement, which AI cannot replicate.

Table 7. Use of AI in the teaching field.

Statement	Strongly disagree	Some-what disagree	Neither agree nor disagree	Some-what agree	Strongly agree	Mean	SD
It could help the teacher to be more accurate	1 (2.08%)	8 (16.67%)	7 (14.58%)	20 (41.67%)	12 (25%)	3.78	1.03
It would require effort to learn how to use it	1 (2.08%)	3 (6.25%)	12 (25%)	21 (43.75%)	11 (22.92%)	3.87	0.86
It could help to save time when reviewing homework	2 (4.17%)	6 (12.5%)	9 (18.75%)	19 (39.58%)	12 (25%)	3.76	1.06
I don't trust it to carry out tasks without error	4 (8.33%)	14 (29.17%)	16 (33.33%)	11 (22.92%)	3 (6.25%)	2.93	1.04
I'm scared it could take someone else's job	4 (8.33%)	11 (22.92%)	15 (31.25%)	13 (27.08%)	5 (10.42%)	3.13	1.11
It could help to save time when creating a time plan for a lesson	2 (4.17%)	5 (10.42%)	14 (29.17%)	19 (39.58%)	8 (16.67%)	3.61	0.98
It could help to save time when looking for materials/content for a lesson	1 (2.08%)	2 (4.17%)	13 (27.08%)	17 (35.42%)	15 (31.25%)	3.98	0.88
Teaching requires human involvement, and I don't think AI can do what is needed	2 (4.17%)	15 (31.25%)	10 (20.83%)	14 (29.17%)	7 (14.58%)	3.24	1.14

4.2. Are there differences in the perceived trustworthiness of AI in relation to the knowledge reported by the students? (RQ2)

In order to answer this research question, we compared the answers of two clusters, one (Group 1) composed of students who perceived a high literacy on AI, and another (Group 2), comprising the remaining students who declared a low knowledge on AI. In our study, the distinction between Group 1 and Group 2 was based on participants' self-reported levels of AI literacy. To categorise participants into these two groups, we employed a mean score calculation derived from responses to the 8 items specifically designed to measure 'AI Knowledge'. This methodological choice was made to quantitatively differentiate between and compare participants exhibiting a high self-reported level of AI literacy ("Moderate", "A lot", "A great deal") and those indicating a lower level of knowledge ("None at all", "A little"). For that task, we used Student's T for a significance check of the two categories, we prioritised the presentation of comparisons between groups based on the presence of statistically significant differences across the items surveyed. Upon reviewing the results (Table 8), a trend emerges that emphasises the significance of AI literacy in shaping individuals' attitudes toward AI's capabilities and limitations. Group 2, with a lower perceived literacy on the knowledge-related dimension, consistently shows higher mean scores across various tasks performed by AI compared to Group 1. This pattern indicates a greater willingness in Group 2 to allow AI to undertake diverse roles, including sensitive ones like performing surgeries or assisting in surgical procedures and providing emotional support. For example, in the task of AI performing surgeries, Group 2's mean score is 3.96, compared to 3.39 in Group 1, highlighting a higher level of trust in AI's capabilities in this critical area. Similarly, for emotional support, Group 2 demonstrates a greater reliance

on AI with a mean score of 3.38 compared to Group 1's 2.66. This consistent trend across various tasks underscores a potential lack of critical assessment of AI's capabilities and limitations by individuals in Group 2, possibly leading to an unjustified elevation in trust and dependence on AI technologies.

Table 8. Comparison of allowing AI performance. *p<0.05 **p<0.001.

Would you allow AI to perform the following tasks?	Group 1 (Perceived literacy on knowledge-related dimension >2) N=44		Group 2 (Perceived literacy on knowledge-related dimension ≤ 2) N=22		Student's T
	Mean	SD	Mean	SD	
Supporting emergency services	3.61	1.00	3.98	1.09	0.998
School / educational support	3.66	0.96	3.90	1.22	0.827
Performing surgical procedures	3.39	0.96	3.96	1.11	1.760*
News reporting	3.18	1.02	4.00	1.22	2.797**
Medical/scientific research	3.45	0.87	4.14	1.20	2.458**
Emotional support	2.66	1.29	3.38	1.56	2.127*
Assisting surgical procedures	3.6	1.01	4.00	1.26	1.341

Analysing Table 9, it emerges that the attitudes and beliefs regarding AI differ between the two groups, but not as drastically as observed in the previous table (Table 8). Both groups find AI exciting with nearly identical mean scores (Group 1: 3.73, Group 2: 3.75). Group 2 has a generally more positive or trusting view of AI. For example, they slightly disagree more with the statement that AI is dangerous, with a mean of 2.80 compared to Group 1's mean of 3.02. Similarly, Group 2 is more favourable to the idea that AI systems can perform better than humans (4), compared to Group 1 (3.08). This pattern is consistent with the idea that Group 2 has a higher, potentially unjustified trust in AI, possibly due to their lower literacy on the knowledge-related dimension. While the differences in mean scores for each statement between the two groups are not vastly distinct, the consistently higher trust and optimism toward AI in Group 2 reinforce the notion that lower AI literacy could lead to uncritical attitudes and unjustified trust in AI technologies.

Table 9. Comparison of attitudes toward AI. *p<0.05 **p<0.001.

How much do you agree with the following statements?	Group 1 (Perceived literacy on knowledge-related dimension >2) N=44		Group 2 (Perceived literacy on knowledge-related dimension ≤ 2) N=22		Student's T
	Mean	SD	Mean	SD	
AI is exciting	3.73	1.11	3.75	1.02	0.281
I think AI is dangerous	3.02	1.00	2.80	1.54	-0.069
I think AI systems make many errors	2.93	0.86	3.10	1.12	1.174
AI systems can perform better than humans	3.08	1.02	4	1.22	2.897**
An AI agent would be better than an employee in many routine jobs	3.23	1.07	4.10	1.12	2.258**
AI can provide new economic opportunities	3.34	1.03	3.25	1.33	0.214
Much of society will benefit from a future full of AI	3.02	1.01	3.20	1.32	1.113

Examining Table 10, a consistent pattern emerges again with Group 2 showing a generally more optimistic view regarding the impact of increased AI use on various aspects of life compared to Group

1. Regarding personal/individual privacy, both groups have similar mean scores (Group 1: 2.73, Group 2: 2.75), indicating comparable expectations. However, for aspects like workforce/labour displacement, Group 2 anticipates less negative impact with a mean of 2.80, compared to Group 1's mean of 3.25, underscoring their more optimistic outlook. Significantly, Group 2 expects more improvement in relevant risks with a mean of 3.45, contrasting with Group 1's mean of 3.09. This is another reflection of Group 2's potentially unwarranted trust in AI, underlining their expectation that AI will handle relevant risks better, possibly without fully grasping the complexities and challenges involved.

Table 10. Comparison of AI future impact. *p<0.05 **p<0.001.

Please indicate whether you expect that the increased use of Artificial Intelligence (AI) will make each of the following? (1 – Much worse, 5 – Much better)	Group 1 (Perceived literacy on knowledge-related dimension >2) N=44		Group 2 (Perceived literacy on knowledge-related dimension ≤ 2) N=22		Student's T
	Mean	SD	Mean	SD	
Personal/individual privacy	2.73	1.00	2.75	1.45	0.647
Equity and fairness	2.98	0.92	3.05	1.10	0.842
Workforce/labour displacement	3.25	1.11	2.80	1.44	-0.729
Relevant risks	3.09	1.06	3.45	1.39	1.540*
Cybersecurity	2.91	1.16	2.95	1.39	0.676

5. Discussion

In this paper, we explored the perceptions, and the attitudes toward AI among students, shedding light on the complex nature of AI understanding and utilisation in various domains, particularly in education. The findings of the questionnaire revealed a spectrum of perspectives, highlighting both the potential and the concerns related to AI and its integration. The results show a trend of awareness regarding the ethical issues surrounding AI, including fairness, accountability, transparency and safety (Gašević et al., 2023; Selwyn, 2022; Perrotta & Selwyn, 2020). This ethical consciousness, which aligns with Druga et al. (2019 & 2022) and Wong et al. (2020)'s emphasis on the ethical aspect of AI literacy and its societal influence, which is fundamental in navigating the complexities of AI, ensuring that advancements are aligned with societal values and norms. Nevertheless, the continued effort to boost this awareness is crucial to fostering responsible and informed AI application and development. Respondents' attitudes towards AI, marked by both openness and caution, further unveil the multifaceted perceptions of AI integration. While a general positivity towards AI's involvement was reported, hesitations, especially regarding more sensible and personalised tasks, underscore the prevailing uncertainty surrounding AI's role in diverse contexts.

In the educational field, the findings emphasise the cautious optimism regarding AI's potential role. The recognition of AI's capabilities to enhance administrative and some pedagogical aspects is promising. However, the persistent reluctance to fully entrust AI with personalised responsibilities highlights the ongoing debate and uncertainty surrounding the balance between technological efficiency and the indispensable human element in education, this balance is crucial, as mentioned by Kim et al. (2021) and Kong & Zhang (2021), in ensuring career readiness and developing essential skills and attitudes. The exploration and understanding of this balance are essential in optimising the integration of AI in educational settings, ensuring the enhancement of educational outcomes while preserving the unique

value of human involvement. The anticipation of positive impacts, as mentioned by Laupichler and colleagues (2023), must be balanced against concerns related to privacy and equity, as noted by Hermann (2022). These findings highlight the need for a measured and ethical approach to AI implementation, aiming to harness its benefits while minimising potential drawbacks. It is worth noting, for example, how Weber et al. (2023)'s insights into data and algorithm literacy could play a crucial role. Such literacy serves as the foundation for building an informed and critically thinking AI user base.

