Empowering Teachers with AI Literacy: The Italian Case

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Abstract

This paper examines the development of Artificial Intelligence (AI) literacy from a teacher-centered perspective in Italy. Despite the growing importance of AI in education, its integration into school curricula remains a major challenge. Key barriers include complex terminology, limited opportunities for hands-on professional development, and the absence of clear national curricular guidelines. The study identifies the main obstacles to developing AI literacy among in-service teachers, explores the tools and strategies currently adopted in professional training, and analyzes the objectives and content of AI-related courses offered through Scuola Futura, the national teacher training platform established under Italy's National Recovery and Resilience Plan (PNRR), as well as university programs for pre-service teachers. Findings show that most training initiatives focus on introductory and general digital skills rather than advanced or discipline-specific applications. Although recent national measures such as Decreto Ministeriale (D.M.) 66/2023 represent a positive step, sustained efforts are still required to bridge the AI knowledge gap and promote meaningful, pedagogically grounded integration of AI in teaching practice.

Keywords

AI Education, AI Literacy, AIED, Teachers' Development

1. Introduction

Artificial Intelligence (AI) is taking on growing importance in educational agendas, highlighting the need for stronger teacher preparation. However, there is no universal definition, as the term reflects diverse interpretations shaped by the pervasive role of AI in society. It generally means having the skills to critically evaluate, communicate about, and use AI tools ethically in various contexts. European policies identify AI literacy as essential for everyone [1], to understand the nature, impact, and ethical issues of AI. Integrating AI literacy into teacher training supports pedagogical and ethical competencies, grounded in both theoretical and practical knowledge. Consequently, numerous initiatives have been launched to foster AI inclusion in teacher training, targeting both pre-service and in-service educators. Historically linked to reading and writing skills, the term literacy has evolved into a more flexible and dynamic concept, aligned with the development of new competencies that place human beings in relation to complex technological constructs. A key definition states that AI literacy is [2]: "a set of competencies that enables individuals to critically evaluate AI technologies; communicate and collaborate effectively with AI; and use AI as a tool online, at home, and in the workplace." According to Long and Magerko [3], AI-literate learners should comprehend fundamental AI terminology, use AI tools effectively, distinguish realistic capabilities from hype, understand safety and security issues, and act responsibly by identifying misconceptions. Within the educational context [4], teachers must develop the skills to ethically select and integrate AI tools in their teaching practice and classrooms [5]. This extends beyond the DigCompEdu framework and can be further restructured according to Miao and Cukurova [6], which defines five key dimensions of AI competence: human-centred mindset, AI ethics, AI foundations and applications, AI pedagogy, and AI for professional development. In summary, AI literacy seeks to provide educators with the knowledge and skills needed to identify both opportunities and risks of AI in education, grounded in principles of human rights, social justice, and humanistic values. It represents an initial phase in the integration of AI into professional development,

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corresponding to the "acquire level" in the proposed framework [6], which should be presented as the essential baseline all teachers should obtain.

The paper is organized into three main sections. The first provides an overview of the current state of research on AI literacy in education, while the second and third present an analysis of the courses and tools employed by in-service and pre-service teachers to foster AI competencies within the Italian educational context.

2. Challenges and Opportunities in AI Education for Teachers

In recent years, several European initiatives have been launched to promote AI literacy in education. Among them, the AI4T project (Erasmus+ K3, 2021) stands out as a major collaborative effort in Europe that aims to improve the abilities of teachers related to AI. The project was structured around three key domains: Teaching for AI (general competencies aligned with the DigComp 2.2 framework), Teaching with AI (teacher-specific digital and pedagogical skills) [7], and Teaching about AI (foundational knowledge of AI concepts and applications). Similarly, these objectives are reflected in the framework "Five Big Ideas in AI" presented by the AI4K12 initiative [8, 9], which emphasizes hands-on engagement and experiential learning. This approach encourages educators to experiment with tools such as ChatGPT and Stable Diffusion, fostering direct and reflective interaction with AI systems. Consistent with this pedagogical perspective, various studies [10] have demonstrated that combining explicit instruction with experience-based discussions and case studies significantly enhances the AI knowledge of teachers, particularly when they already have some initial understanding of AI-related concepts.

Despite the rapid expansion of both online [11] and face-to-face training initiatives, AI literacy is still frequently regarded as a simple extension of digital literacy, often overlooking its ethical dimensions, algorithmic bias, and broader social implications. Moreover, studies [12] show that some teachers, especially in primary schools, do not perceive AI as an urgent topic and, therefore, do not consider understanding AI necessary. However, many of the courses analyzed on Scuola Futura targeted all levels of education. These included not only teachers, but also administrative and technical staff (Amministrativo, Tecnico e Ausiliario - ATA), school directors (Direttore dei Servizi Generali e Amministrativi — DSGA), and principals. This indicates a broad effort to involve various school personnel in AI literacy and education initiatives, addressing the gaps in perception and readiness between different groups of educators.

