What are the dimensions of competence of AI Literacy frameworks for higher education? A scoping review.

Delio De Martino[*], *Fabio Filosofi*[**], *Luca Bianchin*[***], *Maria Meletiou-Mavrotheris*[****], *Anna Dipace*[*****]

Abstract
The rapid diffusion of AI is transforming higher education and raising new questions about the competencies required for students and educators to interact effectively with AI systems. This study presents a scoping review aimed at identifying and synthesizing the competence dimensions included in AI literacy frameworks for higher education. An exploratory search was conducted through different databases. The results show that AI literacy frameworks converge around four main competence clusters: technical-operational, critical-cognitive, ethical-regulatory and human-AI relational competences. These findings may inform future framework development and assessment practices.

Key words: AI literacy; Higher education; Scoping review; Competence frameworks; Competence dimensions

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1. Introduction

The aim of this scoping review is to clarify what are the dimensions of competence of Artificial Intelligence (AI) literacy frameworks in the current shifting higher education context.

[*] Università Pegaso. E-mail: delio.demartino@unipegaso.it.
[**] Università Pegaso. E-mail: fabio.filosofi@unipegaso.it.
[***] Università Pegaso. E-mail: luca.bianchin@unipegaso.it.
[****] European University Cyprus. E-mail: m.mavrotheris@euc.a.cy.
[*****] Università Pegaso. E-mail: anna.dipace@unipegaso.it.
Although all the authors have contributed to the article, D. De Martino has written the §§ 1. Introduction and 5. Conclusions, F. Filosofi 2. Methods and 3.3. Population, L. Bianchin 3.5. Framework and dimensional competences, F. Filosofi and L. Bianchin jointly 3.1. Temporal distribution of studies and 3.4. Methodological Overview, M. Meletiou-Mavrotheris, 3.6. Competence clusters in relation to framework types and 4.1. Limitations, A. Dipace 3.2. Distribution by macro-geographical area and 4. Discussion.

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The scoping review responds to a need for a greater identification of the required new AI competences for student and teacher in an era of digital shifts caused by the disruptive technology of generative AI, linked to new opportunities but also risks (Castillo-Martínez et al., 2024). The individuation of these dimensions of competence is crucial in an age of profound transition.

Nowadays, a lustrum after the Emergency Remote Teaching (ERT) during Covid-19, there is a need for new frameworks that take into account the impact of AI in learning environments.

The spreading of the AI after the Covid-era is a new shocking and stressing change that undermines the didactic paradigms of teachers and students. The mass diffusion of the AI from late 2022 is a turning point of a new digital revolution that unexpectedly hit the entire educational world including the high education, putting in crisis consolidated paradigms. Until early 2022 the focus of the pedagogists, sociologists and tech experts was especially directed toward the "immersive technologies" (A-VR, Metaverse) in a scenario that appeared on the verge of a new pedagogical revolution (De Martino & Di Cataldo, 2023). But unexpectedly on 30th November 2022, the first release of the AI chatbot ChatGPT by Open AI became the starting point of a new and different from what expected revolution, comparable to the Gutenberg revolution and the digital internet era (Rousseau, 2023). Apart from the primary alphabetical literacy (skills of reading-writing-calculation) today a new digital AI literacy is perceived as pivotal for all the actors of the learning process.

In particular the classic Kansanen and Meri (1999) triangle "teacher-knowledge-learner", linked to the traditional learning frameworks, abruptly appeared obsolete because the AI has entered as a fourth element and has had the effect of putting into crisis consolidated teaching practices.

For instance, the cheating problem, yet questioned in the pandemic distance learning, raised new levels of concern~~s~~ (Nartgün & Kennedy, 2024) when AI started giving students the chance to obtain an entire essay or thesis from a prompt in just a few seconds. The unfair possibility for students to use the AI generative chatbots to substitute their own homework writing posed new pedagogical and ethical problems (Leaton Gray et al., 2025). Indeed, a written thesis isn't able to guarantee the development of critical thinking of the student anymore.

In this complex scenario the social impact of AI has led to polarization, citing the Umberto Eco's (2025) categories, between "apocalyptic" and "integrated" (Marzullo, 2025). There are those who apocalyptically see AI as the possible cause of the future end of the human teaching and those who see AI as the keystone of pedagogical innovation.

