Italian Journal of Educational Technology
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
Accepted Manuscript Online
DOI: 10.17471/2499-4324/1328
https://ijet.itd.cnr.it

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

GIUSEPPINA RITA JOSE MANGIONE[A]*, MICHELLE PIERI[B], FRANCESCA DE SANTIS[A]

A National Institute for Documentation, Innovation and Educational Research (INDIRE), Florence, Italy, g.mangione@indire.it, f.desantis@indire.it*

B University of Trieste, Italy, michelle.pieri@units.it

*Corresponding author

HOW TO CITE Mangione, G. R. J., Pieri, M., & De Santis, F. (2024). Revitalizing education in rural and small schools: The role of AI in teachers' professional development. *Italian Journal of Educational Technology*. Accepted Manuscript Online. doi: 10.17471/2499-4324/1328

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 adoption 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 e 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 professional development of teachers 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 constitute important insights for other school realities located in "*place 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 the 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 promote the construction 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. Concurrently, 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 (2022), has been recognised as useful for solving multiple problems, such as, to name but a few, 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 IA (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 discussions. By coordinating movements in various parts of the body 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 and mainly due to the demands of social interaction and affective communication skills of mechanical agents can be overcome with AI hypothesizing for the future in remote areas not only robots with functions of assistant in class or study companion of students, but independent agents capable of maintaining social and affective relationships and managing classroom space management even with situations of hybrid presence in situations of remote school and home related to environmental difficulties that do not allow teachers and students to reach schools (Mangione & Cannella, 2021; Mangione et al., 2023).

The use of AI "*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 indicated in the 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.

6. References

Ahmed, A. A., & Ganapathy, A. (2021). Creation of automated content with embedded artificial intelligence: A study on learning management system for educational entrepreneurship. *Academy of Entrepreneurship Journal*, *27*(3), 1-10.

Albacete, P., Jordan, P., Katz, S., Chounta, I.A., & McLaren, B. M. (2019). The impact of student model updates on contingent scaffolding in a natural-language tutoring system. In *International conference on artificial intelligence in education* (pp. 37–47). Springer.

Al-Zyoud, H. M. (2020). The role of artificial intelligence in teacher professional development. *Universal Journal of Educational Research*, *8*(11B), 6263-6272.

Azano, A. P., Downey, J., & Brenner, D. (2019). Preparing pre-service teachers for rural schools. In *Oxford Research Encyclopedia of Education*.

Baker, T., & Smith, L. (2019). *Educ-AI-tion rebooted? Exploring the future of artificial intelligence in schools and colleges*. Retrieved from: https://www.nesta.org.uk/report/educationrebooted/ (ver. 13.06.2023).

Biswas, G., Leelawong, K., Schwartz, D., Vye, N., & The Teachable Agents Group at Vanderbilt. (2005). Learning by teaching: A new agent paradigm for educational software. *Applied Artificial Intelligence*, *19*(3–4), 363–392.

Bridle, J. (2018). *New dark age: technology and the end of the future*. Verso Books.

Cannella, G., Mangione, G. R. J., & Rivoltella P. C. (Eds.). (2021). *A scuola nelle piccole scuole. Storia, metodi, didattiche*. Morcelliana Scholè.

Capuano, N., Mangione, G. R. J., & Salerno, S. (2013). ALICE: Adaptive learning via interactive, collaborative and emotional approaches. In J. Jovanovic, & R. Chiong (Eds.), *Technological and Social Environments for Interactive Learning* (pp. 121-172). Informing Science Press.

Celik, I., Dindar, M., Muukkonen, H., & Järvelä, S. (2022). The promises and challenges of artificial intelligence for teachers: A systematic review of research. *TechTrends*, *66*(4), 616-630.

Chin, K. Y., Wu, C. H., & Hong, Z. W. (2011). A humanoid robot as a teaching assistant for primary education. *2011 Fifth International Conference on Genetic and Evolutionary Computing*, 21–24.