Nevertheless, despite the apparent balance between scepticism and trustworthiness, a deeper analysis reveals that a significant proportion of respondents report only a moderate understanding of AI definitions and theoretical foundations. This reflects a baseline level of AI literacy. This gap in knowledge levels might influence the perceived utility and trustworthiness of AI technologies among students. This might show an interesting emerging pattern: the manifestation of the Dunning-Kruger effect within the responses (Kruger & Dunning, 1999). This psychological principle suggests that individuals with low competences overestimate their knowledge on the subject. Applied to the AI context, the respondents with lower AI literacy, display a higher trust in AI's capabilities across various tasks, reflecting a possible overestimation of their understanding of AI technologies. This reflects the observed data, where, despite demonstrating an uncritical attitude, there is a high level of unjustified trust in AI's capability to manage diverse and sensitive tasks. Such a trend underscores the importance of comprehensive AI literacy education which considers not only technical abilities but also cultural and subjective dimensions (Yi, 2021) and highlights that educational initiatives need to emphasise not only AI's capabilities but also their limitations and potential biases, as suggested by the multidimensional approach to AI literacy (Cuomo et al., 2022).

6. Limitations

One significant limitation of this study lies in the convenience sample and in its size: with only 66 students participating, the sample is not adequately representative of the broader population. A larger and more diverse sample would be necessary to draw more generalisable conclusions about AI literacy and attitudes across various segments of society. Furthermore, the study focuses on a specific educational setting, which limits its applicability to other contexts. The experiences and perceptions of students in this setting may differ markedly from those in other educational environments or in different cultural or socioeconomic contexts. Another limitation is the reliance on self-reported measures, which can be subject to biases such as social desirability or self-assessment inaccuracies. While the survey method provides valuable insights, it inherently relies on the participants' own perceptions and understanding, which might not always align with objective measures of AI literacy. Finally, the study did not investigate past AI technology exposure outside academia. Our research did not examine how participants' daily AI experiences affected their perceptions and knowledge. Given these limitations, future studies should use larger and more demographically diverse samples, emphasise a variety of educational and cultural backgrounds, and use a mix of qualitative and quantitative research methods to reduce self-reported data biases.

7. Conclusions

This study's comprehensive analysis of student AI comprehension and attitudes shows the complex relationship between AI literacy and AI technology perception and trust. The report shows that

AI literacy is essential in today's fast-changing landscape of technology role in society. This literacy helps people understand and manage AI's advances, threats and possibilities, enabling them to make educated decisions and participate in relevant discussions. It plays a significant role in contributing to shaping the ethical, societal, and educational dimensions of AI, safeguarding against uninformed and potentially detrimental reliance on AI technologies in diverse and sensitive domains. Despite varying levels of understanding showcased in the survey, the participants' anticipation for AI's positive contributions, coupled with concerns regarding privacy, equity and cybersecurity, highlights the critical necessity for promoting AI literacy. The findings from our study underscore the need for an integrative approach to AI literacy, blending technical know-how with ethical, social and humanistic understanding. This essential literacy and awareness can be fostered through robust educational initiatives, professional development programmes and the provision of accessible resources. Such efforts will improve AI literacy and equip people to productively and critically use AI technologies and constructively contribute to the growing narrative of AI integration in diverse areas. Educational and policy stakeholders must emphasise AI literacy programme creation and distribution in the future. The ultimate goal is the balanced and judicious use of AI, where its benefits are exploited, and its negatives are carefully managed to benefit society. This balanced approach will be instrumental in guiding the ethical integration of AI into our daily lives and societal structures, paving the way for a future where technology and humanity coexist in constructive collaboration.

8. Authors' contributions

Although the present work was jointly conceived and carried out by the authors, for attribution purposes, M. Ranieri wrote paragraphs 1,5 and 6, G. Biagini wrote paragraphs 2.2, 3, 4.1 and S. Cuomo wrote paragraphs 2.1, 4.2, 7.

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AI chatbots as Open Educational Resources: Enhancing student agency and Self-Directed Learning

I chatbot AI come Risorse Educative Aperte: potenziare l'efficacia della partecipazione nel processo educativo e l'apprendimento autoregolato dello studente

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ABSTRACT In modern education, self-directed learning (SDL) is paramount. SDL empowers learners, OERs democratize access, and AI chatbots, as virtual companions, offer enriched learning experiences. Balancing AI's advantages and challenges in education is vital. This paper explores AI chatbots' role in promoting SDL and student autonomy, highlighting their potential to guide and empower learners in navigating the knowledge landscape. By uncovering this potential, the study encourages educators and learners to embrace AI chatbots as partners in achieving self-directed, limitless education.

KEYWORDS Self-Directed Learning; Student Agency; AI Chatbots; Self-Regulated Learning; Open Educational Resources.

SOMMARIO Nell'istruzione moderna, il Self-Directed Learnig (SDL) è fondamentale. Il SDL conferisce potere agli studenti, le OER (risorse educative aperte) democratizzano l'accesso e i chatbot AI, come compagni virtuali, offrono esperienze di apprendimento arricchite. Bilanciare i vantaggi e le sfide dell'IA nell'istruzione è essenziale. Questo articolo esplora il ruolo dei chatbot AI nel promuovere l'SDL e l'autonomia degli studenti, evidenziando il loro potenziale nel guidare e rafforzare gli studenti nella navigazione del panorama della conoscenza. Scoprendo questo potenziale, lo studio incoraggia gli educatori e gli studenti ad accettare i chatbot AI come partner per raggiungere un'istruzione auto-diretta e senza limiti.

PAROLE CHIAVE Self-Directed Learning; Agency dello Studente; Chatbot AI; Apprendimento Autoregolato; Risorse Educative Aperte.

1. Introduction

The integration of technology in education has fundamentally transformed the way students access and engage with learning materials. One groundbreaking development on this frontier is the emergence of Artificial Intelligence (AI), particularly AI chatbots. While there exists a somewhat negative

perception of AI in education due to the challenges it may pose, it is imperative to strike a delicate balance between the advantages offered by AI chatbots and the potential obstacles they present. This conceptual paper explores literature about self-directed learning (SDL), student agency and the use of AI chatbots as open educational resources (OERs) to delf into their potential to not only facilitate learning but also to foster an environment where students take the reins of their education, making informed choices and pursuing knowledge in a more self-regulated manner. OERs are educational materials that are freely accessible and openly licensed, enabling users to legally engage in activities such as use, adaptation, and redistribution. These resources encompass a wide range of digital assets, including textbooks, multimedia content, learning assessments, and increasingly, chatbots and open internet resources. In this exploration, we uncover the multifaceted ways in which AI chatbots, when integrated into educational settings, can elevate the concept of SDL, and enhance student agency.

2. Rationale and Problem statement

In the fast-evolving landscape of education, the concept of learning has transcended traditional boundaries (Yang & Kongjit, 2022). Today, the pursuit of knowledge is not confined to the classroom or tethered to a set curriculum. Instead, it is increasingly becoming a self-directed pursuit, driven by individual curiosity and the quest for lifelong learning (Vázquez, 2017). This paradigm shift is at the heart of SDL, a pedagogical approach that places learners at the helm of their educational journey, fostering autonomy, motivation, self-regulation, and a profound sense of ownership over the learning process (Chen et al., 2023).

It is important to first distinguish between SDL, self-regulated learning (SRL) and student agency. These three related constructs have been used ambiguously in the literature (Taub et al. 2020). These concepts can also be confused with similar terms like autonomous learning, self-planned learning, self-teaching and independent study (Saks & Leijen 2013). Self-directed learning is an adult-education concept, also called andragogy, developed by the American adult educator Malcolm Shepherd Knowles. Knowles (1975:18) defines SDL as "[A] process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes". Situated in cognitive psychology, as a micro-level construct, SRL is "the process through which individuals control their own learning from a cognitive, meta-cognitive, behavioural, emotional and motivational point of view" (Bartolomé et al., 2010). Then, student agency is characterized by one's intentionality, forethought, self-reactiveness, and self-reflectiveness, which enable a student to ensure an activity occurs (Bandura, 2001). In essence, in this study SDL is viewed as the overarching paradigm, with SRL and student agency operating as integral components within its educational framework (Figure 1). The figure highlights SDL as a broader, macro-level construct enveloping SRL and student agency within smaller circles to indicate relatedness as narrower micro-level constructs, all situated within the overarching framework of life-long learning.

The acquisition of 21st-century skills has become not merely advantageous but essential for individuals seeking academic and professional success (Murshidi, 2017). These skills encompass critical thinking, problem-solving, effective communication, collaborative teamwork which are sought-after workplace skills, whereas digital literacy, adaptability, and a steadfast commitment to self-directed and lifelong learning has become paramount for success in the fourth industrial revolution (Jagals, 2020). As traditional educational paradigms undergo significant transformation in the wake of Education 4.0

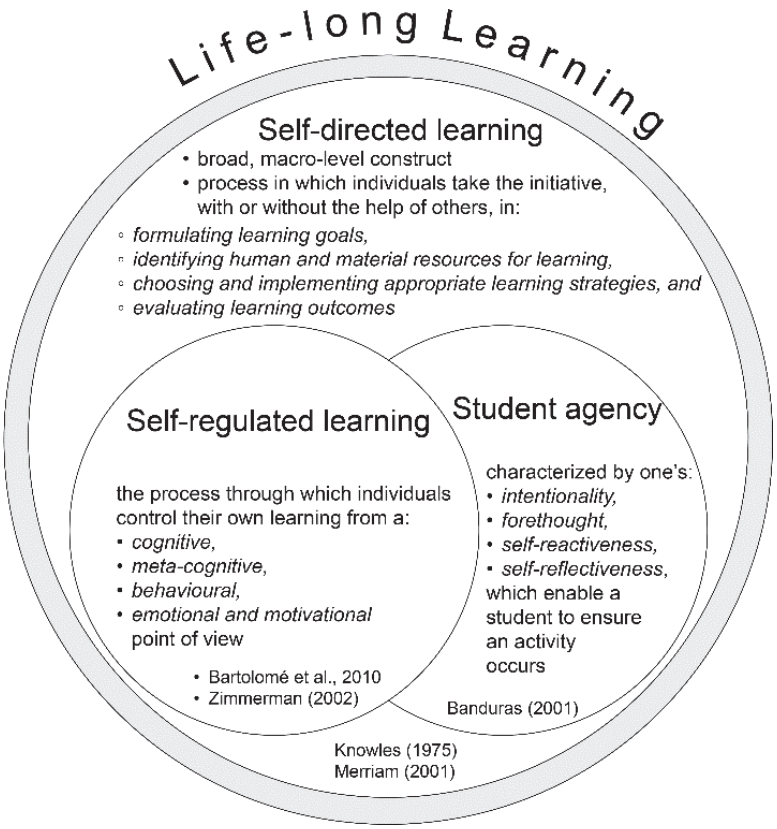

Figure 1. Schematic illustration depicting the hierarchical relationship among key constructs in learning theories, namely self-directed learning (SDL), self-regulated learning (SRL), and student agency to visualise how these constructs are viewed in this paper.