In accordance with this polarization, two main tendencies have emerged: the technophobic ban of AI in some universities and, at the opposite, the attempt to integrate this new technology in a framework that could be ethical and viable.

The current major problem is how to create a sustainable university able to promote the development of new competences for instance pushing metacognitive skills (Suryahadikusuma et al., 2024), enabling students to meta-reflect on the AI generated content.

An example of these attempts to create new AI literacy frameworks is the Critical Artificial Intelligence Literacy Scale, proposed by Ranieri (et al., 2025), a tool to measure AI literacy across the following four dimensions: knowledge-related, operational, critical and ethical ones.

To reach a paradigm change it is pivotal to explore the dimensions of competence of AI Literacy frameworks for higher education.

It is a question that involves both students and teachers: the teachers have to be able to promote the AI literacies and so to know and to be capable of assessing the new AI digital skills of the students.

On the other hand, also students need to have a clear vision of which are the skills related to generative AI to develop in the higher education courses. They live and will work in a world where AI is going to be more and more crucial in the workflows and in the professional procedures.

To sum up this scoping review aims to go into detail of the required renovation of higher education didactic frameworks due to AI. The main purpose is to verify if and how new frameworks are being developed to integrate the AI in university education in a sustainable way and in particular what are the dimensions of competence linked to AI literacy to be assessed.

The results could be useful to shed light also on new possible forms of assessments in educational contexts where AI became a technology impossible to ignore.

2. Method

2.1. Study design

This study was conducted as a scoping review following the methodological framework proposed by Arksey and O'Malley (2005) and further refined by Levac (Levac et al., 2010). The review process was reported according to the PRISMA guidelines (Liberati et al., 2009; Page et al., 2021). The aim of the review was to map and synthesize existing frameworks addressing AI literacy and AI competences in higher education.

The search was conducted on February 20, 2026. The Boolean search string was adapted to the syntax of each database: in Scopus, it was applied to the TITLE-ABS-KEY fields; in ERIC, to the default descriptor and abstract fields; and in PubMed, to Title/Abstract. Scopus was selected for its broad multidisciplinary coverage of peer-reviewed literature in education and technology; ERIC was included as the primary database for educational research; and PubMed was chosen to capture emerging AI literacy discussions in health professions education, an area increasingly integrated with higher education scholarship. Google Scholar was excluded due to limited algorithmic transparency and the difficulty of replicating search results, which may reduce methodological reliability in scoping reviews.

2.2. Search strategy

To identify relevant literature, a systematic search was conducted using a Boolean search string combining terms related to AI literacy and AI education with terms referring to frameworks, models, and taxonomies, together with references to higher education and competence-related concepts. The search string used was:

> ("AI literacy" OR "artificial intelligence literacy" OR "AI education") AND (framework* OR model* OR taxonom*) AND ("higher education" OR universit*) AND (competenc* OR skill*).

The search was carried out across three academic databases: Scopus, ERIC, and PubMed. The search was conducted in Scopus, ERIC, and PubMed because these databases provide extensive coverage of peer-reviewed literature in education, social sciences, and interdisciplinary research on technology and learning. Google Scholar was not included due to its limited transparency in search algorithms and the difficulty of replicating search results, which may reduce methodological reliability in systematic and scoping review studies.

Only studies published between January 2022 and February 2026 were considered, to capture the most recent developments in AI competence frameworks following the widespread diffusion of generative AI technologies. Search results were exported and compiled into a single dataset using reference management software.

2.3. Eligibility criteria

Studies were *included* if they met the following criteria:

a. published between 2022 and 2026;

b. written in English or Italian;
c. focused on the higher education context;
d. included a clear reference to AI competence dimensions or structured AI literacy frameworks;
e. available in full-text format.

Studies were *excluded* if they:

a. focused exclusively on primary or secondary education;
b. addressed general digital literacy without explicit reference to AI competences;
c. discussed AI in higher education without proposing or analysing a competence framework or structured dimension.

Editorials, opinion pieces, abstracts without accessible full text, conference summaries lacking sufficient methodological detail, and other non-scholarly publications were also excluded.

2.4. Screening and selection process

The screening followed the PRISMA workflow. A total of 355 records were identified (Scopus = 175, ERIC = 120, PubMed = 60). After removing 33 duplicates, 322 records were screened by title and abstract, leading to the exclusion of 258 records.