China's State Council. (2017). *A new generation artificial intelligence development plan.* https://digichina.stanford.edu/work/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/

Collins, T. (1999). *Attracting and retaining teachers in rural areas*. ERIC Digest.

Chounta, I.A. (2019). *A review of the state-of-art of the use of machine-learning and artificial intelligence by educational portals and oer repositories* (white paper).

Chounta, I. A., Bardone, E., Raudsep, A., & Pedaste, M. (2022). Exploring teachers' perceptions of artificial intelligence as a tool to support their practice in estonian K-12 education. *International Journal of Artificial Intelligence in Education*, *32*(3), 725–755.

Dahl, T. S., & Kamel Boulos, M. N. (2013). Robots in health and social care: A complementary technology to home care and telehealthcare? *Robotics*, *3*(1), 1–21. MDPI AG. https://doi.org/10.3390/robotics3010001

Di Tore, P. A., Mangione, G. R. J., Di Tore, S., & Aiello, P. (2013). Human machine interaction, embodied cognition and phenomenology: the body in digital storytelling. *Learning & Teaching with Media & Technology*, *1*, 448-459.

Duncan, H. E., & Stock M. J. (2010). Mentoring and Coaching Rural School Leaders: What Do They Need? *Mentoring and Tutoring: Partnership in Learning*, *18*(3), 293-311.

Edwards, B. I., & Cheok, A. D. (2018). Why not robot teachers: Artificial intelligence for addressing teacher shortage. *Applied Artificial Intelligence*, *32*(4), 345–360.

EU (2023). Teachers' competences. *Briefing report No. 1 European Digital Education Hub's squad on artificial intelligence in education* (in press).

Fargas-Malet, M., & Bagley, C. (2022). Is Small Beautiful? A scoping review of 21st-century research on small rural schools in Europe. *European Educational Research Journal*, *21*(5), 822-844.

Ferraro, F. V., Ambra, F. I., Aruta L., & Iavarone, M. L. (2020). Distance Learning in the Covid-19 Era: Perceptions in Southern Italy. *Education Sciences*, *10*(12), 355.

Francom, G. M. (2016). Barriers to technology use in large and small school districts. *Journal of Information Technology Education. Research*, 15, 577.

Füller, C., & Spiewak, M. (2020). Digitale Hausaufgabe. *Die Zeit*, 37, 38.

Fuster, M., & Burns, T. (2020). Back to the future of education: Four OECD scenarios for schooling. OECD iLibrary. https://www.oecd.org/education/back-to-the-future-s-of-education-178ef527-en.htm

Goodpaster, K. P., Adedokun, O. A., & Weaver, G. C. (2012). Teachers' perceptions of rural STEM Teaching: Implications for Rural Teacher Retention. *The Rural Educator*, *33*(3).

Green, R. A. (2014). *The Delphi technique in educational research*. Sage Open, 4(2).

Handal, B., Watson, K., Petocz, P., & Maher, M. (2018). Choosing to teach in rural and remote schools: The zone of free movement. *Education Research and Perspectives*, 45, 1-32.

Hannum, W. H., Irvin, M. J., Banks, J. B., & Farmer T. W. (2009). Distance education use in rural schools. *Journal of Research in Rural Education*, *24*(3), 1.

Hargreaves, L. M. (2009). Respect and Responsibility: Review of Research on Small Rural Schools in England. *International Journal of Educational Research*, *48*(2), 117-128.

Hawkes, M., Halverson, P., & Brockmueller, B. (2002). Technology facilitation in the rural school: An Analysis of Options. *Journal of Research in Rural Education*, *17*(3), 162-170.

Heffernan, N.T., & Heffernan, C .L. (2014). The assistments ecosystem: building a platform that brings scientists and teachers together for minimally invasive research on human learning and teaching. *International Journal of Artificial Intelligence in Education*, 24(4), 470–497.

Hinojo-Lucena, F. J., Aznar-Díaz, I., Cáceres-Reche, M. P., & Romero-Rodríguez, J. M. (2019). Artificial intelligence in higher education: A bibliometric study on its impact in the scientific literature. *Education Sciences*, *9*(1), 51.