(Moraes et al., 2023), the concept of SDL has risen to prominence as an educational approach that not only fosters these critical skills but also harmonizes seamlessly with the demands of the 21st century (Shamsuddin et al., 2017).

The significance of this study lies in the intersection of three compelling forces shaping modern education: SDL, OERs and AI. SDL, often regarded as the pinnacle of student agency, empowers individuals to take charge of their learning paths, fostering a deep sense of motivation and relevance (Chen et al., 2023). OERs embody the spirit of open knowledge-sharing, democratizing education by providing free and accessible resources to learners worldwide (Zulaiha & Triana, 2023). While AI chatbots are intelligent virtual companions designed to effectively assist and enrich the process of learning (Han et al., 2022). There might exist a somewhat negative perception of AI in education due to the challenges it may pose. It is imperative to strike a delicate balance between the advantages offered by AI chatbots and the potential obstacles they present. (Mair et al., 2023; Moldt et al., 2023).

This study seeks to answer a fundamental question: What is the potential of AI chatbots as Open Educational Resources to enhance student agency and self-directed learning? To address this question, we will delve into the multifaceted dimensions of SDL and student autonomy, examining the potential of AI chatbots as OERs to assist students in taking ownership of their educational destiny. By embarking on this exploration, we aim to shed light on the symbiotic relationship between technology and education, paving the way for a new era of self-directed, AI-augmented learning experiences.

This paper is strategically tailored for a diverse audience encompassing educators, academic researchers, policymakers, practitioners in technology-enhanced learning, and students engaged in higher education. For educators and curriculum designers, the study offers insights into integrating AI chatbots to enhance learner autonomy and 21st-century skills. Students benefit by understanding how AI chatbots can be virtual companions, assisting them in navigating the knowledge landscape and taking control of their educational journey. The research adds to the academic discourse on the evolving educational landscape, emphasising the balance needed for AI chatbots. Ultimately, it serves as a catalyst for informed decision-making, advocating for accessible and democratised education on a global scale by promoting the sharing of knowledge resources through AI chatbots, thereby breaking down geographical and financial barriers.

3. Literature review

3.1. Self-directed learning

In the contemporary age, the demand for SDL has grown significantly. SDL represents an educational paradigm where individuals assume primary responsibility for planning, initiating, and managing their own learning process. SDL fosters autonomy, motivation, and a lifelong commitment to learning (Lew et al., 2020). Its relevance spans diverse educational settings, including formal education, workplace training, and personal development, empowering individuals to cultivate self-reliance, intrinsic motivation, and a continuous learning ethos (Shamsuddin et al., 2017; Xiao-hong et al., 2018).

In contrast, traditional classroom environments often employ didactic methods, resulting in passive student roles (Yuan, 2018). Wang and Walkington (2023) argue that students in such settings may lack motivation. Conversely, active learning thrives when learners engage in self-directed educational journeys, driven by their eagerness to pursue authentic challenges (Suroto et al., 2022). Guglielmino (1977) outlines the characteristics of highly self-directed learners, emphasizing qualities like initiative, independence, and persistence. Such learners also display self-discipline, curiosity, and self-confidence (Okafor, 2022).

Integrating SDL techniques aims to mimic how individuals naturally acquire knowledge (Dewi & Primayana., 2019). Therefore, learners must realize the importance of their knowledge, attitudes, and SDL skills in active learning (Adnan & Sayadi, 2021) and understand that educators now serve as facilitators rather than exclusive sources of information (Saks & Persky, 2020). Educators play a pivotal role in guiding learners toward greater self-direction (Leahy & Smith, 2021). They should help learners plan, execute, and evaluate their own learning. Educators should grant learners more autonomy, particularly in resource identification and alternative learning methods (Yuliansyah & Ayu, 2021) and offer options for resource utilization, learning approaches, and objectives (Loeng, 2020). They should also challenge learners, provide constructive feedback, and promote critical thinking (Song et al., 2022; van Woezik et al., 2021). An open and trusting environment encourages student engagement and questioning (van Woezik et al., 2021).

3.2. Student Agency

In the 21st century, the concept of student agency holds profound relevance and significance in education (Stenalt, 2021). It represents a shift from traditional, teacher-centred approaches to a more learner-centred paradigm (Borokhovski et al., 2018). Student agency encompasses the capacity and inclina-

tion of learners to actively participate in their educational journey, making choices, setting goals, and taking ownership of their learning experiences (Tong & An, 2022). While a multifaceted concept, fundamentally involves students' ability to make choices and decisions regarding their learning (Tong & An, 2022). This sense of agency is rooted in several psychological and educational theories.

One prominent theory underpinning student agency is Bandura's social cognitive theory (Bandura. 1982), which emphasizes the role of self-efficacy in shaping human behaviour (Klemenčič, 2015). Self-efficacy refers to an individual's belief in their ability to accomplish tasks and achieve goals. In the context of student agency, high self-efficacy is associated with learners' confidence in their capacity to take charge of their learning process (Ahrens, 2022; Ngarisan et al., 2022). Another relevant theoretical framework is Deci and Ryan's self-determination theory (SDT) (Deci & Ryan, 1985). SDT posits that individuals have innate psychological needs for autonomy, competence, and relatedness (Chiu & Chai, 2020; Klemenčič, 2015). Autonomy, in particular, aligns closely with the concept of student agency. It suggests that individuals are inherently motivated when they have a sense of control and volition over their actions (Lozano-Jiménez et al., 2021). In the educational context, fostering autonomy corresponds to empowering learners to make choices, set goals, and determine their learning path (Zhou, 2021), all of which are central to SDL. Vygotsky's sociocultural theory (Vygostsky, 1987) highlights the importance of social interaction and collaboration in learning. student agency, while often seen as an individual attribute, can also be cultivated through social interactions and collaborative learning experiences (Torres & LePeau, 2022). When learners have opportunities to engage with peers, share their perspectives, and collectively shape their learning environment, they are more likely to develop a sense of agency (Moissac et al., 2020).

The integration of student agency into the educational process can significantly enhance the practice of SDL. When learners are equipped with the skills, mindset, and motivation to take ownership of their learning, they are better prepared to engage in self-directed learning activities (Djatmika et al., 2022). Educators have at their disposal a range of strategies to facilitate the cultivation of student agency, thereby enhancing SDL. Educators can offer learners the opportunity to exercise agency by providing them with choices regarding their learning journey. This may involve allowing learners to select what they learn, how they learn it, and how they demonstrate their understanding (Wehmeyer, 2022). The provision of flexible learning pathways and diverse assessment methods allows learners to personalize their educational experiences according to their preferences and interests (Liu et al., 2018). Learners should be encouraged to establish both short-term and long-term learning goals that can infuse a sense of purpose and direction into their educational endeavors. Educators can guide learners in formulating SMART (Specific, Measurable, Achievable, Relevant, Time-bound) goals that align with their individual aspirations. The act of setting and pursuing these goals reinforces agency by putting learners in control of their educational trajectory (Chitra et al., 2022). The development of metacognitive skills, such as self-reflection and self-assessment, plays a pivotal role in fostering agency and is closely intertwined with SDL. By honing these skills, learners can effectively monitor their progress and make informed decisions about their learning strategies (Wong & Kan, 2022).

Although SDL often emphasises independent learning, collaborative experiences can serve as a catalyst for agency development. In collaborative settings, learners can assume leadership roles, engage in negotiations, and establish learning goals (Nazarianpirdosti et al., 2021). These interactions empower learners to actively shape their learning experiences, fostering a sense of agency within a cooperative framework. Encouraging regular feedback and self-reflection equips learners with the tools needed to assess their learning strategies and make adjustments as necessary (Rapi et al., 2021). When learners

engage in reflective practices and seek feedback from peers and educators, they become more adept at self-directed learning. Educators can create an inclusive classroom environment characterized by trust, open communication, and a growth mindset (Liu et al., 2018). Such an environment is conducive to nurturing student agency. When learners feel secure in taking risks and making choices, they are more likely to engage in SDL with confidence (Van Wyk, 2017). Establishing a supportive learning community fosters a sense of agency among learners, empowering them to take an active role in their education (Hostetter et al., 2007) The integration of technology, including AI chatbots and other digital tools, presents opportunities to bolster student agency. These technological resources can provide learners with immediate access to educational materials, personalized learning experiences, and the autonomy to explore their interests independently (Wong & Kan, 2022).

3.3. Open Educational Resources

OERs have emerged as a catalytic force within the realm of education, fundamentally reshaping the landscape of knowledge generation, dissemination, and accessibility (Bahrawy, 2019). Distinguished by their open licenses, OERs empower users with a spectrum of rights, including the liberty to access, adapt, and share content without constraints (Huang et al., 2019). Typically available in digital formats, these resources offer unparalleled ease of distribution and customization. What sets OERs apart from conventional copyrighted materials are these open licenses, which not only liberate creators but also endow users with specific rights and freedoms, encompassing the modification, sharing, and distribution of educational materials (Downes, 2019). Among the most widely embraced open licenses for OERs are the creative commons licenses, providing creators with standardized options to select the degree of openness and flexibility they wish to imbue into their works (Huang et al., 2019).

At the core of OERs lie the foundational principles of accessibility and equity, intimately entwined, and together they underpin the transformative potential of OERs within the educational domain (Kinskey & Miller, 2019; Menzel, 2023). Traditional educational materials, often exemplified by expensive textbooks and learning resources, routinely pose substantial financial barriers for many learners. In stark contrast, OERs champion unimpeded accessibility, effectively dismantling the financial hurdles associated with procuring textbooks and educational content (Serrano et al., 2019). This affordability transcends economic boundaries, rendering education an achievable pursuit for individuals from diverse financial backgrounds (Huang et al., 2019). Through a steadfast commitment to creating accessible content, OER creators ensure that learners with varying needs can actively and inclusively engage with educational materials, thus nurturing a learning environment that accommodates a wide spectrum of learners (Ferri et al., 2020). Furthermore, OERs serve as a potent equalizer, bridging educational disparities by offering learners, regardless of their socioeconomic backgrounds, access to the same high-quality educational resources. This harmonization of educational opportunities mitigates discrepancies in educational access and outcomes, propelling the cause of educational equity. Additionally, OERs empower educators to customize materials to meet the unique requirements of their learners (Ujakpa et al., 2020).