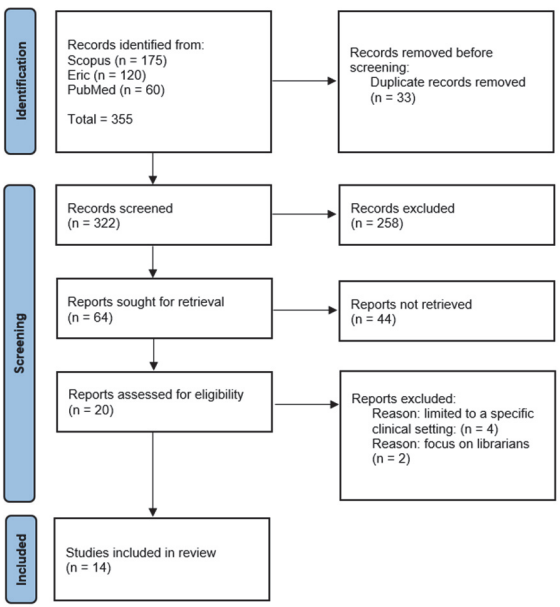

Fig. 1 - PRISMA diagram

Two researchers independently conducted the screening and coding processes. Discrepancies were resolved through discussion and consensus.

Sixty-four reports were sought for full-text review, but 44 weren't retrieved, leaving 20 studies assessed for eligibility. Of these, 6 were excluded (4 for highly specialized clinical focus, 2 for librarian-specific contexts).

Eventually, 14 studies were included. The small number reflects strict inclusion criteria, particularly the focus on structured AI literacy frameworks in higher education, as well as the emerging nature of the field.

Finally, competence dimensions from the selected frameworks were extracted and grouped through iterative coding, resulting in four main competence clusters.

The study selection process is illustrated in the PRISMA flow diagram (Fig. 1).

3. Results

3.1. Temporal distribution of studies

The temporal distribution of the selected studies shows a clearly uneven pattern (fig. 2), characterized by a strong concentration of publications in the most recent years. The earliest contribution in the dataset dates back to 2022 (1 article), followed by a modest increase in 2024 (2 articles). The most significant growth occurs in 2025, which represents the peak of the publication trend with 8 articles, accounting for the majority of the studies included in the review. In 2026, the number of publications decreases slightly to 3 articles, though the year may still be incomplete at the time of analysis.

Overall, the distribution shows a marked increase in publications in the most recent period.

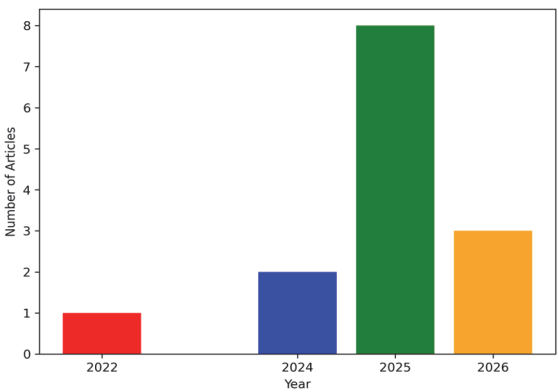

Fig. 2 - Articles by year

3.2. Distribution by macro-geographical area

The geographical distribution shows a predominance of European studies (6; 43%), suggesting a leading role of Europe. Asia and North America each contribute 3 studies (21%), indicating moderate engagement, while 2 studies (14%) are multi-country. Overall, research is Europe-centred but increasingly international, with growing global interest despite persistent regional disparities.

Tab. 1 - Distribution by macro-geographical area

Macro-area	**n.**	**Authors (year) - Country**
Europe	6	Oliveira et al. (2025) - Netherlands Laupichler et al. (2022) - Germany Zhou & Schofield (2024) - United Kingdom Malik (2025) - United Kingdom Lucas & Lioy (2025) - Austria / Czech Republic Hackl, Müller & Sailer (2026) - Germany
Asia	3	Wang et al. (2026) - China Yan et al. (2025) - Japan Hershkovitz et al. (2025) - Israel
North America	3	Hazari (2024) - United States Kennedy & Gupta (2025) - United States Petrova (2026) - Mexico
Multi-country	2	Asghar et al. (2025) - Bangladesh, China, Finland, Turkey Burneo-Arteaga et al. (2025) - Ecuador, Portugal, United States

3.3. Population

The analysis of the populations examined in the selected studies (Tab. 2) shows a clear distribution: out of 14 studies, 7 focus only on students (50%), 2 on teachers or educators (14.3%), and 5 on both groups (35.7%).