During the COVID-19 pandemic, Massive Open Online Courses (MOOCs) were widely adopted, acting as a catalyst for digital transformation and online professional learning. Although this experience familiarized most educators with digital platforms, the integration of AI into teaching practice has progressed more slowly, as many still lack confidence and hands-on experience with AI-based tools [13]. In contrast, many STEM teachers seem to show higher self-efficacy than their colleagues in other disciplines [14]. National initiatives such as the National Digital School Plan (Piano Nazionale Scuola Digitale, PNDS) and PNRR programs (e.g., Decreto Ministeriale D.M. 65/2023 and D.M. 66/2023) have expanded AI training, but barriers still remain: time constraints, technical issues, limited resources [15] and internal factors such as skepticism [14], perceived risks and pedagogical knowledge gaps [12]. In detail, algorithm aversion [16] reflects resistance to AI-based assessment, rooted in confirmation bias, where humans are superior to AI in some activities such as the grading task. In addition, the emergence of generative AI (GenAI) tools raised concerns about academic integrity, privacy, misuse, bias, and the erosion of critical thinking.

Acceptance or resistance to AI in educational technology (AI EdTech) is strongly influenced by teachers' AI literacy [17], which is essential to mitigate biases and misconceptions [18]. In fact, some educators integrate AI into pedagogy through exploration, critical evaluation, and collaborative work [19]. For a responsible adoption, it is essential to know how to evaluate tools in terms of reliability, performance, precision, and ethical implications. Educators with strong AI literacy should collaborate with AI specialists in co-designing curricula, teaching strategies, and learning activities that meaningfully integrate AI into classroom practice [20]. An ideal opportunity to foster this collaboration is during

PATH, a summer school program promoted by INDIRE, the Italian National Institute for Educational Research and Innovation, which supports experimentation and teacher professional development. In addition, research [16] shows that educators are more likely to explore and adopt AI tools when they feel autonomous in their choices and confident in their ability to use them. This sense of competence and control fosters greater motivation and openness to innovation.

AI offers opportunities to address teaching challenges and engage students in real-world problem solving [21], but this requires developing both pedagogical and technical skills. Institutional support plays a crucial role in meeting teachers' psychological needs for autonomy and competence, thereby fostering AI literacy. Equipping educators with foundational AI skills promotes lifelong professional growth and enables them to contribute to the future of society [13].

3. Educational Tools and Resources for AI Literacy

For educators, robust information is crucial to effectively integrate AI into teaching and assessment. This involves guiding students in managing information through AI, developing digital resources, and applying diverse systems in instructional design, while also fostering ethical and privacy-conscious use of AI in communication and collaboration. Moreover, integration can be supported by accessible plug-and-play tools designed to introduce AI concepts in education, such as *PictoBlox* and *mBlock*, which are preferably free or provide open-access versions, without registration to ensure accessibility and avoid account-related issues.

Our analysis of in-service teacher training courses presented in Scuola Futura [22] and DIDACTA workshops 2025 [23] suggests the following recommended tools:

- Hands-on lab activities: *Teachable Machine* and *Quick, Draw!* (by Google), as well as AI-based applications on Code.org such as *AI for Oceans*.
- General-purpose use: *ChatGPT*, *Copilot*, *Gemini AI*, and *NotebookLM*, available in Google Workspace for Education suite.
- Image generation: *DALL·E*, *Gemini AI*, *Padlet*, and *Leonardo.ai*.
- Music creation: *Suno*.
- AI-enhanced presentations: *Canva AI* and *Gamma*.
- Lesson planning and advanced learning design: *Linda* and *AIforL* (by FEM).

A critical factor in the adoption of AI in education is not only the understanding of the technology by educators, but also the degree of trust and perceived transparency that AI systems inspire. Indeed, teachers are often reluctant to use AI-based tools because they do not trust the information provided [24]. This is largely due to the perception of AI as a "black box", making it difficult for them to understand how and why algorithms generate certain outputs or make specific decisions. For this reason, AI literacy is essential to explain in a clear and accessible way how AI systems operate. In this context, Explainable Artificial Intelligence (XAI) [25] focuses on making AI systems more transparent and interpretable. To promote ethical and flexible AI use in education, schools and teachers should adopt a vendor-neutral, "agnostic approach" [26], choosing models and tools that align with pedagogical goals and uphold transparency and interpretability.

