

# Empowering Primary School Teachers with AI Literacy: The Role of Communities of Practice

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## Abstract

The widespread adoption of Artificial Intelligence in society highlights the urgent need to equip early-school teachers with a conscious and critical understanding of such emerging technologies. Recent surveys [1] reveal that only one in two Italians claims to have a good understanding of AI, exposing a cultural gap that risks reflecting in educational contexts. This study investigates how a 20-hour in-person workshop, grounded in a Community of Practice (CoP) approach, can enhance both AI literacy and self-efficacy in learning among 20 pre-primary and primary school teachers. The methodology integrated pre- and post-workshop questionnaires, aimed at assessing perceived self-efficacy and AI knowledge, with collaborative inquiry activities. These included co-production tasks, the co-design of the workshop environment, and the cultivation of participants' explicit awareness of their role as active contributors to the research process. Results indicate a significant improvement in the understanding of AI concepts and applications, with more than 70% of participants reporting increased knowledge and confidence with complex technological topics. The analysis of the data shows a marked shift in participants' attitudes: initially characterized by reluctance and apprehension towards innovation, their approach evolved into a more open and proactive stance. Post-workshop responses reveal stronger understanding of specific AI concepts and increased interest in integrating AI-related activities into their teaching. These findings suggest that CoP-based workshop models offer an effective strategy to strengthen AI literacy among teachers, contributing to bridge the cultural gap identified at the national level and supporting an inclusive and competent approach to AI in education.

## Keywords

Artificial Intelligence Literacy, Communities of Practice, Teacher Training, Adult Education, Educational Innovation

## 1. Introduction

Artificial Intelligence is increasingly shaping the tools and environments surrounding education. Teachers are now expected to understand and integrate AI-based systems into their professional practice [2], both to enhance their own teaching strategies and to prepare students for a society deeply influenced by intelligent technologies.

In this context, we designed and implemented a 20-hour AI literacy workshop, drawing on the pedagogical methodologies of communities of practice and learning. The core of the workshop focused on supporting teachers in building a shared understanding of AI in education, fostering peer dialogue, and enabling them to design meaningful classroom applications. The methodological framework adopted was that of the Community of Practice [3], understood as a dynamic and socially situated learning environment where participation, shared repertoires, and mutual engagement contribute to identity development and professional growth. The research methodologies have been based on the case study approach [4] and Community-Based Participatory Research [5].

The workshop was administered to two groups of in-service teachers from a public preschool and primary school in Salerno, Italy. Each edition lasted three consecutive days, for a total of 20 hours per each edition, and was held in person. Twenty female teachers participated in total, split equally in each edition.

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**Motivations** Discussing communities of practice within a professional development workshop on AI for teachers is not merely a matter of instructional strategy, but a deliberate response to the epistemological nature of teaching and learning in adult education contexts in the age of "intelligent" technologies.

The integration of AI in education requires more than the acquisition of technical knowledge; it demands a situated process of meaning-making [6], negotiation of professional identity, and collaborative reflection on the pedagogical change and opportunities. These are processes that unfold most effectively within relational and participatory contexts, such as those enabled by a community of practice.

In parallel, evaluating the effectiveness of such learning experiences requires methodological approaches capable of capturing the complexity of human interactions, identity shifts, and the emergence of collective knowledge. Post-quantitative methods — which emerge from critiques of traditional measurement-based paradigms and emphasize relational, contextual, and affective dimensions of knowledge production — offer a framework better suited to exploring how teachers engage with AI concepts, reconfigure their practices, and co-construct understandings in dynamic, socially embedded settings [7]. Thus, both the pedagogical model and the research approach reflect a commitment to interpreting learning as a transformative, situated, and co-produced process. To this end, we employ a mixed methods strategy, combining qualitative and quantitative approaches: we observed interaction dynamics and participation, integrated creative tools from social research, and complemented these with more conventional pre/post questionnaires.

To the authors' knowledge, no other examples of AI literacy-driven community of practice are mentioned in the literature, except for expert networks.

This paper is organized as follows: Section 2 outlines the methodological choices adopted for the case study. Section 3 discusses the theoretical framework of Communities of Practice. Sections 4 and 5 situate this framework within the workshop context and present the data and observations collected. Finally, Section 6 offers conclusions, highlighting the study's limitations as well as future directions and potential developments.