Overall, the distribution highlights a prevalence of student-centred research within the selected studies.

Tab. 2 - Population

Category	n.	Authors (year) - details
Only students	7	Wang et al. (2026) - Undergraduate students Oliveira et al. (2025) - Undergraduate and master's students Yan et al. (2025) - Undergraduate e graduate students Asghar et al. (2025) - Undergraduate e graduate students Hershkovitz et al. (2025) - Undergraduate e graduate students Hackl, Mueller & Sailer (2026) - Higher education students Hazari (2024) - College students
Only teachers/educators	2	Burneo-Arteaga et al. (2025) - Higher education teachers Petrova (2026) - Higher education experts/educators
Students and teachers	5	Laupichler et al. (2022) - Higher education learners; non-expert learners Zhou & Schofield (2024) - Higher education students and educators Kennedy & Gupta (2025) - Higher education students and educators (framework target) Malik (2025) - Higher education students and staff (framework target population) Lucas & Lioy (2025) - Students and teachers (framework target population)

3.4. Methodological Overview

The analysis reveals a diverse methodological landscape, including empirical, review, and conceptual studies. Empirical studies are the largest group (n = 6), spanning quantitative, qualitative, and mixed methods, mainly focused on validation and exploration of AI literacy frameworks. Two studies use literature reviews, while four are conceptual, reflecting the field's early stage. Two hybrid studies combine conceptual and empirical or review approaches. Overall, research remains largely conceptual, with empirical validation emerging more recently.

Tab. 3 - Methodological Overview

Category	n.	Authors (year)	Methodology
Empirical quantitative	2	Wang et al. (2026); Hershkovitz et al. (2025)	Surveys with statistical validation (e.g., factor analysis, correlations)

Empirical qualitative	2	Yan et al. (2025); Lucas & Lioy (2025)	Case study; document analysis with thematic/metaphor coding
Empirical mixed-method	2	Oliveira et al. (2025); Asghar et al. (2025)	DBR and cross-sectional mixed methods (stats + qualitative)
Review studies	2	Burneo-Arteaga et al. (2025); Laupichler et al. (2022)	Bibliometric + framework analysis; scoping review
Conceptual studies	4	Zhou & Schofield (2024); Hazari (2024); Kennedy & Gupta (2025); Malik (2025)	Theoretical framework development

3.5. Framework and dimensional competences

The analysis (Tab. 4) identified fourteen AI literacy frameworks in higher education, grouped into three types: new (n = 7), applied (n = 4), and mixed (n = 3). New frameworks propose original models to define AI competencies, while applied ones rely on existing models (e.g., UNESCO or knowledge-skills-attitudes). Mixed frameworks combine both approaches.

Across these frameworks, competence structures vary: some are concise, focusing on core skills such as understanding, using, evaluating, and ethically reflecting on AI; others are more articulated, including domains like technical knowledge, pedagogy, and responsible AI.

Despite these differences, common dimensions emerge: technical use of AI, critical evaluation of outputs, and ethical awareness (e.g., bias, privacy). Some models also emphasize human-AI collaboration.

Overall, the diversity of frameworks reflects a still heterogeneous understanding of AI literacy, with different emphases on technical, cognitive, ethical, and relational competences.

Tab. 4 - Framework and dimensional competences

Type	**Framework**	**Key Competencies**
New	Petrova (2026)	AI literacy; human-AI collaboration; equity; ethics
New	Burneo-Arteaga et al. (2025)	GenAI competencies (technical, pedagogical, ethical + soft skills)
New	Hackl et al. (2026)	Technical knowledge; application; critical thinking; ethics; social impact; integration; legal