OERs strongly advocates for open pedagogical practices that prioritize collaboration and learner-centred learning (Huang et al., 2019). These innovative approaches foster active engagement among learners from diverse backgrounds, thereby nurturing a sense of equity within the educational experience (Vlachopoulos & Makri, 2019). By embracing open pedagogies, educators cultivate inclusive learning environments that embrace and celebrate the diversity of their learners. Open pedagogies

have evolved in response to the evolving educational landscape, driven by technological advancements and a growing demand for more participatory and learner-centric approaches (Bali et al., 2020). Early forms of open pedagogy were rooted in the emergence of OERs, and these principles have since expanded to encompass a broader spectrum of openness in education (Nascimbeni & Burgos, 2019). Open access to educational materials laid the foundational groundwork for open pedagogical practices, extending beyond content to encompass collaborative, transparent, and inclusive teaching and learning approaches. In addition, open pedagogies prioritize transparency within teaching and learning processes (Seraphin et al., 2019). Educators openly share course materials, objectives, and assessment criteria, cultivating an environment of trust and collaboration among learners. Central to open pedagogies is the promotion of student agency, empowering learners to co-create content, define learning objectives, and shape their educational journeys, fostering a sense of ownership over their learning expedition (Nascimbeni & Burgos, 2019). Learners actively engage in collaborative projects, engage in peer evaluations, and contribute to the co-creation of open educational resources, thereby enriching their learning experiences.

3.4. AI chatbots in Education

The integration of Chatbot systems in education has witnessed a remarkable evolution, reflecting the continuous advancement of technology and the expanding applications of these intelligent conversational agents. Initially designed to automate administrative tasks and provide basic information, the development of natural language processing (NLP) and machine learning algorithms has propelled AI chatbots into multifaceted roles across various educational domains (Adıgüzel et al., 2023; Kamalov et al., 2023). In the realm of teaching and learning, chatbots have emerged as conversational agents, delivering course content and accurate information through online platforms (Adamopoulou & Moussiades, 2020; Okonkwo & Ade-Ibiijola, 2021). Notable free AI chatbots such as ChatGPT, Google Bard, Microsoft Bing AI, Lyro, Drift, ChatSpot, and MobileMonkey have played pivotal roles in transforming educational experiences. Educators now recognize their value in creating engaging learning experiences, allowing students to ask questions and receive personalised assistance (Medeiros et al., 2018; Chen et al., 2020; Wu et al., 2020). Administratively, chatbots have contributed to areas such as orientation, recruitment, and retention, optimising services and enhancing cost efficiency (Ranoliya et al., 2017; Hien et al., 2018; Lee et al., 2019;). Moreover, they've become integral to student assessments, powering automated and intelligent teaching systems that analyse and assess students' learning abilities (Ndukwe et al., 2019; Sreelakshmi et al., 2019; Durall & Kapros, 2020). In the context of research and development, these AI tools have supported students in STEM-related research concepts and information retrieval (Mckie & Narayan, 2019). While the advantages of chatbots in education are abundant, spanning content integration, quick access to information, motivation, engagement, multi-user accessibility, and immediate assistance, it's imperative to acknowledge potential challenges. Factors like content relevance, ethical considerations, and evolving AI landscapes in education require careful consideration for the optimal utilisation of chatbots (Durall & Kapros, 2020; Hien et al., 2018; Wu et al., 2020).

3.5. AI chatbots as Open Educational Resources

Within the transformative landscape of OERs marked by their open licenses and steadfast commitment to accessibility and equity, there lies an opportunity to amplify their impact through the strategic

integration of AI chatbots. OERs have already revolutionized the educational landscape, reshaping how knowledge is generated, shared, and accessed (Bahrawy, 2019; Huang et al., 2019). Their open licenses, granting users the freedom to access, adapt, and share content freely, are pivotal in making education more inclusive and affordable. AI chatbots, harnessed for their advanced capabilities in AI and natural language processing, have emerged as transformative educational tools (Wang and Walkington., 2023). These intelligent companions possess the capacity to hyper-personalize learning experiences, offer instant access to a wealth of educational resources, provide timely guidance, and feedback, and nurture a sense of autonomy among learners.

When we seamlessly merge AI chatbots with the principles of OERs, a powerful synergy emerges. One of the cornerstones of OERs is accessibility, and AI chatbots can further enhance this aspect by providing learners with immediate access to resources and personalized support (Serrano et al., 2019). Regardless of a learner's location or time constraints, AI chatbots are available around the clock, breaking down traditional barriers to learning access. Moreover, these chatbots can adapt content to meet diverse learner needs, including those with disabilities, thereby promoting inclusive education (Ferri et al., 2020).

AI chatbots also extend the adaptability of OERs, allowing learners to interact with educational materials in a dynamic and responsive manner. Through natural language interfaces, chatbots engage with learners to understand their specific goals, preferences, and challenges, tailoring content recommendations and learning pathways accordingly (Ujakpa et al., 2020). Learners are empowered to navigate their educational journey with flexibility and personalization, aligning seamlessly with the principles of learner-centred learning. By promoting collaboration, transparency, and student agency, AI chatbots can also enhance open pedagogical practices (Nascimbeni & Burgos, 2019). Learners can collaborate with chatbots in problem-solving, engage in peer-reviewed assessments, and even participate in the co-creation of open educational resources (Bali et al., 2020). The transparency of AI chatbots in providing learning support and guidance cultivates trust within the learning community, fostering a culture of collaboration among learners (Seraphin et al., 2019).

Central to the integration of AI chatbots within OERs is the promotion of student agency (Nascimbeni & Burgos, 2019). Learners, guided by these intelligent companions, have the autonomy to co-create content, set learning goals, and shape their educational experiences. This active involvement empowers learners to take ownership of their learning journey, aligning seamlessly with the principles of SDL and open pedagogies. Learners can engage in self-directed projects, explore topics of interest, and receive personalized guidance from chatbots, thus enriching their learning experiences. Therefore, the strategic integration of AI chatbots within OERs represents a harmonious partnership that amplifies the transformative potential of both technologies. AI chatbots enhance the accessibility, adaptability, and effectiveness of OERs, aligning seamlessly with the principles of openness and equity. By fostering student agency and promoting self-directed learning, this integration empowers learners to take charge of their educational journeys, navigate the complex landscape of knowledge, and thrive in the 21st century.

The role of AI chatbots as Open educational resources in promoting Self-directed learning The integration of AI in education has garnered both excitement and scepticism (Rainey et al., 2021). While some still have a negative sentiment towards AI's role in education due to concerns about the depersonalisation of education, quality control, and overreliance on technology, it is crucial to emphasise that AI, when harnessed effectively, can serve as a powerful tool to enhance student agency and SDL (Rainie et al., 2021; Schiff, 2021;). It is essential to clarify that the integration of AI chatbots as OERs is

not about substituting human educators but augmenting their capabilities (Kasneci et al., 2023). These AI chatbots are designed to complement the learning experience, providing learners with additional support, resources, and opportunities for personalised learning. AI chatbots, when integrated strategically, can play a pivotal role in fostering learner agency (Rainie et al., 2021). AI chatbots, as OERs, offer several advantages in this regard. Firstly, they provide learners with immediate access to a vast array of educational resources. This access empowers learners to explore topics of interest independently, facilitating the development of autonomy and self-directedness (Wang & Walkington, 2023). Moreover, AI chatbots can personalise learning experiences, tailoring content and activities to individual needs and preferences (Hannan & Lui, 2023). This level of customization not only engages learners but also nurtures their sense of ownership over their learning journey. However, it is crucial for facilitators to recognize and respect the individual variations in students' levels of self-directedness, tailoring their support and guidance accordingly to foster a personalized and effective learning experience for each student. Educators can effectively utilize Grow's 1991 Self-Directed Learning (SDL) model (Grow, 1991) as a framework to assist them in tailoring their teaching approaches across the four stages—coaching, guiding, facilitating, and empowering. One of the key components of SDL is the ability to set goals and make choices about what and how to learn. AI chatbots can assist learners in this process by helping them define learning objectives, suggesting relevant resources, and tracking progress (Hannah & Lui, 2023; Rainie et al., 2021). For instance, an AI chatbot can guide a learner through the creation of a learning plan, breaking down long-term goals into manageable steps. This guidance aligns with the concept of SDL, where individuals take the initiative to design their learning experiences based on their specific needs and interests.

Additionally, AI chatbots can provide timely feedback and support. They can offer explanations, answer questions, and even engage in interactive learning activities (Limna et al., 2023). This immediate feedback not only enhances the learning experience but also bolsters learners' self-efficacy—the belief in their ability to accomplish tasks and achieve goals. When learners feel supported and capable, they are more likely to take ownership of their learning process. While highlighting the potential of AI chatbots in enhancing student agency and SDL, it is essential to acknowledge and address ethical considerations. (Adnan & Sayadi, 2021). These include issues related to data privacy, algorithmic bias, and equitable access to technology. Educators and policymakers must work collaboratively to establish ethical guidelines for the use of AI in education, ensuring that it serves all learners, regardless of their background or circumstances. The negative perceptions associated with AI in education should not overshadow its potential to enhance student agency and SDL. When used judiciously, AI chatbots as OERs can empower learners to take charge of their educational journey, aligning with the principles of SDL. Educators and institutions should embrace AI as a valuable ally in education, recognizing that it can augment human teaching and learning, equipping learners with the skills and autonomy needed to thrive in the 21st century. From the literature discussed above a list of guidelines is compiled for the use of AI chatbots as OERs to enhance SDL and student agency (Table 1).