## 2. Design of the study

### 2.1. Case Study Design

The adoption of the case study method stems from the awareness that certain human behaviors cannot be directly observed and that their understanding requires approaches able to capture contextual complexity. Within the post-positivist paradigm, which recognizes an external reality as only partially knowable and mediated by contexts and interactions, qualitative research proceeds through conversation, observation of phenomena in natural settings, and analysis of their historical development.

According to the classic definition provided by Yin [4], a case study is "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, particularly when the boundaries between phenomenon and context are not clearly evident". It addresses situations characterized by the presence of a large number of variables of interest relative to the available data, drawing on multiple sources of evidence, and benefiting from the development of preliminary theoretical propositions that guide both data collection and analysis.

In Yin's perspective, a case study entails a structure articulated in fundamental elements, which in our study are defined as follows:

**Research Questions** – In our case, the central research question is: in what ways can the Community of Practice serve as an effective methodological tool to guide and support a path of AI literacy for adult learners?

**Theoretical Propositions** – In our case, the main theoretical proposition is that participation in a Community of Practice fosters not only the acquisition of knowledge about Artificial Intelligence but also the development of positive attitudes and a sense of self-efficacy in the use of complex technologies.

**Unit of Analysis** – This represents the concrete object of investigation. Here, the unit of analysis is composed of a group of 20 preschool and primary school teachers, divided into two groups of ten, who

participated in an intensive 20-hour AI literacy workshop held over three consecutive days.

**Logic Linking Data to Propositions** – This defines the way in which the data collected are related to the initial hypotheses. In this study, the connection was established through thematic qualitative analysis, aimed at identifying recurrences, patterns, and discrepancies between the training experience and the principles of the Community of Practice [3], as well as the resulting sense of self-efficacy.

**Criteria for Interpreting Findings** – The effectiveness of the training was assessed by comparing the collected evidence with the key concepts of Wenger’s theory [3], examining both the consistencies and the discrepancies that emerged, and evaluating the extent to which context-specific adaptations were necessary. This approach made it possible to judge not only whether the training met its objectives, but also how the Community of Practice framework functioned within the specific school environment.

## 2.2. Types of Data Collected

During the implementation, data of both qualitative and quantitative nature were collected through complementary methodologies:

**Creative methods for social research** – As initial step, the activities involved the creation of images with artificial intelligence tools, in a deliberately “naïve” mode. Participants were asked to represent, through AI-generated images, “how they felt” at the beginning of the workshop. The activity was carried out using the Padlet platform, which was later employed as a shared space for materials and communications.

**Pre-test / Post-test** – Administration of questionnaires before and after the workshop, aimed at detecting variations in teachers’ perceptions of self-efficacy and knowledge related to AI.

**Field observation** – Direct monitoring of interaction dynamics, participation, and modalities of activity implementation throughout the entire training process.

To interpret the evolution of teachers’ beliefs and attitudes observed during the workshops, the study also refers to Bandura’s concept of self-efficacy [8], understood as the individual’s belief in their own capability to organize and execute the courses of action required to manage prospective situations. In professional development contexts, this construct provides a theoretical bridge between the social learning mechanisms of a Community of Practice and individual transformations in confidence and agency.

## 2.3. From Case to Theory: Analytical Generalization

Our approach to generalization is based on the principle of analytical generalization as opposed to statistical generalization [4]. The latter would require numerically and statistically representative samples of the reference population, a condition that would be unrealistic to apply to a group of 20 teachers. In analytical generalization, instead, empirical results are compared with the theoretical propositions formulated at the outset, using theory as a “benchmark” for data interpretation. The theoretical framework adopted—that of Communities of Practice—does not merely provide a retrospective interpretation of the data but has influenced, from the very beginning, the methodological choices, the design of the activities, and the observation criteria.

In this perspective, the analytical generalization we pursue does not consist in mechanically transferring the results to similar contexts, but in testing and refining the theoretical framework of Communities of Practice in light of concrete experience. This circular relationship between theory and empirical case is the key to understanding both the results achieved and the broader implications of our work. From this point, it is necessary to examine the origins, features, and potential of the Community of Practice model, showing how it served both as a conceptual reference and as an operational framework for the workshop and for interpreting the collected evidence.