Holstein, K., McLaren, B. M., & Aleven, V. (2017). Intelligent Tutors as Teachers' Aides: Exploring Teacher Needs for Real-time Analytics in Blended Classrooms. *Proceedings of the seventh international learning analytics & knowledge conference*, 257-266.

Howley, A., Wood, L., & Hough, B. (2011). Rural Elementary School Teachers' Technology Integration. *Journal of Research in Rural Education*, *29*(9), 1-18.

Ingersoll, M., Hirschkorn, M., Landine, J., & Sears, A. (2018). Recruiting international educators in a global teacher shortage: Research for practice. *The International Schools Journal, 37*(2), 92–102.

Lucisano, P. (2020). Fare ricerca con gli insegnanti. I primi risultati dell'indagine nazionale SIRD. Per un confronto sulle modalità didattica a distanza adottate nelle scuole italiane nel periodo di emergenza COVID-19. *Lifelong Lifewide Learning*, *17*(36), 3-25.

Jian, L. (2020). Improving teacher development in rural China: A Case of "Rural Teacher Support Plan". *Beijing International Review of Education*, *2*(2), 301-306.

Jiang, C. (2021). Technical framework and model of artificial intelligence for boosting the revitalization of rural education. *2021 2nd International Seminar on Artificial Intelligence, Networking and Information Technology (AINIT)*, 107–110.

Kaden, U. (2020). COVID-19 School closure-related changes to the professional life of a K–12 teacher. *Education Sciences*, *10*(6), 165.

Kale, U., Goh, D. (2014). Teaching style, ICT experience and teachers' attitudes toward teaching with Web 2.0. *Education and Information Technologies*, *19*(1), 41-60.

Kormos, E. M. (2018). The Unseen Digital Divide: Urban, Suburban, and Rural Teacher Use and Perceptions of Web-Based Classroom Technologies. *Computers in the Schools*, *35*(1), 19-31.

Kuleto, V., Ilić, M., Dumangiu, M., Ranković, M., Martins, O. M. D., Păun, D., & Mihoreanu, L. (2021). Exploring Opportunities and Challenges of Artificial Intelligence and Machine Learning in Higher Education Institutions. *Sustainability*, *13*(18), 10424.

Kusmawan, U. (2023). *Redefining teacher training: The promise of ai-supported teaching practices*. *Journal of Advances in Education and Philosophy*, 332–335. https://doi.org/10.36348/jaep.2023.v07i09.001

Laferrière, T., Hamel, C., Allaire, S., Turcotte, S., Breuleux, A., Beaudoin, J., & Gaudreault Perron, J. (2011). *L'ecole eloignee en reseau, un modele*. Rapport-synthèse, CEFRIO.

Li, J., Shi, Z., & Xue, E. (2020). The problems, needs and strategies of rural teacher development at deep poverty areas in China: Rural schooling stakeholder perspectives. *International Journal of Educational Research*, *99*, 101496.

Liu, Y., Chen, L., & Yao, Z. (2022). The application of artificial intelligence assistant to deep learning in teachers' teaching and students' learning processes. *Frontiers in Psychology,* 13.

Lowe, J. M. (2006). Rural education: Attracting and retaining teachers in small schools. *Rural Educator*, *27*(2), 28-32.

Luckin, R. (2017). Towards artificial intelligence-based assessment systems. *Nature Human Behaviour*, 1(3), 1–3.

Mangione, G. R. J. (2013). *Istruzione adattiva: approcci, tecniche e tecnologie*. Lecce: Pensa.

Mangione, G. R. J., & Calzone, S. (2019). The Italian Small School Toward Smart Pedagogy. A Cross-Reading of Opportunities Provided by the National Operational Program (PON) "For Schools 2014–2020–Skills and Learning Environments". *Didactics of Smart Pedagogy: Smart Pedagogy for Technology Enhanced Learning*, 233-252.