New	Zhou & Schofield (2024)	Understand; use; create/evaluate AI; ethics
New	Hazari (2024)	Awareness; practical skills; application; ethics
New	Kennedy & Gupta (2025)	Technical & cognitive skills; ethics; collaboration; creativity (4 levels)
New	Malik (2025)	Human-AI interaction strategies
Applied	Wang et al. (2026)	Human-centered mindset; ethics; AI techniques; system design
Applied	Yan et al. (2025)	Knowledge; skills; attitudes
Applied	Lucas & Lioy (2025)	Roles of students, teachers, AI
Applied	Laupichler et al. (2022)	Understanding; using; evaluating AI; ethics
Mixed	Hershkovitz et al. (2025)	GenAI use; prompting; verification; ethics
Mixed	Oliveira et al. (2025)	Guided interaction; visible expertise
Mixed	Asghar et al. (2025)	AI literacy; collaboration; inclusive leadership

3.6. Competence clusters in relation to framework types

The distribution of competence clusters across the reviewed frameworks (Tab. 5) shows that all four clusters – technical-operational, critical-cognitive, ethical-regulatory, and human-AI relational/collaborative – are present, though with varying emphasis.

The technical-operational cluster is the most widespread, appearing across all framework types. It includes competences related to understanding, using, and applying AI tools, and represents a foundational component of AI literacy.

The critical-cognitive cluster is also widely represented, focusing on critical thinking, evaluation of AI outputs, and analytical engagement with AI.

The ethical-regulatory cluster appears in nearly all frameworks, highlighting the importance of ethical awareness, responsibility, and societal implications such as bias, accountability, and regulation.

The human-AI relational/collaborative cluster includes competences related to collaboration with AI, human agency, and leadership in AI-mediated contexts. It is especially emphasized in newer frameworks that view AI as a partner in learning.

Overall, these four clusters capture the key technical, cognitive, ethical, and relational dimensions of AI literacy in higher education.

Tab. 5 - Competence clusters in relation to framework types

Cluster	Type of framework	Authors
Technical-operational	New, Applied, Mixed new & applied	Wang (2026); Yan (2025); Laupichler et al. (2022); Hazari (2024); Zhou & Schofield (2024); Hershkovitz et al. (2025); Hackl, Müller & Sailer (2026); Burneo-Arteaga et al. (2025); Kennedy & Gupta (2025); Lucas & Lioy (2025)
Critical-cognitive	New, Applied, Mixed new & applied	Burneo-Arteaga et al. (2025); Hackl, Müller & Sailer (2026); Kennedy & Gupta (2025); Yan (2025); Laupichler et al. (2022); Hershkovitz et al. (2025); Oliveira et al. (2025); Lucas & Lioy (2025)
Ethical-regulatory	New, Applied, Mixed new & applied	Petrova (2026); Burneo-Arteaga et al. (2025); Hackl, Müller & Sailer (2026); Zhou & Schofield (2024); Hazari (2024); Wang (2026); Hershkovitz et al. (2025); Asghar et al. (2025); Yan (2025); Kennedy & Gupta (2025); Lucas & Lioy (2025)
Human-AI relational/collaborative	New, Mixed new & applied, Applied	Petrova (2026); Malik (2025); Kennedy & Gupta (2025); Burneo-Arteaga et al. (2025); Asghar et al. (2025); Yan (2025); Lucas & Lioy (2025); Oliveira et al. (2025); Hackl, Müller & Sailer (2026)

4. Discussion

The findings of this review offer a structured overview of how AI literacy competences are currently conceptualized in higher education. By mapping existing frameworks, clustering competence dimensions, and analyzing their distribution across framework types, the study identifies several key patterns in the development of the field.

First, the analysis confirms that AI literacy research remains highly framework-oriented and conceptually heterogeneous. A substantial number of studies propose new models rather than empirically validating existing ones, indicating that the field is still in a phase of theoretical development. At the same time, there is a coexistence of new, applied, and mixed frameworks, which reveals the absence of a consolidated framework. This has important implications for both research and practice. Without greater conceptual alignment, comparisons across studies remain difficult, assessment instruments risk measuring different constructs, and institutions may struggle to translate AI literacy into coherent curricular objectives. The current stage of development therefore calls less for further conceptual proliferation and more for efforts aimed at validation, standardization, and implementation across educational contexts. The recent increase in publications, particularly after 2022, is consistent with the rapid diffusion of generative AI tools and the growing institutional attention to AI-related competences in education.