### 3. Community of Practice (CoP)

As theorized by Wenger [3], a CoP is grounded in three fundamental and interconnected resources: a group of mutually engaged individuals, a shared repertoire, and a joint enterprise. The community emerges when a group of people establishes mutual participation in carrying out an activity. This process is sustained by the diversity of roles and competences, which intertwine to form a collective action where each member contributes their own expertise and identity. Over time, mutual engagement is further reinforced through the functional and social relationships that develop and consolidate within the practice. The second element is the shared repertoire, consisting of the set of objects and procedures elaborated and used by the community. Objects may include tools, documents, concepts, and languages, as well as physical or digital artifacts. Procedures concern the modes of work, norms of interaction, and established practices that regulate the life of the community. This repertoire is not static; rather, it is continuously enriched and transformed through everyday practice [9, 10]. Finally, the joint enterprise represents the collective goal that guides and gives meaning to the community's activities. It is the outcome of an ongoing negotiation, in which the roles and tasks of each member are defined and renegotiated according to emerging needs. Involvement in the joint enterprise is measured by the members' ability to perceive themselves as active contributors to the project, while mutual relevance ensures that each individual's work is necessary and recognized by all [3].

Practice within a community is expressed through three interrelated activities:

- **Reification** – the production of objects, documents, tools, or concepts that represent and stabilize the community's knowledge.
- **Participation** – the active and continuous involvement in activities and interactions.
- **Negotiation of meaning** – the process through which shared sense is attributed to experiences and actions, by reinterpreting and adapting the repertoire.

This perspective was adopted in the present study because of its strong focus on the interaction between experience—understood as situated interpretation—and competence, namely the set of knowledge and skills mobilized in an operational environment. The strategic objective, in a professional development perspective, was to identify and elaborate practices and activities capable of guiding and reshaping the teaching action of the participating teachers.

Within this framework, **negotiation of meaning** also acquires a broader value: it is a constant process of social production of meaning in everyday life, through which participants extend and reorient the narratives they belong to. This negotiability represents a key mechanism for adapting and transforming the community's shared repertoire [3]. Another important feature is the **unsaturated density of artifacts and reifications**, which, as Scaratti notes in his introduction to Wenger's work, reflects the presence of non-exhaustive artifacts and representations. These elements remain open to multiple interpretations and uses, thus fostering plural and evolving practices [10].

Finally, the **social ecology of identity** highlights how participants, through constant interaction with others in context, select and transform into meaningful learning only part of the experiences potentially available. In our case, this dynamic was visible in the progressive focus on one's own domain of action, the clarification of tasks and boundaries ("what one is called to do, and not to do"), and the identification of operational priorities in relation to the use of AI with pre-pubescent children.

The theoretical framework is situated within a situational and constructionist orientation to knowledge [11, 12], according to which knowledge develops in relation to the contexts in which it is enacted and negotiated. As Gherardi [9] emphasizes, practice refers to a coherent set of culturally situated activities mediated by language and by the technologies that organize heterogeneous elements—people, knowledge, artifacts, and technological tools. These theoretical dimensions directly informed both the workshop design and the interpretation of empirical data: the observation of collaborative negotiation during co-design phases was explicitly analyzed as an instance of meaning negotiation, while the emergence of a shared chat group represented the consolidation of a shared repertoire. Rooted in a socio-constructivist view of learning, the Community of Practice framework resonates with Vygotsky's theory of the Zone of Proximal Development [13], which describes learning as a relational process

taking place in the space between what a learner can do independently, through collaboration, dialogue, through the reciprocal scaffolding provided by community members, and what can be achieved with the guidance of more knowledgeable peers. Furthermore, Bandura's notion of self-efficacy [8] complements this view by explaining how participation in socially supportive environments reinforces individuals' belief in their own capabilities to act effectively. The community, therefore, functions as both a context of mediated learning (in the Vygotskian sense) and a generator of perceived competence (in Bandura's terms). The Community of Practice also served as a conceptual and methodological vocabulary, providing a systematic structure for designing and interpreting the workshop. As Durkheim notes [14], communities alternate between forms of mechanical and organic solidarity: in this study, the CoP among teachers enabled both shared objectives and individual interpretations. It also offered a lens to observe teachers not only as participants but as reflective practitioners within the PNRR training context, in line with Wenger's idea of the vignette as an ethnomethodological account capturing situated and relational learning processes [3].