Trust in AI is a dynamic phenomenon [27], influenced by multiple factors such as context, frequency of use, prior experience with the system, and the credibility of the institution promoting it (e.g., Platone AI platform sponsored by INDIRE [28]). Indeed, teachers are more likely to trust and integrate AI tools when they align with their pedagogical approaches, contribute to workload reduction, and are developed or supported by credible institutional providers. In general, teachers approach automated tools with considerable skepticism, but ensuring the pedagogical quality can be a key factor in building greater confidence [29].

4. Exploring AI Literacy through Scuola Futura Platform for In-Service Teachers

To gain a comprehensive overview, this study conducted a structured analysis of the courses available on Scuola Futura. The platform provides free professional development for teachers, school staff, and principals, accessible through the national authentication systems Sistema Pubblico di Identità Digitale (SPID) or Italian electronic ID system (CIE), and delivered in in-person, hybrid, or predominantly online formats.

Data collection took place between late July and the first week of August 2025. The search was carried out directly through the Scuola Futura public interface using the keywords "AI" and "intelligenza artificiale" within the filtering category "Transizione digitale". No relevant results were retrieved when searching for "generative AI" or "GenAI". The initial dataset consisted of 100 active courses available nationwide. Each course entry included information such as title, short description, training modality, and geographic location of the hosting institution. After removing duplicates and inactive listings, a manual screening was performed to assess thematic relevance. Courses that did not explicitly mention AI, or that focused solely on generic digital literacy, were excluded. This process yielded a final dataset of 63 unique courses distributed across all Italian regions, covering multiple education levels, from primary to secondary teachers' training. The results highlight a strong and growing interest in AI-supported teaching, with a particular focus on themes such as inclusion, creativity, and emerging technologies. The data analysis followed a manual content-coding procedure applied to course titles and descriptions. The process involved the following steps:

1. Identify recurring keywords and concepts emerging from course titles and descriptions;
2. Cluster similar items into broader thematic categories;
3. Analyze and quantify the occurrence of each theme, and generate visual representations using Python Matplotlib.

This approach allowed the identification of four main macro-categories as illustrated in Figure 1.

- General pedagogy (e.g., "*insegnare con AI*", "*curricolo digitale*"): predominantly linked to terms such as "*strumenti*", "*strategie*", "*MOOC*" and "*sfide*".
- Machine Learning and technical AI: focused on developing a technical understanding of algorithms and deep models.
- Inclusion (e.g., *BES*) and accessibility: central in courses on personalized learning pathways.
- Storytelling and digital creativity: aimed at fostering student engagement through narrative and creative approaches.

Geographical distribution and course typologies were then examined to highlight national trends and potential imbalances between regions. This analysis revealed a concentration of initiatives in schools located in both Northern and Southern Italy, suggesting that AI literacy programs are increasingly perceived as a nationwide priority. All data were drawn from publicly available sources; no personal or sensitive information was collected. However, it is important to note that the analysis does not include locally organized training initiatives that are not publicly listed on Scuola Futura, representing a possible limitation of the presented dataset. Among the 100 courses initially considered, only a few focus on emerging topics such as educational robotics, metaverse, VR/AR, blockchain, NFTs, and digital security and privacy. The predominance of general courses on digital education and AI indicates that the current training provision is primarily oriented toward fostering a foundational level of AI literacy, focusing more on practical use than on a deep understanding of AI. However, the growing presence of courses on machine learning (as illustrated in Figure 2), GenAI, and tools indicates increasing interest in pedagogical approaches augmented by AI technologies. This trend underscores the need to invest in more advanced, technically oriented training, particularly for STEM educators, while progressively extending AI literacy to non-STEM subjects. National policies could therefore promote interdisciplinary training models, certification pathways in AI literacy, and the creation of regional AI labs where