The teaching-learning strategy of inquiry-based learning (IBL) can seamlessly incorporate AI chatbots as OERs by following this set of proposed guidelines (Table 1). First, these chatbots can aid learners in goal setting and progress tracking by assisting in the formulation of clear and measurable objectives while continuously monitoring and providing constructive feedback on their advancement. Furthermore, AI chatbots can offer immediate feedback and support for inquiries, fostering a sense of accountability and facilitating an SDL approach. They can also recommend relevant learning resources, progressively guiding learners through scaffolded activities that increase autonomy over time. The

Table 1. Guidelines for the use of AI chatbots to enhance SDL and student agency.

Nr	Guideline	Sources
1	Strategic Integration of AI Chatbots: Carefully plan and integrate AI chatbots into the educational environment to complement, not replace, human educators. Ensure that their role aligns with fostering SDL and student agency.	Kasneci et al. (2023). Schiff (2021); Rainie et al. (2021).
2	Hyper-personalized Learning Paths: Utilize AI chatbots to offer personalized learning experiences. Tailor content, resources, and activities to learners' individual needs and preferences, allowing them to choose their learning paths.	Hannan & Lui (2023); Tong & An (2022); Ahrens (2022).
3	Goal Setting and Progress Tracking: Implement AI chatbots to assist learners in setting clear, measurable learning goals. Chatbots can also track and provide feedback on learners' progress towards these objectives, fostering a sense of accountability.	Suroto et al., (2022); Nazarianpirdosti et al. (2021); Wang & Walkington (2023).
4	Immediate Feedback and Support: Leverage AI chatbots to provide instant feedback on assignments, assessments, and questions. Ensure that chatbots offer constructive feedback that encourages reflection and improvement.	Song et al. (2022) van Woezik et al. (2021); Limna et al. (2023).
5	Resource Recommendations: AI chatbots can suggest relevant learning resources, such as articles, videos, or interactive modules, based on learners' interests and learning objectives. Encourage learners to explore these resources independently.	Loeng (2020); Yuliansyah and Ayu (2021).
6	Scaffolded Learning: Gradually introduce learners to self-directed learning with the support of AI chatbots. Begin with structured activities and gradually increase autonomy as learners become more comfortable with SDL.	Lalitha & Sreeja (2020; Chitra et al. (2022).
7	Skill Development: Incorporate AI chatbots to help learners develop essential SDL skills, such as self-regulation, time management, and critical thinking. Offer guidance on how to navigate SDL effectively.	Wong & Kan (2022); Djatmika et al. (2022).
8	Peer Collaboration: Promote collaborative SDL by using AI chatbots to facilitate peer interactions and group projects. Encourage learners to take on leadership roles within these collaborative activities.	Torres & LePeau (2022); Huang et al. (2019).
9	Develop reflective practices: Reflection is central to SDL skill development. Mindfully plan to include reflective activities, e.g. on learning progress and their own thinking.	Ojeda-Ramirez et al. (2023).
10	Ethical Use of AI: Emphasize the ethical use of AI chatbots, including considerations related to data privacy and algorithmic bias. Ensure that learners understand the limitations and potential biases of AI systems.	Schiff (2021); Rainie et al. (2021).

integration of AI chatbots is instrumental in developing crucial SDL skills, including self-regulation, time management, and critical thinking, providing tailored guidance for effective learning. Moreover, these chatbots can foster peer collaboration by facilitating interactions and group inquiries, encouraging learners to assume leadership roles within such collaborative endeavors. To ensure responsible and reflective practices, IBL should include discussions on the ethical use of AI, addressing concerns related to data privacy and algorithmic bias, and ensuring learners comprehend the limitations and potential biases of AI systems. This approach not only aligns with IBL principles but also harnesses the capabilities of AI chatbots to enhance the learning experience. Table 2 suggests student and teacher roles and how the AI chatbot might be integrated.

4. Conclusion

The concepts of SDL and student agency have emerged as pivotal components for equipping learners with the skills and mindset needed to thrive in the 21st century. This paper has explored the

Table 2. Roles suggested for the teacher and the students during an IBL activity with AI Chatbot integration.

Roles	Use case of AI chatbots during IBL activity
Teacher	
Facilitator	Use chatbots to generate open-ended questions for discussions. Design inquiry tasks that utilize chatbots to guide student research.
Mentor / Coach / Guide	Continuously provide guidance on effective interaction with chatbots. Address challenges or misconceptions encountered while using chatbots.
Evaluator	Review progress reports generated by chatbots to assess individual progress. Assess students' critical thinking based on chatbot feedback.
Monitor	Monitoring student progress is crucial during the entirety of the activity where the integration of AI chatbots is used. It is also important for the teacher to monitor the level of each student's SDL skills in order to cater for the diversity in digital literacy.
Student	
Active participant	Ask probing questions to deepen understanding using chatbots. Seek clarifications on complex concepts or information from chatbots.
Researcher	Actively explore learning resources suggested by chatbots. Cross-reference information obtained from chatbots with other sources.
Goal setter	Collaborate with chatbots to set clear, measurable learning goals.
Learning monitor	Task coordination and progress tracking can be supported by Chatbots assigning specific tasks and responsibilities to group members. For instance, the chatbot could help distribute research subtopics or outline individual contributions. Through regular check-ins with the chatbot, students provide progress updates on their tasks. The chatbot compiles this information, allowing the group to track overall progress.
Collaborator	Engage in collaborative activities facilitated by chatbots via group research and information sharing. Students can use chatbots to initiate group research projects. For example, the chatbot could suggest a broad topic, and students collaboratively refine it. Share findings and insights with peers using chatbots.
Reflective learner	Reflect on progress reports generated by chatbots.
Responsible user	Reflect on the ethical use of AI while interacting with chatbots. Report ethical concerns or issues encountered with chatbots to the teacher.

interplay between SDL, student agency, and the integration of AI chatbots as OERs, highlighting the transformative potential of this synergy. We began by recognizing the significance of SDL in nurturing essential 21st-century skills, including critical thinking, adaptability, digital literacy, and a commitment to lifelong learning. However, traditional educational models often struggle to fully harness the potential of SDL, leaving learners facing barriers related to motivation, access to resources, and personalized guidance. In this context, AI chatbots, powered by advancements in artificial intelligence and natural language processing, have emerged as promising facilitators of SDL. When thoughtfully integrated as OERs, AI chatbots offer personalized learning experiences, immediate access to vast educational resources, timely guidance, and opportunities for learners to explore their interests independently. However, it is essential to strike a balance between the benefits and potential drawbacks of AI in education to ensure a holistic understanding of its impact on SDL and student agency.

In the planning and integration of tasks and activities involving AI chatbots, it is crucial to uphold the principles of Self-Directed Learning (SDL). The focus should be on empowering students to take charge of their learning experiences, fostering autonomy, and encouraging critical thinking. Incorporating AI chatbots within the framework of SDL principles ensures that technological

advancements align with educational goals, promoting a learner-centric environment. As education embraces AI, maintaining a balance between innovation and the core principles of SDL becomes paramount for cultivating a holistic and effective learning landscape. The provision of free access to such advanced technologies, as exemplified by the mentioned chatbots, is crucial for fostering inclusivity and ensuring that educational benefits are accessible to all, irrespective of financial constraints. The evolving landscape of AI applications in education emphasises the need for educators and institutions to navigate the integration of chatbots with a balanced consideration of their benefits and potential limitations.

The authors acknowledge that teachers may face limitations in adopting and integrating chatbots due to varying levels of technological proficiency, potential misalignment with pedagogical principles, a need for comprehensive professional development, perceived barriers to implementation, ethical and privacy concerns, and a limited awareness of AI capabilities. These challenges could impede the seamless incorporation of chatbots into educational practices, hindering the optimization of teaching-learning activities. The identified limitations underscore the importance of targeted professional development, ethical guidelines, and increased awareness to empower educators in effectively leveraging AI chatbots within the educational landscape. Addressing these challenges is crucial for promoting a more inclusive and technologically adept approach to teaching and learning.

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Facilitating a paradigm shift for teaching and learning with AIs

Facilitare un cambio di paradigma per l'insegnamento e apprendimento con le intelligenze artificiali

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ABSTRACT This paper explores how the role of educators is transforming into that of facilitators of change. The main idea is prioritising human learners, enhancing their capacity to learn autonomously, and seamlessly integrating upcoming technologies into an educational framework focused on the individual. This approach uses technology to support and refine learners' metacognitive abilities, allowing them to analyse and interpret digital and real-world information critically. Artificial Intelligences (AIs) are crucial in information retrieval, content generation, proofreading, validation, deduplication, and assessment in education. Human educators must work collaboratively with AIs, redefining the boundaries of professional and personal education. One of the critical challenges for educators working with learners is to build trust in individuals' unique cognitive skills and engage in open dialogues about the ethical implications of technological advancements, including the potential risks of relinquishing our human capabilities to AI systems.

KEYWORDS Faculty Development; ChatGPT Challenges; Facilitating Human Learning; Teaching Paradigm Shifts; Learning Mindset.

SOMMARIO Questo articolo delinea ipotesi di evoluzione del ruolo degli educatori in facilitatori di cambiamento. L'ipotesi in discussione ruota attorno al dare priorità agli studenti, al miglioramento della loro capacità di apprendere autonomamente e all'integrazione delle tecnologie future in un quadro educativo centrato sull'individuo. Questo approccio sfrutta le tecnologie per supportare e affinare le capacità metacognitive degli studenti, consentendo loro di analizzare e interpretare criticamente le informazioni digitali e del mondo reale. Le Intelligenze Artificiali (IA) sono fondamentali nel recupero delle informazioni, nella generazione di contenuti, nella correzione di bozze, nella convalida, nella deduplicazione e nella valutazione in ambito formativo. Gli educatori devono collaborare con le IA, ridefinendo i confini dell'educazione professionale e personale. Una sfida per gli educatori risiede nel coltivare la fiducia nelle capacità cognitive degli individui e nell'impegnarsi in dialoghi aperti sulle ramificazioni etiche dei progressi tecnologici.

PAROLE CHIAVE Formazione dei Docenti; ChatGPT; Facilitare l'Apprendimento; Cambi di Paradigma; Cambi di Mentalità.