## 4. Workshops

The workshop was part of the framework of the initiatives set forth by Ministerial Decree No. 66 of April 12, 2023, related to the Italian National Recovery and Resilience Plan (PNRR), Mission 4 – Component 1, Investment 2.1 “Integrated Digital Teaching and Training for the Digital Transition of School Staff” [15].

All participants were female teachers. The vast majority came from preschool and primary education, with only one participant belonging to lower secondary education. The average age of the group was 55 years (minimum 43, maximum 65, SD = 6.78), placing them in a mid-to-advanced career stage, with long-standing professional seniority and extensive teaching experience. It is noteworthy that the group included the last teachers in the school who had not yet attended DM 66/2023 training, so participation was mainly mandatory rather than interest-driven. Moreover, the teachers had never previously attended an AI literacy course.

During the activities, a significant change in participants' attitudes was observed. They progressively developed, first in small groups and later in plenary sessions, a collaborative disposition. The authors attribute this evolution to the methodology adopted, which promoted active involvement and the construction of a climate of reciprocal trust.

From the descriptive analysis, approximately half of the participating teachers (47%) reported having little or no familiarity with the concept of Artificial Intelligence; 84% had never, or almost never, experimented with educational activities involving AI. At the same time, more than half (67%) declared that they frequently or very frequently used digital tools in their teaching practice.

Although participation in the workshop was not voluntary, the majority of teachers (74%) acknowledged the strong need for targeted training. A large proportion expressed significant interest (79%) in acquiring deeper competences in AI tools and showed a strong desire (84%) to learn practical strategies for introducing AI to students in a simple and playful manner.

Consensus was less evident, however, on aspects related to the integration of AI into teaching practice. Only 68% believed that AI could improve the overall quality of their teaching, and, when asked “I believe that AI can contribute to personalizing and differentiating my teaching,” nearly half of the teachers (42%) responded neutrally, indicating a lack of knowledge regarding the potential of AI. On these latter aspects, a major shift was observed between pre- and post-workshop responses, likely due to the acquisition of greater competence and awareness.

**Activities Description** The workshop was delivered in two instances, delivered by the same trainer, who is also the first author. The 20 hours of workshop were divided into five thematic blocks of equal duration. The workshop pathway was structured into main modules, among which two co-design activities represented key moments of collaborative learning.

**Module 1 – Introduction to AI and Image Recognition.** Presentation of the basic concepts of Artificial Intelligence, with a specific focus on image recognition. The concluding activity involved the use of *Teachable Machine* to apply the concepts in practice.



**Module 2 – Generative AI and Content Creation.** Exploration of the Canva platform and its AI-integrated components. The final activity consisted of creating a thematic postcard (Easter or Mother's Day) to be shared within participants' WhatsApp groups.

**Module 3 – Co-design Activity 1: AI Unplugged for Primary School.** Development of unplugged AI activities designed for primary school contexts. Each group developed two or three activities drawn from *aiunplugged.org*, inspired by the AI4K12 initiative [16]. These sessions were self-directed by participants, who were provided with instructions and materials. At the end of the activity, groups shared their results and reflected on the challenges encountered.

**Module 4 – Co-design Activity 2: Project-Based Activity with Chatbots and Prompting.** Design of a lesson on a topic chosen by the groups, through an iterative process of interaction with a chatbot, following a Project-Based Learning approach [17].

**Module 5 – Ethics of Artificial Intelligence and Metacognitive Reflection.** Discussion of the overall learning pathway and the changes in participants' positioning towards technology. Teachers collectively watched a video and initiated a largely self-managed discussion. Particular emphasis was placed on how to teach *with* AI and *about* AI, integrating technology into teaching in a critical, age-appropriate, and pedagogically meaningful way [18].