Mangione, G. R. J., Calzone, S., & Bagattini, D. (2017a). Digital Environments for Small Schools. the Enhancement of Laboratory Spaces within a Renewed Classroom Concept. *Form@ re-Open Journal per la formazione in rete*, *17*(3), 83-100.

Mangione, G. R. J., Garzia, M., & Pettenati, M. C. (2017b). Neoassunti nelle piccole scuole. Sviluppo di competenza e professionalità didattica. *Formazione & Insegnamento*, *14*(3), 287-306.

Mangione, G. R. J., & Cannella, G. (2021). Small School, Smart Schools: Distance Education in Remoteness Conditions. *Technology, Knowledge and Learning*, (26), 845-865.

Mangione, G. R. J., Fante, C., Della Mutta, E., & Benigno, V. (2023). Exploring Educational Practices for Non-Standard Didactic Situations in Small Schools. In E. Podovšovnik, T. De Giuseppe, & F. Corona (Eds.), *Handbook of Research on Establishing Digital Competencies in the Pursuit of Online Learning.* (pp. 50-72). IGI Global.

Mangione, G. R. J., Gaeta, M., Gaeta, M., & Salerno, S. (2012). Apprendimento basato sulle Conversazioni nel Social Semantic Web. *Journal of E-Learning and Knowledge Society - Italian Version*.

Mangione, G. R. J., Pieri, M., De Santis, F. (2023). Intelligenza artificiale ed educazione nei contesti rurali: una scoping review per orientare la ricerca. *New literacies - Nuovi linguaggi, nuove competenze*, *Book of Abstracts*. Brescia: Editrice Morcelliana.

Michinov, N., Morice, J., & Ferrières, V. (2015). A Step Further in Peer Instruction: Using the Stepladder Technique to Improve Learning. *Computers & Education, 91,* 1-13.

Mijwil, M. M., Aggarwal, K., Mutar, D. S., Mansour, N., & Singh, R. S. S. (2022). The Position of Artificial Intelligence in the Future of Education: An Overview. *Asian Journal of Applied Sciences*, *10*(2).

Miller, R. (2018). *Transforming the future: Anticipation in the 21st century* (p. 300). Taylor & Francis.

Ministry of Education of the People's Republic of China. (2018). *Education Informatization 2.0 Action Plan*.

Mitchell, R., Hampton, P., & Mambwe, R. (2022). Teacher Futures: Global Reaction to Teacher Shortages in Rural Locations. *IAFOR Journal of Education*, *10*(3), 9-30.

Mitchell, R., Olsen, A. W., Hampton, P., Hicks, J., Long, D., & Olsen, K. (2019). Rural Exposures: An Examination of Three Initiatives to Introduce and Immerse Preservice Teachers into Rural Communities and Rural Schools in the U.S. and Australia. *The Rural Educator, 40*(2), 12–22.

Panciroli, C. & Macauda, A. (2021). Intelligenza artificiale in una prospettiva educativo-didattica. In A. Di Pace, A. Fornasari, M. De Angelis (Eds.), *Elementi di didattica post-digitale* (pp. 37-44). FrancoAngeli.

Panciroli, C., & Rivoltella, P. C. (2023). *Pedagogia algoritmica. Per una riflessione educativa sull'Intelligenza Artificiale*. Morcelliana Scholè.

Park, E. A., Sinha, H., & Chong, J. (2007). Beyond Access: An Analysis of the Influence of the E-rate Program in Bridging the Digital Divide in American Schools. *Journal of Information Technology Education: Research*, *6*(1), 387-406.

Pedró, F., Subosa, M., Rivas, A., & Valverde, P. (2019). *Artificial Intelligence in Education: Challenges and Opportunities for Sustainable Development*. Paris: Unesco.

Pieri, M., & Repetto, M. (2019). *Piccola scuola come comunità educante*. I QUADERNI DELLE PICCOLE SCUOLE, Anno 2019 - Quaderno N. 1 – Strumenti. Rimini: Maggioli editore.