1. Facilitating a paradigm shift in teaching and learning with AIs

The term "digital learning" has lost some of its original meaning as almost all media and information processing have become electronic and digital. Machine Learning (ML) and Artificial Intelligence

(AI) are becoming more efficient for adaptive learning. Traditional teaching methods centred around the professor are no longer adequate for students to retain knowledge and change their behaviour. It is also becoming apparent that we must shift towards a new era of AI-augmented learning (Huang et al., 2021).

To tackle the potential threat of being entirely replaced by data-driven technologies, educators must redefine the concept of lifelong learning. The digital world is a platform for continuous learning journeys focusing on self-directed adult learners. In this transformed landscape, professors can be change facilitators, guiding learners along adaptive paths towards autonomy while navigating innovative AI contexts and prioritising a human-centric approach (Mastrogiacomi, 2020).

Educators have traditionally believed that robots cannot possess sentience due to the complexity of human emotions and unstructured consciousness. However, some educators have recently delved into exploring self-awareness in robots and reimagining artificial consciousness in the context of synthetic knowledge. This journey has led to reevaluating assumptions related to memory, adult learning, deep learning, anticipation, subjective experiences, emotional intelligence, ethics, metaphors, and semantics (Gulyamov et al., 2023).

The emergence of robust Large Language Models like ChatGPT also marks a significant turning point. Professors have realised that AI is here to stay, and academia has a choice: resist and restrict technologies like ChatGPT or embrace and leverage them to redefine teaching and learning methods. Adopting these technologies is the wiser path, as students in an increasingly diverse and global society must be prepared to navigate a world filled with AI possibilities (Lambert & Stevens, 2023).

2. Teaching and learning centres as safe learning places for supporting the faculty

Given the recent emergence of a new era marked by significant advances and widespread use of AI technologies, it is crucial for the field of lifelong education to systematically integrate a thorough examination of AI into the comprehensive curriculum of teacher preparation programs (Willis et al., 2013). This strategic initiative is essential for equipping educators at all grade levels with the necessary knowledge and skills to thoughtfully incorporate AI, such as technologies like ChatGPT, into their teaching methods. This comprehensive pedagogical transformation aims to prepare students for an era increasingly influenced by AI-driven phenomena (Trust et al., 2023).

The core hypothesis to be explored in this paper revolves around cultivating a paradigm shift among educators whose focal point should persistently centre on human learners, fostering their inherent capacity for metacognitive learning. The primary challenge is harmoniously assimilating forthcoming technologies into a robust pedagogical framework built around the learner. This framework should function as a scaffolding mechanism, engendering and catalysing students' metacognitive abilities and enabling them to analyse and interpret information critically, whether digital or empirical. AI can play a pivotal role in streamlining various aspects of education, including information retrieval, content creation, spell-checking, validation, deduplication, testing, and more (Azevedo, 2018).

However, the ultimate challenge confronting human educators is to work alongside AI collaboratively as complementary tools, effectively reshaping the boundaries delineating the domains of professional and personal education in the context of humanity's future. Concurrently, educators must wrestle with instilling trust in their students' unique cognitive capabilities while facilitating candid discussions concerning the ethical implications of technological innovations and their overarching impact on human existence (Mastrogiacomi, 2023).

Specifically in the business context of adult informal learning (Matthews, 2013) and in the continuous effort to reinvent and reimagine management education (Steyaert et al., 2016) to best anticipate the disrupting forces at work in AI technological and business landscapes, many Teaching and Learning Centres are proliferating in academia and business schools for supporting teaching excellence in the classroom and enabling innovative pedagogies for effective learning outside of it. By being highly transversal, they are designed to impact multiple stakeholders and act as resources for improving the standards of teaching by standardising teaching materials, supporting faculty training, researching innovative teaching methods, recommending assessment, grading, and feedback best practices, and facilitating engagement and interaction with the corporate world.

One common challenge for Teaching and Learning Centres is supporting faculty members' onboarding, reskilling, and upskilling towards facilitating and sustaining a profound paradigm shift, specifically in the professional contexts of adult education and business schools. Faculty orientation programs are available at different universities to onboard new faculty members. For instance, McCombs offers the new faculty symposium, Hong Kong University of Science and Technology (HKUST) offers a University teaching and learning course, and Berkeley Haas provides new faculty orientation videos.

Many universities offer teaching excellence awards like the faculty awards at UCLA Anderson. Additionally, several universities support their faculty members in integrating DEI and ERS topics as much as technology into their teaching. As recently reported by The Financial Times, teaching awards have been used by innovative business schools to push towards a brighter future; the top-tier business schools mentioned are improving their teaching on sustainability and the climate crisis by combining hands-on experience with tools such as VR headsets and AI. Another example is Georgia Tech, which offers learning and technology initiatives, and McCombs also provides a technology-enhanced learning symposium. Continuous improvement of the quality of teaching is becoming a priority at many universities. NYU Stern offers ongoing workshops, and Berkeley Haas provides continuous learning events, workshops, videos, and seminars. Lastly, universities such as Carey, ESCP and Berkeley Haas have a database of teaching cases and syllabi, teaching and learning resources, and a reference library to assist faculty members in teaching.

These and other major higher education institutions are centralising the efforts around the setup and maintenance of Teaching and Learning Centres; these global players are to be taken as a reference in the educational field also to ingrain AI solutions in the formative curriculum of tenured professors and adjunct faculty:

- The *Initiative for Learning Innovation and Teaching Excellence* (iLITE) supports teaching cases for INSEAD faculty and beyond. It facilitates the development of instructors within a *diverse community* of learners.
- The *Centre for Teaching and Learning* (CTL) at the Georgia Institute of Technology promotes a fully engaged, sharing community by providing communication networks, resources, and innovative programs for faculty, postdoctoral scholars, and graduate students.
- The *Centre for Education Innovation* (CEI) at The Hong Kong University of Science and Technology (HKUST) is an *academic support unit* that proactively advances HKUST's teaching and learning strategy.
- The *Centre for Teaching and Learning* (CTL) at McCOMBS collaborates with the University of Texas faculty, graduate-student instructors, and the University's programs and leadership to create an environment that focuses on teaching for student learning and success.

- The *Centre for Excellence in Teaching and Learning* (CTL) at ESADE promotes excellence and innovation for teaching and student learning. The CTL encompasses all areas of the educational experience and teaching innovations, particularly on learning models. It is structured in four key areas: 1) faculty office for innovation; 2) excellence, learning and impact measurement; 3) learning factory; 4) learning innovation, technology and spaces.
- The *Future of Learning Advisory Group* enables Melbourne Business School to gain new insights and address business problems by testing ideas, stimulating robust conversations about the future of learning, and exploring new offerings and services that can help tackle those business challenges.
- The *Centre for Learning and Management Practice* (CLMP) at ISB - Indian School of Business - focuses on 1) encouraging and supporting the writing and publication of high-quality India-specific cases; 2) implementing the AOL (*Assurance of Learning*) programme for all degrees and programmes at ISB; 3) assisting the measurement of the impact of executive training programmes conducted at ISB; 4) enabling teaching excellence in the classroom at ISB and in business schools across India; 5) Encouraging the practice of innovative pedagogies in the classroom, in the form of technology and simulations.
- The *Learning Science Lab* at NYU STERN collaborates with faculty to build meaningful learning environments, uses research in the learning sciences to inform *design practice*, and partners with instructors to create engaging and interactive courses for business school education.

In the spring of 2022, LUISS Business School initiated the *Teaching and Learning Lab*, inspired by other esteemed higher education institutions. This establishment is designed to support professors in their continuous transformation journey, building on the foundation of the pilot *Faculty Transformation Program*. The lab aims to reinvent and relaunch an ongoing *Digital Teaching for Learning Program*, inviting newly appointed core and adjunct faculty members and senior fellows to participate. The program refreshes tenured professors, adopting a *hybrid* train-the-trainer curriculum with synchronous and asynchronous components, personalised sessions, peer collaboration, and individualised exercises. The *curriculum*, deeply rooted in pedagogical principles, includes *Universal Design for Learning* (UDL) and *Backwards Design* in teaching planning (Laurillard, 2012). This approach *reshapes instructional objectives* and improves *assessment* practices by integrating educational technology. The lab promotes *soft skills* among educators, emphasising constructive *feedback* as a crucial competency. A key focus is training educators as *facilitators* and fostering *psychological safety* in learning environments (Henriksen et al., 2022). This approach develops a strong sense of community, reciprocal care, empathy, and collaborative problem-solving across various educational settings, including virtual, AI-augmented, in-person, or hybrid environments (Gleason & Mehta, 2022).

2.1. Scaffolding the paradigm shift while sensing the sentiment amongst the faculty

Teaching and Learning Centres, as observed across the cited examples, share a common *trend* of creating a secure environment that encourages applied research, open discussions and exchanging ideas. One of their primary focus is consistently assessing *faculty perspectives* on the advantages and challenges of EdTech, AI, and ChatGPT solutions. Often, their goal is to keep faculty members engaged, monitored, and reflective in using AI tools while fostering opportunities for training, discussions, and collaboration with industry partners (Khaddage & Flintoff, 2023). Regular *surveys* are recommended to assess faculty understanding and willingness to use technological tools efficiently in teaching and learning practices. Such surveys can focus on critical dimensions such as efficiency, cus-

tomisation, scalability, accessibility, and interactivity. For instance, LUISS Business School involved faculty rating their agreement on ChatGPT's added value in terms of these dimensions in a *pilot survey*. Indeed, if reiterated systematically, such surveys can gather opinions on disadvantages, including time consumption, ecosystem integration, error generation, trial periods, and the potential for cheating. Expanding these surveys to many education institutions can explore the *faculty readiness* and the perceived value of ChatGPT for specific activities like creating teaching materials, live interaction with students, crafting assessment tests, and grading. Qualitative interviews can then follow surveys to provide deeper insights and an opportunity to stimulate reflection as much as further adoption. Qualitative and quantitative investigations can trigger educators' curiosity about AI tools, including potential applications in exams and research. Concerns about AI's societal and educational impacts, skill obsolescence, and the need for human validation of AI-generated results may be expressed anonymously. Faculty consensus may emerge regarding areas susceptible to AI disintermediation, emphasising the importance of critical thinking, discernment, and higher-order cognitive skills. These insights can *foster reflective conversations* and knowledge-sharing among faculty members, highlighting the need for shared *discourse* on effective education in a rapidly evolving technological landscape beyond technical training (Mastrogiacomi, 2023).