## 5. Analysis of the Results

### 5.1. Empirical Results: General Overview and Focus on Co-design Activities

The overall analysis of the data collected shows a significant improvement in perceived competences related to AI literacy, both in terms of basic knowledge and in teachers' confidence in integrating elements of artificial intelligence into their teaching practices. At the same time, a reinforcement of group work was observed: participants progressively developed collaborative dynamics that led to the autonomous creation of a dedicated chat group aimed at sharing tools, resources, and teaching practices based on the use of artificial intelligence, even beyond the conclusion of the workshops.

However, substantial differences emerged in the processes observed during the co-design phases, which deserve specific attention. During these moments, teachers displayed a strong tendency to reinterpret the proposed activities according to the disciplinary logics of their own subjects. This phenomenon, attributable to the dynamic of "shifting stories" [19], resulted in a reformulation of the original objectives of AI literacy activities, integrating them with pedagogical aims and disciplinary knowledge tied to curricular content (or by drawing on participants' extra-professional competences).

In other words, when teachers were asked to discuss how to reintegrate the activities into their own school contexts, they often sought to adapt them to the continuation of ongoing curricular paths. This was manifested in two main modalities:

*Direct transposition* – using the activity as it had been proposed, without substantial modifications, but within a specific disciplinary context.

*Targeted adaptation* – modifying the activity to emphasize aspects and content specific to the subject taught, thereby reducing the focus on the AI concepts that the activity was originally designed to highlight.

This dynamic revealed a metacognitive difficulty in maintaining the focus on AI literacy competences, with the consequent risk of "absorbing" innovation into pre-existing disciplinary frameworks.

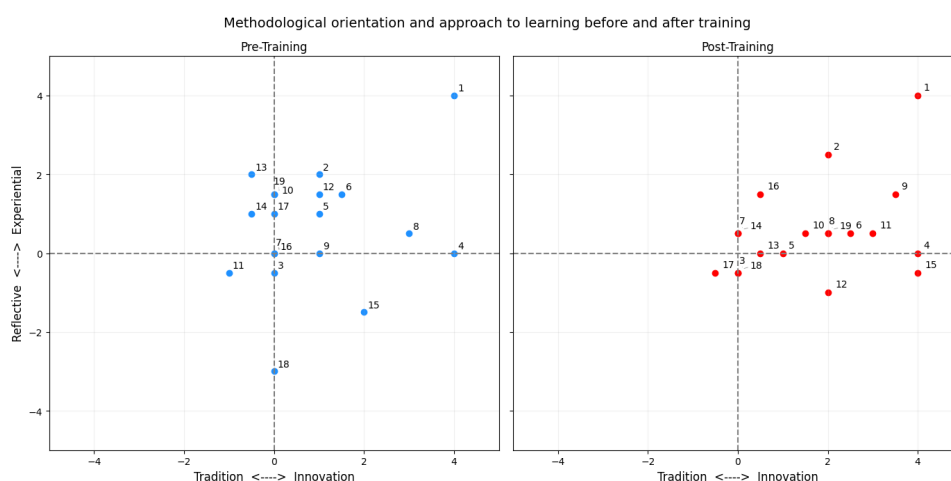
From a professional development perspective, this process can be interpreted in light of the concepts of the zone of proximal development [13] and of the expansive learning [20]: teachers operated in the margin between new technological knowledge and their pre-existing competences, but the mediation was oriented more towards continuity with the curriculum than towards the exploration of radically new practices.

These findings suggest that, in order to achieve the dual objective of consolidating AI literacy and integrating AI into school practices, it is necessary to explicitly and consistently maintain reference to AI-related conceptual objectives, while simultaneously supporting the development of metacognitive awareness during the phases of activity adaptation.

At the end of the workshop, all participants declared feeling more motivated to experiment with advanced digital technologies in their future professional practice. This shift, starting from an initial reluctance, is a clear sign of greater self-confidence and increased self-efficacy.

The workshop also contributed to enhancing participants' perception and awareness of AI use in educational contexts. Almost all teachers (95%) reported a positive change in their pedagogical ideas regarding the use of digital technologies, as well as an increased critical awareness of the educational and ethical implications of Artificial Intelligence (84%). Moreover, 79% considered that the tools presented could effectively improve student learning and engagement, and 89% perceived AI as an effective and sustainable resource for everyday teaching.