The identification of four overarching competence domains suggests that the apparent fragmentation of AI literacy frameworks may be less substantial than it initially appears. While studies employ diverse terminologies and organizational structures, they tend to converge around a common set of educational concerns. This finding indicates that the current proliferation of frameworks may reflect differences in emphasis rather than fundamentally competing conceptualizations of AI literacy. In this sense, proliferation doesn't necessarily signal conceptual dispersion, but rather an ongoing process of refinement through which the field is progressively negotiating the scope and priorities of AI literacy in higher education.

A more detailed examination of the distribution of these clusters across framework types (Tab. 5) provides further insight. Technical-operational and ethical-regulatory competences appear consistently across all types of frameworks, suggesting that they constitute foundational dimensions of AI literacy. Critical-cognitive competences are also widely represented, reinforcing the importance of reflective and evaluative engagement with AI systems. In contrast, the human-AI relational cluster is more prominently associated with newly proposed frameworks, where AI is increasingly conceptualized not only as a tool but as an interactive partner in learning and knowledge production. This pattern indicates an emerging shift toward more relational and process-oriented understandings of AI literacy.

Additional patterns emerge from the broader mapping of the literature. The predominance of European contributions may be linked to recent regulatory and policy developments, such as the AI Act, which have increased attention to AI competences in educational contexts. At the same time, the analysis of target populations shows that research is still predominantly student-centred, with

comparatively limited focus on teachers and professional development. The methodological distribution of studies, which includes a mix of conceptual and empirical approaches, further suggests that the field is still consolidating its research designs and validation strategies.

Overall, these findings indicate that AI literacy is evolving from a predominantly technical skill set toward a multidimensional construct that integrates operational, cognitive, ethical, and relational competences. However, the absence of a consolidated model and the heterogeneity of existing frameworks suggest the need for future research to move beyond conceptual proliferation and focus more systematically on empirical validation, curricular implementation, and the long-term evaluation of AI literacy initiatives in higher education.

4.1. Limitations

This review has some limitations. The search was limited to three databases, which may not cover all relevant studies. The small number of included studies reflects the emerging nature of the field. In addition, the diversity of frameworks may affect the comparability of competence dimensions.

5. Conclusions

In conclusion, the results of this review contribute to clarifying the conceptual landscape of AI literacy by identifying recurring competence domains and highlighting the evolving orientation of the field. By organizing diverse competence dimensions into a coherent set of analytical clusters, the study offers a framework for comparing existing models and for guiding future research on AI literacy education in higher education contexts.

Going beyond the identification of the four competence clusters a wider consideration could be made to present a forward-looking perspective.

In a period of historical changings in the educational technology scenario of Ai literacy, we could observe a general trend that brings to a polarization. On one hand some authors seem to try to adapt an old framework, born in a traditional didactic epoch, to a renovated scenario, making an effort to expand the epistemological boundaries to embrace a new social context where Ai is changing the way to teach, to learn and to assess. Trusting in the adaptability of old-fashioned frameworks, some researchers are confident to add more specific clusters of competences to old paradigms. It is true also in specific technical areas such for instance the medical area.

On the other hand, other authors try to propose totally new frameworks starting from a sort of tabula rasa, in order to propose a completely new perspective on AI literacies.

The epistemological AI-evolution in some ways reflects the classical theory of scientific revolution of Thomas Kuhn (1962), who claimed that when an old scientific paradigm enters into crisis due to a new context, after a period to attempts to adapt the "anomalies" to old paradigm, a new revolution is close. Just in the current edge of a new AI digital revolution old frameworks appear in crisis and new emerging substitutive paradigms are trying to be built, but the effort to create new game changer Ai-literacy epistemologies until now may appear generally blurry and poor defined yet. Although the four clusters of AI literacy are undoubtedly interesting starting points, there could be space for a whole new epistemology that is capable of accounting the AI-literacy in higher education in all its profound and complex dimensions.

In this phase of transition between old and new paradigms, an interesting path in the attempts to create a new paradigm is the assumption by some authors of the metaphors as a new starting point to build new constructs (Lucas & Lioy, 2025).

The creative conceptual opening provided by rhetorical instruments of this typology could be the key to profoundly renew the status quo. The creative strength of the figurative language, closely linked to pedagogy science, could be a powerful tool for a truly innovative AI Act literacy pedagogy frameworks, that are capable of accounting for epochal, social and pedagogical changes, incomparable with the past in terms of pervasiveness and effectiveness.

These frameworks could lead to new concrete practises and guidelines for the proper use of AI in educational environment.

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