2.2. Contemplating risks and drawbacks of current and future AI in education

Such reflective conversations amongst faculty should tackle the risks and drawbacks of AI solutions for education, even though experts identified *personalised learning* as the most prominent advantage in examining the advantages and disadvantages of AIs and Large Language Models (LLM) in education. Numerous specialists highlighted how tools like ChatGPT can be harnessed to deliver subject matter tailored to each learner's unique needs and learning environment. It is worth noting that the most frequently cited *disadvantage* by far is *plagiarism* (Jahic et al., 2023). Beyond plagiarism, inherent limitations in ChatGPT can be identified in generating wrong information and *biases* in data training, which may augment existing biases and *privacy* issues (Baï doo-Anu et al., 2023). Specifically in K-12 education, the most significant risks of integrating such AI algorithms were identified as 1) perpetuating existing systemic bias and discrimination, 2) perpetuating unfairness for students from mostly disadvantaged and marginalised groups, and 3) amplifying racism, sexism, xenophobia, and other forms of injustice and inequity (Akgun & Greenhow, 2022). More generally, in lifelong education, the prospective ethical and societal risks associated with AI applications were perfectly outlined:

- *Privacy Concerns*: This involves compromising students' privacy by exploiting data via biometrics recognition and recommender systems.
- *Bias and Discrimination*: These risks pertain to perpetuating gender, racial bias and social discrimination through automated scoring systems.
- *Autonomy*: The potential ethical concern jeopardises students' autonomy and *agency* in governing their lives by implementing *predictive* systems.
- *Surveillance*: Another area of concern involves monitoring student activities through personalised learning systems and social networking sites (SNSs) (Akgun et al., 2022).

In light of the risks associated with Artificial Intelligence in Education (AIED), there is a widely recognised need for educators' *skilling*, *reskilling*, and *upskilling* in the areas mentioned above. While at the same time, keep having open and candid conversations among experts. This process should integrate new technologies within a robust *pedagogical framework* centred on learners. Furthermore, adhering to

the *ethical principles* outlined for AIED is advisable. These *ethical principles* encompass diverse dimensions, including governance and stewardship, transparency in data and algorithms, accountability, sustainability and proportionality, privacy, security, safety, inclusiveness in accessibility, inclusiveness in data and algorithms, and a human-centred approach to AIED. Adhering to these principles can guide technology integration into education responsibly and learner-centric (Nguyen et al., 2023).

2.3. Facing fears and challenges for facilitating teaching and learning with AIs

Historically, apprehensions regarding humans' interactions with robots, AI, and Machine Learning have deep-seated roots. During the onset of discontinuous technological evolution in our lives, the benefits of these innovations often became entangled with emotional reactions (Kennedy et al., 2022). The *social discourse* surrounding new *adaptive* technologies has struggled with balancing perspectives from humanists, futurists, and technologists. Successfully nurturing and *scaffolding* a *paradigm shift* in how humans approach lifelong learning involves having honest conversations while comprehending the technical intricacies, broader implications and future applications.

Emotionally, creating safe spaces that engage tech professionals, educators, *facilitators*, students, and learners in an open *social discourse* is crucial, and *Teaching and Learning Centres* can offer such spaces. This discourse aims to *normalise* the integration of new technological developments within a human-centred pedagogical *framework*. By fostering such conversations and collaboration, we can navigate the ever-evolving terrain of educational technology while prioritising *human values* and academic efficacy (D'Mello et al., 2014).

In the pre-ChatGPT era, teachers commonly employed collaborative projects and gamified elements to engage students in *problem-solving* and experimentation with intelligent agents and robots. Among these activities, interacting with robotics, engaging in software development, and interacting with intelligent agents emerged as the most prevalent learning tools for fostering students' understanding of Artificial Intelligence (AI). Despite their effectiveness, educators faced *challenges* teaching AI in classrooms, including providing cognitive *scaffolding* and syntax comprehension for novice programmers and enhancing teachers' *confidence* and digital competence in AI (Ng et al., 2023).

A long-haul literature review conducted by Celik et al. (2022), dating to before the emergence of ChatGPT, had already highlighted the numerous *advantages* of integrating AI into education across different teaching dimensions. In the *planning phase*, AI was already considered a valuable tool for providing student information, aiding decision-making on learning content, and assisting in planning activities. During *implementation*, AI could transform teaching practices by enabling timely monitoring, reducing teacher workload, providing immediate feedback, selecting/adapting learning activities, facilitating timely intervention, tracking student progress, enhancing the teaching process, and increasing interaction between teachers and students. AI would also transform the *assessment* phase by offering better prediction/assessment of *teacher performance*, automating *assessment* and *evaluation* processes, providing *feedback* on instructional practices, and assisting in *decisions* (Earl, 2012).

Despite these benefits, this pre-ChatGPT literature review already identified several *challenges* in AI adoption in education, which in some cases have been overcome by the rapid evolution of AIs and LLMs; some reported limited reliability of AI algorithms, technical capacity issues, infrastructure limitations in schools, inapplicability to multiple settings, inefficiency in assessment and evaluation, lack of technological knowledge among teachers, limited interest in AI, slow AI feedback, and little *adaptive feedback*. Overall, the need for collaborative efforts was also emphasised at the time as required across

disciplines, involving AI developers, pedagogical experts, teachers, and students to develop AI systems that would contribute significantly to quality education (Ng et al., 2023).

After the storm of LLMs across multiple languages, experts and educators have expressed concerns about detecting text generated by ChatGPT, which poses a significant hurdle to current *assessment* methods (Jahic et al., 2023). Indeed, *assessment* plays a foundational role in formal education, and both *formative* and *summative* assessments should align with the current state of technology. The role of AI and digital tools in the evaluation process can either be perceived as a threat or a *facilitator*, contingent on the awareness and preparedness of educators (Willis et al., 2013). As *facilitators* of educational change, educators must actively incorporate new tools into their *pedagogical toolbox*. They should serve as exemplars in providing and receiving *feedback*, engaging in open discussions about disruptive solutions, and adapting to the evolving landscape driven by technology.

The application of AI in education holds *promise* in supporting both teachers and students through various means, such as 1) delivering effective instruction in mixed-ability classrooms; 2) providing students with thorough and timely feedback on their *written assignments* (Kim et al., 2019); 3) relieving teachers from the obligation of possessing exhaustive knowledge. Educators would have more opportunities to assist students in collaborative knowledge-building through observation, discussion, and information gathering (Akgun et al., 2022).

Many *instructional strategies* could offer *guidelines* for leveraging AI to develop educational materials efficiently, supporting the implementation of these strategies by aiding students in comprehending *challenging* and abstract concepts through the provision of numerous examples, offering diverse explanations and analogies to address common misconceptions, administering low-stakes tests for information retrieval and knowledge assessment, conducting assessments to identify knowledge gaps and gain insights into student learning, and employing distributed practice to reinforce learning (Mollick et al., 2023).

Generating many examples for a single concept is a time-intensive endeavour that can be delegated to AI for expeditious execution. The AI can rapidly produce numerous examples, serving as a valuable resource for instructors. In supporting instructors, the AI can generate multiple explanations from various perspectives, employ a step-by-step approach, and enhance existing explanations with additional details. It is essential to note that all AI-generated explanations serve as starting points and necessitate validation by instructors before dissemination to students (Henriksen et al., 2022).

Furthermore, AI can assist instructors in creating practice tests, quizzes, and short answer assessments related to specific topics or readings, and it can contribute questions designed to assess student knowledge during lectures. The AI's ability to identify patterns and common themes in student responses will likely expedite this process. Incorporating AI into distributed practice, instructors can task the AI with generating questions that assess student knowledge across a series of course topics throughout the course duration. This approach ensures the integration and assessment of newly introduced and previously learned concepts, thereby optimising the effectiveness of distributed practice. Recently, STEM subjects also benefitted from *adaptive learning* systems such as Squirrel AI Learning (Shuai et al., 2023).

2.4. Meeting the opportunities of teaching and learning with AIs

The hypothesis for facilitating a *paradigm shift* in teaching and learning to make it future-proof in a world dominated by AI originates from a fundamental conviction. This conviction centres on the necessity of collaborating with AIs rather than opposing them to redefine the boundaries and essence of pro-

fessional and personal education. Within this context, educators face the challenge of fostering *trust* in learners' cognitive abilities while *facilitating* open dialogues concerning the *ethical* ramifications of technological advancements. Simultaneously, they must confront the inherent risks of relinquishing essential human skills and outsourcing them to increasingly powerful AI systems (Nguyen et al., 2023).

This awareness of a unique set of *challenges* presents an array of untapped opportunities that merit collective exploration. Among these opportunities are the following:

- *Confronting complex conversations:* The advent of AI-powered writing tools, exemplified by ChatGPT, necessitates comprehensive and thoughtful *dialogues* among students, educators, and professionals. These discussions should revolve around the intricate domain of academic integrity, encompassing an examination of what constitutes *plagiarism* when employing AI writing tools, a clear distinction between permissible and non-plagiaristic utilisation of these tools, and discernment of scenarios wherein AI writing tools can augment critical thinking, communication, and learning (Baï doo-Anu et al., 2023). These *conversations* bear significance not solely for students and educators but also for individuals pursuing careers in writing disciplines. They serve as a mechanism to tackle the multifaceted *legal* and *ethical* aspects entailing AI writing tools, which have assumed roles previously carried out exclusively by human writers (Trust et al., 2023). After a comprehensive exploration of potentialities and implications, it becomes urgent to establish *standardised guidelines* and *achieve consensus* regarding explicit and ethical applications that maximise the advantages afforded by AI writing tools (Nguyen et al., 2023).
- *Exploring pedagogical strategies:* Educators can serve as exemplars of effective practices by integrating AI tools into their instructional methods and *curriculum*. This proactive approach allows students to gain a more profound understanding of and leverage the potential of this transformative technology, ultimately enhancing their productivity, comprehension, and creative capabilities (Trust et al., 2023). Furthermore, it is reasonable to contemplate the adoption of *adaptive learning* as a substitute for traditional *personalised learning* paradigms (Shuai et al., 2023). *Adaptive learning* considers variables such as the diversity in learners' preferred learning styles and the nature of proposed activities, ensuring the creation of effective adaptive and generative learning pathways customised to individual needs. In this context, the role of the *facilitator* assumes a pivotal position in bridging the gap between *adaptive* systems and *novice learners*. While AI-driven dynamic knowledge management systems aim to automate strategies at an *expert level*, it is vital to instil *metacognitive* awareness among motivated learners (Azevedo, 2018). This *metacognitive* perspective enables learners to gain insight into their *learning strategies* and skills, fostering adaptability and enhancing their overall learning proficiency. Furthermore, training learners and educators to reflect on expert theories and practices within dynamic and fluid contexts, enriched by data-driven insights, becomes critical. Given the unpredictable pace and extent of change in didactic technologies, future educators must cultivate the ability to engage in continuous learning and remain attuned to the ongoing development of digital resources. Embracing an awareness of emerging methodological and technological possibilities equips educators with the flexibility to effectively place the learner at the core of the teaching and learning process across various disciplines.
- *Augmenting metacognitive skills via problem-solving dynamics:* Educational exercises and *assessments* can pivot toward cultivating problem identification skills and resolving pre-defined problems, as presented by instructors and reinforced through AI systems. Introducing *metacognitive* elements in *problem-solving* exercises and subsequent debriefing sessions can significantly enhance the intellectual value of these educational efforts (Oravec, 2023). Within this framework, the *faci-*

litator is critical in providing a spectrum of AI-assisted *scaffolding* support encompassing conceptual, *metacognitive*, procedural, and strategic dimensions. *Conceptual* support entails guiding learners in discerning the subject matter for learning and recognising the inherent relationships within the relevant knowledge domains. AI technologies can play a central role in enhancing *conceptual* support. Conversely, *metacognitive* support entails assessing a learner's knowledge, including subtle references to *learning objectives* or ambiguously defined issues, and engaging in intricate decision-making processes. In this realm, human intervention remains indispensable. *Metacognitive scaffolding* contributes to reducing cognitive burdens and fostering critical thinking and reflection. Additionally, AI-augmented *procedural* scaffolding can expedite learners' navigation and utilisation of the educational system. In contrast, *strategic* scaffolding can provide diverse approaches to addressing a specific task, offering access to human expert guidance and available AI-enriched datasets. While AI demonstrates proficiency in delivering extensive support, it remains crucial for the *facilitator* to maintain an active role, entailing the stimulation of inquiries, cultivating investigative cognitive habits, and facilitating discussions that effectively influence learners' values and beliefs. Encouraging *metacognitive* reflection on their learning styles within technology-driven contexts and fostering direct experiences in *cooperative* learning design and *heuristic* work empower future educators and learners to cultivate dynamic and adaptable skills. These skills enable them to swiftly integrate technological platforms into their teaching and learning practices. Thus, a profound reflection on the transfer and deliberate negotiation of complex expertise remains essential, achieved through *metacognitive* analyses of expert strategies for information organisation and the management of interactive dynamics and decision-making (Caro et al., 2014).

– *Reflecting on AI interactions:* Engagement in contemplative exercises aimed at eliciting *metacognitive* insights and personal reflections can serve as a *facilitator* for students to harness the potential of generative AI systems to augment their intellectual capacities rather than circumvent them (Oravec, 2023). Creating dedicated spaces for personal and *collective introspection* concerning the human experience of interacting with AI helps facilitate this process. Such introspection should encompass a spectrum of *inquiries*, including the *emotional dimensions* of AI interaction, the quality of outcomes, the *experiential journey* leading to results, and the educational *insights* gleaned through engagements with AI and Large Language Models (LLMs). Additionally, this process should explore whether AI interactions are viewed as a *competitive* arena between humans and machines or as an avenue for synergistic *collaboration*. Deliberations on the optimal role of AI in the human context, strategies for influencing the technological agenda to align it with human problem-solving needs, and a comprehensive examination of associated *challenges* and *benefits* are essential components of this approach. It encourages *constructive discourse* and promotes the comprehensive integration of technological innovations into daily life, mitigating unwarranted apprehensions (D'Mello et al., 2014).
– *Co-design for productive failure:* Within the contemporary landscape of business education and applied research, a compelling necessity exists to nurture the capacity for *rapid failure* and expedited learning within psychologically secure environments conducive to innovation-driven problem-solving (Schein, 2016). As a result, in both personal and professional educational contexts, pedagogical approaches should increasingly pivot toward creating problem scenarios and *problem-solving* sequences that incorporate AI as an invaluable tool. Furthermore, given that *problem-based learning* is already an externally imposed structural *framework* within learning and performance, certain studies posit that there may be no need for excessive structuring of problem-solving activ-

ities in ill-structured domains. Rather, permitting students to confront challenges, including the prospect of *failure*, can be a productive pedagogical exercise (Kapur, 2008). The deliberate cultivation of such instances of *failure* - within a secure learning environment, wherein students collaborate and co-create solutions to intricate problems with the assistance of AI and under the tutelage of human experts who *facilitate*, *scaffold*, and *validate* processes and content - can accelerate the seamless integration of human capabilities with augmented realities (Gulyamov et al., 2023).

– *Measuring efficiency:* Recent investigations have demonstrated that AI technology has the potential to enhance students' learning and cognitive capacities to a certain extent, concurrently improving the *efficiency* of teaching and learning processes (Huang et al., 2021). Beyond merely utilising these technologies in daily educational practices, adopting new digital and AI tools necessitates educators to adopt a rigorous approach to delineating *Learning Objectives* (LO) for each learning endeavour. This approach prioritises achieving *Intended Learning Outcomes* (ILO) as tangible evidence of genuine and authentic learning outcomes for human participants (Mastrogiacomi, 2023). Precision in articulating and declaring *action verbs* can elevate the quality of an ILO-driven educational practice. However, it is noteworthy that recent experiments simulating the application of *high-level cognitive skills* through ChatGPT dialogue have indicated its adept performance across all *Bloom's Taxonomy* learning tiers (Bloom et al., 1956). While ChatGPT proficiently generates content that emulates various mental levels, educators are encouraged to adhere to an ILO-driven, stringent, and evidence-based instructional approach to ensure the comprehensive measurability of the overall impact of the learning experience. Digital platforms offer a wealth of *data* that necessitates integration with empirical data from human interactions and personal *learning portfolios* amassed throughout the *learning journey*. The convergence of these data streams onto measurable and observable dimensions enhances the precision of *formative* and *summative* assessments, yielding dependable evaluations of learners' competencies and skills cultivated throughout their *lifelong learning* journey (Earl, 2012).

3. Heading towards learners' autonomy and adaptive learning with AIs

During the early stages of the pandemic, educators grappled with the rapidly advancing technological landscape, aiming to maintain a human-centric perspective amid *digital transformation*. Their focus was on integrating technology with the fundamental principles of the humanities. Many educational organisations faced the necessity to embrace digital platforms without fully understanding the profound consequences and disruptions brought by the subsequent massive advent of AI.

The initial wave of *digital transformation* significantly impacted educators, requiring them to swiftly acquire new skills and adapt to digital tools. In this challenging period, educators were primarily concerned with the practical aspects of their daily work. Many transitioned from the traditional role of a *sage on the stage* to that of a *facilitator*, driven by the need for adaptation and survival. This shift began in a renewed, entirely *hybrid* professional context, further complicated by the disruptive dynamics of the global pandemic.

Technological mediation's pervasive and all-encompassing influence accelerated the onset of a new era propelled by Artificial Intelligences (AIs). This era is now witnessing intricate connections between humans and technologically augmented entities, resulting in complex interfaces merging biological "wet-ware" with non-biological "hardware" (Bono et al., 2008). These complex interdependencies highlight the evolving landscape of human-technology interaction, indicating a profound impending shift in the very essence of human existence and societal structures.

The rapid and profound technological transformations, especially in Artificial Intelligence and Machine Learning, necessitate thoroughly reassessing a *renewed pedagogical paradigm*. This reassessment must occur with heightened awareness and a tangible sense of urgency. In the contemporary landscape, marked by numerous Artificial Intelligences, multiple Expansive Language Models, and the prevalence of Distributed Machine Learning, the approach to teaching and learning must pivot toward accommodating *adaptive learning trajectories* for human learners. These adaptive pathways are critical due to the swift pace at which human society advances towards what can aptly be termed a *posthuman* condition (Braidotti, 2013).

Traditionally, the study of humanity focused on "Man" as the primary subject of analysis. However, in the present and future context, the proper subject of examination becomes the intricate interplay between "humans" and "non-human" agents (Braidotti & Gilroy 2016). This shift underscores the necessity of understanding the complex dynamics and consequences of human interactions with non-human entities in an increasingly AI-driven world. It is essential to reevaluate traditional *ontological categories* and *boundaries* in the face of technological and cultural transformations, introducing a more *inclusive* and nuanced understanding of *identity*, *culture*, and *society* that challenges conventional notions of *human identity* and *subjectivity* in an advanced technological landscape.

4. Conclusions and further considerations

This paper explored the *paradigm shift* from educators to *facilitators* of change, focusing on strengthening human learners' ability to learn *autonomously* and incorporating future technology into an individual-centred pedagogy. It envisioned AI as a *collaborative partner* in various educational tasks, emphasising the need for educators to work with AI to redefine the boundaries of professional and personal education. Identified *challenges* for teachers included nurturing *trust* in learners' cognitive abilities and engaging in open dialogues about the *ethical* implications of technological innovations. In physical and virtual learning communities, educators have been imagined as fully transitioning into *facilitators* within authentic *apprenticeship* contexts, guiding students in *experiential* and project-driven problem-solving scenarios. The *augmented facilitator* has been encouraged to collaborate with cyber-learners, gradually receding as learners progress towards autonomy. Peer-tutoring mechanisms have been presented as crucial, creating a fluid boundary between educator and learner. The future *challenge* has risen to embrace AI as a collaborative partner, building trust, fostering open dialogues, experimenting with AI tools, enhancing *metacognitive* skills, reflecting on AI interactions, embracing *productive failure*, and *measuring* educational efficiency to navigate the evolving educational landscape effectively while maintaining *ethical integrity*.

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