Pieri, M. (2022). *Classi in rete. Un modello innovativo per le piccole scuole*. Lecce: Pensa Multimedia.

Powell, M., & Priestley, M. (2015). Teacher Agency: What is it and why does it matter? *British Educational Research Association Blog*, September. London: Routledge.

Qian, H., Youngs, P., Hu, S., & Prawat, X. J. (2020). Will China's Free Teacher Education Policy Address Teacher Shortages in Rural Schools or Reproduce Existing Inequality? *Compare, 50*(5), 713–725.

Rundel, C., & Salemink, K. (2021). Bridging Digital Inequalities in Rural Schools in Germany: A Geographical Lottery? *Education sciences*, *11*(4), 181.

Razia, B., Awwad, B., & Taqi, N. (2022). The Relationship between Artificial Intelligence (AI) and its Aspects in Higher Education. *Development and Learning in Organizations,* 37(3), 21-23.

See, B. H., Morris, R., Gorard, S., & El Soufi, N. (2020). What Works in Attracting and Retaining Teachers in Challenging Schools and Areas? *Oxford Review of Education*, *46*(6), 678-697.

Sindelar, P. T., Pua, D. J., Fisher, T., Peyton, D. J., Brownell, M. T., & Mason-Williams, L. (2018). The Demand for Special Education Teachers in Rural Schools Revisited: An Update on Progress. *Rural Special Education Quarterly*, *37*(1), 12–20.

Sinha, R. & Swearingen, K. (2002). The role of transparency in recommender systems. *CHI '02: CHI '02 extended abstracts on Human factors in computing systems* (pp. 830-831), New York, NY, USA: ACM.

Straub, I. (2016). 'It Looks Like a Human!' The Interrelation of Social Presence, Interaction and Agency Ascription: A Case Study about the Effects of an Android Robot on Social Agency Ascription. *AI & SOCIETY*, *31*(4), 553–571.

Sundeen, T. H., & Sundeen, D. M. (2013). Instructional Technology for Rural Schools: Access and Acquisition. *Rural Special Education Quarterly*, *32*(2), 8-14.

Tarus, J.K., Niu, & Z., Mustafa, G. (2018). Knowledge-based recommendation: a review of ontology-based recommender systems for e-learning. *Artificial Intelligence Review*, 50(1), 21–48.

UNESCO (2015). The Challenge of Teacher Shortage and Quality: HaveWe Succeeded in Getting Enough Quality Teachers into Classrooms? In *12th Session of the Joint ILO/UNESCO APPLIED ARTIFICIAL INTELLIGENCE 359 Committee of Experts on the Application of the Recommendations Concerning Teaching Personnel* (CEART). Paris: GMR and UNESCO.

Verbert, K., Ochoa, X., De Croon, R., Dourado, R. A., & De Laet, T. (2020). Learning analytics dashboards: The past, the present and the future. In *LAK 2020 Conference Proceedings - Celebrating 10 years of LAK: Shaping the Future of the Field - 10th International Conference on Learning Analytics and Knowledge* (pp. 35-40). (ACM International Conference Proceeding Series). Association for Computing Machinery. https://doi.org/10.1145/3375462.3375504

Yan, S., & Yang, Y. (2021). Education Informatization 2.0 in China: Motivation, Framework, and Vision. *ECNU Review of Education*, *4*(2), 410-428.

Yao, W. (2020). Educational Equity in the Age of Artificial Intelligence—Taking the Construction of Rural Teachers as an Example. *US-China Education Review A*, *10*.

Wang, J., Tigelaar, D. E., & Admiraal, W. (2019). Connecting rural schools to quality education: Rural teachers' use of digital educational resources. *Computers in Human Behavior*, 101, 68-76.

Zhang, X. (2015). Achievements and Difficulties in the Construction of Rural Small-scale School Teachers-Based on a Nationwide Survey of 1032 Rural Small-scale School Teachers. *Journal of Suzhou University*, *3*(2), 85-92.