In line with the increased confidence gained during the workshop and the enthusiasm fostered by the community-of-practice approach, 79% of the participants declared that they planned to personally experiment with the activities and tools proposed during the workshop and 68% indicated that they would integrate them regularly into their daily teaching practices. Furthermore, we map the orientations of the participants within a semiotic square [21, 22] describing their methodological position (whether they were more inclined to try innovative activities - 'innovation' - or to repeat established activities - 'tradition') and their learning approach (whether they preferred to study extensively before adopting a new tool - 'reflective' - or preferred to learn through practice - 'experiential'). As expected given the school level they teach at, the majority of teachers positioned themselves as enthusiastic about innovation and more inclined to experiential learning. Note that only three teachers reported having attended other training courses during the same period, which allows us to attribute the observed effects to the 20 hours of AI literacy workshop.



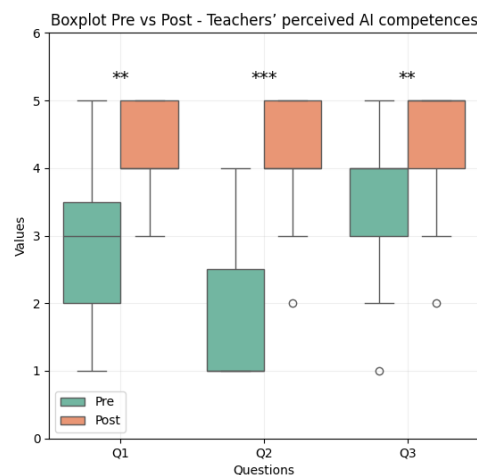
**Figure 1:** Semiotic square of teachers' methodological stance and learning approach. After the workshop, participants felt more open to innovation but also more cautious regarding the learning approach, showing a stronger preference for structured training before experimenting with new practices.

However, what is particularly notable is how participants' self-perceptions changed after the workshop. As shown in Figure 1, they declared being even more inclined to try innovative activities, but also displayed greater caution about the learning approach, showing a stronger preference for structured training before experimenting with new practices. This may indicate a general appreciation for the program and a recognition of the importance of targeted preparation. It is also significant that teachers who had initially positioned themselves as strongly reluctant toward experiential learning (e.g., participant 18) declared, after the workshop, a greater willingness to experiment, likely due to the intensive collaborative work carried out during the workshops.

## 5.2. Perceived Competences and Knowledge Gains

The analysis of the pre- <https://forms.gle/7xzgmaMVPuSjKeyy5> and post-workshop <https://forms.gle/TcLre3K8j89NhPRg9> questionnaires shows a marked increase in teachers' perceived knowledge of

AI's main theoretical concepts and in their perceived competence regarding the educational use of Artificial Intelligence. At the end of the workshop, 89% of the participants reported having acquired new and specific competencies in the pedagogical application of AI. To compare responses before and after the workshop, the Wilcoxon signed-rank test was applied. Results clearly indicate that participants' perceived competences in relation to AI knowledge improved significantly. In addition, pre-post questions that capture broader attitudes toward Artificial Intelligence were tested. Findings suggest that, beyond knowledge gains, the workshop also fostered a more positive general perception of AI and a bigger interest in AI-related educational activities, while levels of fear and concern remained substantially unchanged.



**Figure 2:** Boxplots showing pre- and post-test differences in teachers' perceived AI competences. Asterisks indicate statistical significance (Wilcoxon signed-rank test, \* - weakly significant, \*\* - moderately significant, \*\*\* - highly significant).

Q1: I understand what "machine learning" mean.

Q2: I know what an AI-based automatic classification is.

Q3: I am familiar with the basic principles of reinforcement learning.

**Knowledge Indicators** Figure 2 presents Boxplots illustrating changes in knowledge-related items between pre- and post-test questionnaires. Statistically significant improvements were observed in participants' self-assessed understanding of key AI concepts. In particular, teachers reported a stronger comprehension of what is meant by machine learning (Q1,  $p = 0.001$ ), of what an AI-based automatic classification is (Q2,  $p = 0.0003$ ), and of the basic principles of reinforcement learning (Q3,  $p = 0.005$ ). Statistical significance is highlighted in Figure 2 with asterisks.