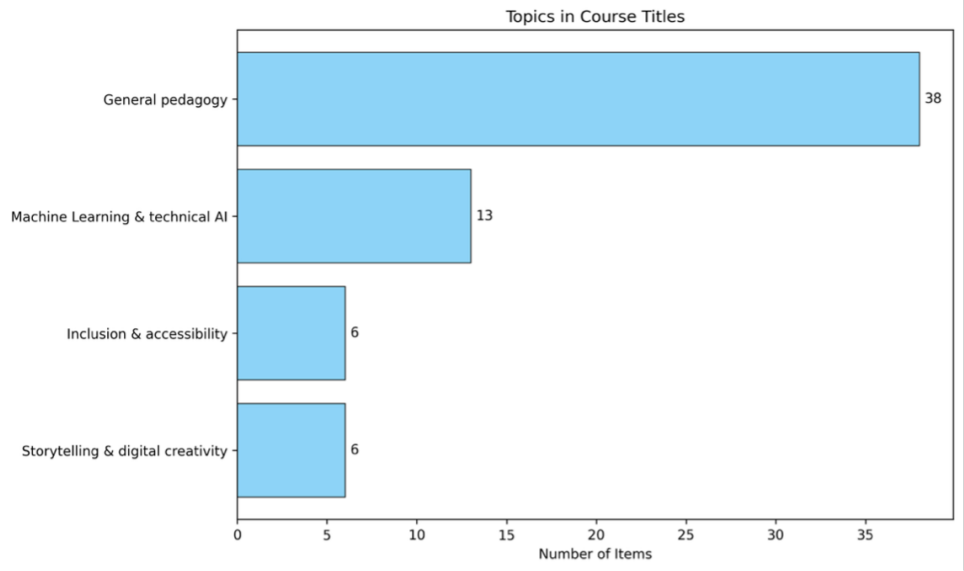

Figure 1: Topic distribution inferred from titles of the 63 analyzed courses.

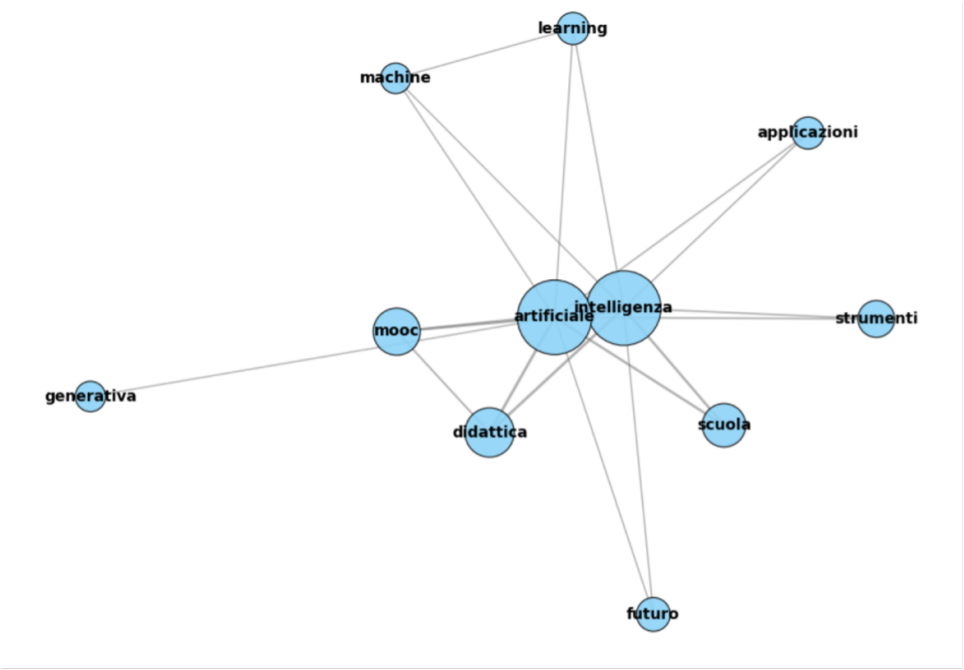

Figure 2: Co-occurrence (>= 3-word frequency) network of keywords in 63 analyzed courses' titles.

teachers can collaboratively experiment with AI tools in authentic learning contexts. Moreover, Figure 3 highlights the importance of moving beyond isolated, project-based initiatives by embedding AI literacy systematically within national education policies. Whereas current programs often remain fragmented or limited to temporary projects (such as those funded under the PNRR), a coherent policy framework is required to ensure the long-term integration of AI literacy into teacher education at all levels. Such an approach would foster not only advanced, technically oriented training but also the gradual inclusion of AI-related pedagogies across the humanities, social sciences, and arts, enabling teachers to address the ethical, societal, and creative dimensions of AI.

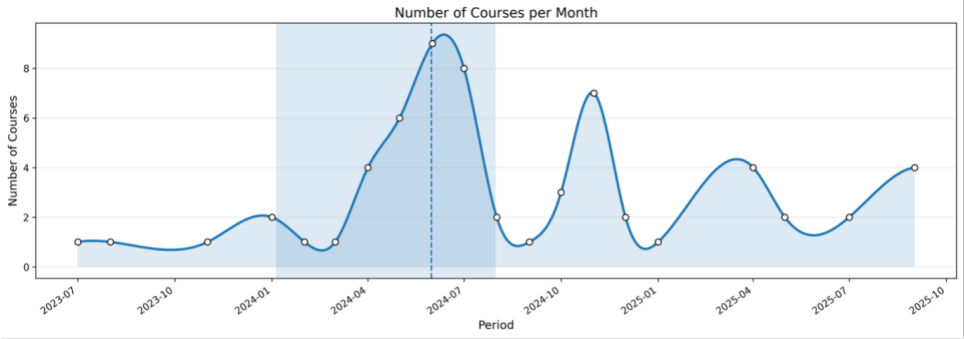

Figure 3: The mid-2024 peak may reflect PNRR-related timing effects, funding cycles, and milestone pressure [30], rather than a structural shift in demand.

5. Exploring AI Literacy for Pre-Service Teachers

To assess the integration of AI literacy into future teacher training, we examined the courses offered by accredited Italian universities to deliver teacher qualification programs, as listed in the official register of the Ministry of University and Research [31]. Specifically, we focused on 25 universities that offer the qualification for the A041 teaching class, which refers to Computer Science. However, to the best of our knowledge, and based on information available on public university webpages, the analysis revealed that only 2 out of 25 universities offer courses explicitly dedicated to AI:

- "*Laboratorio di intelligenza artificiale e cybersecurity nei contesti educativi*" at the University of Venice.
- "*Pillole di reti neurali*" at the University of Udine.

These findings highlight the need for more balanced national planning and systematic consolidation of AI competencies throughout the school system, targeting both in-service and pre-service teachers [32], and extending AI education in and beyond computer science subjects.

6. Conclusion and New Perspectives

This study examined AI literacy in the Italian educational system through an analysis of training opportunities for in-service and pre-service teachers. Despite emerging initiatives and increasing awareness, AI education remains largely introductory, with limited focus on advanced technical skills or cross-disciplinary applications.

In addition, current AI-based tools are often limited to single modalities, such as text input, which constrains personalization and creativity. Expanding toward multimodal systems that integrate images, sound, video, and text could enable more adaptive and engaging learning experiences, as demonstrated in studies with pre-service teachers using generative AI for project-based exploration [21].

A significant challenge remains the absence of a shared framework for assessing AI literacy [33]. The paper argues for clear policy guidelines aligned with curricula and systematic integration of AI literacy to develop critical, creative, and ethical AI competencies among educators and, consequently, their learners.

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Declaration on Generative AI

During the preparation of this work, the authors used GPT-5 in order to grammar and spelling check. After using these tools, the authors reviewed and edited the content as needed and assumed full responsibility for the publication's content.

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A. Appendix

Table 1
List of acronyms and abbreviations used in the paper.

Acronym	Meaning	Description
AIED	*Artificial Intelligence in Education*	Research field focusing on AI applications in educational contexts
ATA / DSGA	*Amministrativo, Tecnico e Ausiliario / Direttore dei Servizi Generali e Amministrativi*	Non-teaching and administrative school staff in Italian schools
D.M.	*Decreto Ministeriale*	Ministerial Decree, official directive issued by the Italian Ministry of Education under the PNRR framework (e.g., D.M. 65/2023, D.M. 66/2023)
BES	*Bisogni Educativi Speciali*	Special Educational Needs, referring to students requiring personalized educational support
CIE	*Carta d'Identità Elettronica*	Italian Electronic Identity Card used for secure online authentication in public services
DigCompEdu	*Digital Competence Framework for Educators*	European framework developed by the Joint Research Centre (JRC) to define educators' digital competencies.
GenAI	*Generative Artificial Intelligence*	Branch of AI focused on the autonomous generation of text, images, and other creative content
INDIRE	*Istituto Nazionale di Documentazione, Innovazione e Ricerca Educativa*	Italian National Institute for Educational Research and Innovation
MOOC	*Massive Open Online Course*	Free and open online training format
PNDS	*Piano Nazionale Scuola Digitale*	National Digital School Plan promoting innovation and digital literacy in education
PNRR	*Piano Nazionale di Ripresa e Resilienza*	National Recovery and Resilience Plan (Italy)
SPID	*Sistema Pubblico di Identità Digitale*	National digital identity system for public services
STEM	*Science, Technology, Engineering and Mathematics*	Academic disciplines related to scientific and technical education
UNESCO	*United Nations Educational, Scientific and Cultural Organization*	International organization defining global education and AI policy frameworks
XAI	*Explainable Artificial Intelligence*	Subfield of AI dedicated to model transparency and interpretability

B. Online Resources

The dataset used in this study can be accessed via an open-access repository