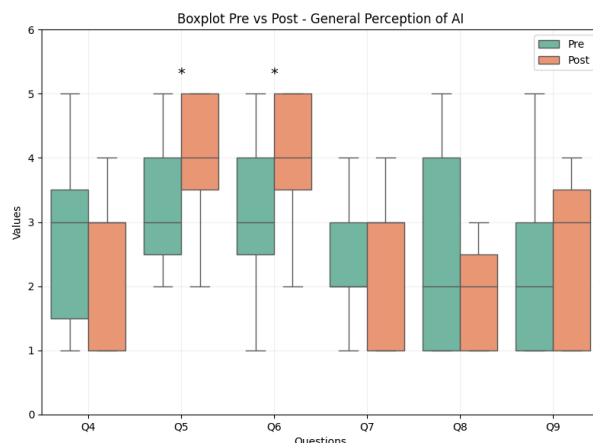
**General Perceptions of AI** Beyond perceived knowledge gains, participants' general perceptions of AI were also examined. Results summarized in Fig. 3 show that the workshop significantly increased both their interest in educational activities involving AI ( $p = 0.03$ ) and their belief that AI is important for students' education ( $p = 0.04$ ). No significant changes were observed regarding the perceived difficulty of AI as a topic ( $p = 0.63$ ), concerns about excessive complexity in introducing AI content into their teaching ( $p = 0.63$ ), fears of AI replacing teachers' roles ( $p = 0.23$ ), or expectations of practical or organizational resistance in using AI-related activities in their school ( $p = 0.9$ ).

Overall, these findings suggest that while the workshop did not reduce general anxieties or perceived difficulties, it significantly increased teachers' interest in AI, their recognition of its importance for student education, and their perceived knowledge of core AI concepts.

## 6. Conclusions and Future Work

This study has demonstrated how a 20-hour workshop program, based on the Community of Practice model, can foster a significant increase in AI literacy and in perception of self-efficacy among preschool





**Figure 3:** Boxplots showing pre- and post-test differences in teachers' general perceptions of AI. Asterisks indicate statistical significance (Wilcoxon signed-rank test, \* - weakly significant, \*\* - moderately significant, \*\*\* - highly significant).

Q4: Artificial Intelligence is a difficult topic to understand.

Q5: I am interested in educational activities that involve Artificial Intelligence.

Q6: I believe AI is important for students' education.

Q7: I am concerned that introducing AI-related content into my teaching may be too complicated.

Q8: I fear that AI-based technologies could replace some educational roles of teachers.

Q9: I think I will face practical or organizational obstacles when using AI activities in my school.

and primary school teachers. The empirical results highlight not only an improvement in technical knowledge and self-reported competences but also a shift in attitudes. The overall picture is that of a workshop initiative capable of producing impact simultaneously on three levels: the cognitive level (new knowledge and competences related to AI), the affective level (reduction of fears, increased confidence and interest), and the relational level (building professional ties and strengthening group collaboration). The Community of Practice methodology has therefore proven to be not only a useful theoretical lens through which to interpret the experience, but also an operational framework capable of guiding transformative training processes in real educational contexts. This study is limited by its single-case design and the small number of participants, which restricts the statistical generalizability of the results. Moreover, since the workshop was conducted in April–May 2025, it is too early to assess the actual transfer of practices into everyday teaching, which will only occur in the 2025/26 school year. Future research should investigate the metacognitive processes involved in adapting AI literacy activities to disciplinary contexts, as current findings suggest a risk of subordinating AI-specific goals to existing curricular objectives. Extending the observation to different school levels and contexts will also help to refine the application of CoP in AI literacy training and strengthen the empirical basis for collaborative, practice-oriented professional development models. In addition, a comparative case study with a parallel course based on more traditional training methods would be valuable to assess differences in outcomes and to better understand the specific contribution of the CoP approach.

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## Declaration on Generative AI

During the preparation of this work, the authors used ChatGPT (OpenAI, GPT-4/5) exclusively for grammar, spelling, and language refinement. After using the tool, the authors carefully reviewed and edited the content as needed and took full responsibility for the content of the publication.

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