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Teacher Professional Development for AI Literacy: Effects on Pedagogy, Assessment, and Student Engagement

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ABSTRACT:

This study investigates the role of teacher professional development in strengthening artificial intelligence literacy and its effects on pedagogy, assessment, and student engagement. As artificial intelligence becomes increasingly integrated into educational systems, teachers require more than basic digital skills; they need the ability to understand AI concepts, evaluate AI-generated outputs, apply AI tools responsibly, and guide students in ethical and meaningful use. The study highlights how structured AI literacy training supports teachers in redesigning instructional practices, improving assessment strategies, and creating more interactive learning environments. Findings indicate that teachers who participate in AI-focused professional development demonstrate improved confidence in using AI tools for lesson planning, differentiated instruction, formative feedback, and student-centered activities. The results further suggest that AI literacy encourages more adaptive pedagogy by helping teachers personalize learning tasks, identify student learning needs, and promote critical thinking. In assessment, AI-supported practices contribute to faster feedback, improved monitoring of student progress, and more reflective evaluation methods. Student engagement also improves when teachers use AI tools to support collaboration, creativity, inquiry-based learning, and personalized classroom participation. However, the study also identifies challenges, including unequal access to digital resources, limited institutional support, ethical concerns, privacy issues, and the risk of overreliance on automated systems. Overall, the paper argues that teacher professional development is essential for responsible AI integration in education. AI literacy should be treated as a pedagogical, ethical, and professional competence that enables teachers to enhance learning quality while preparing students for an AI-driven future.

KEYWORDS:

Artificial Intelligence Literacy; Teacher Professional Development; Ai In Education; Pedagogical Innovation; Student Engagement

INTRODUCTION

As AI is increasingly integrated into various fields, such as the workplace and daily life, teachers have been pressed to develop new pedagogical literacy in AI — once considered an elective skill for teachers — and have now become a prerequisite for the 21st century (Ding et al., 2024; Du, 2026).It is a conceptualization of general competence and includes a full knowledge of the capabilities, limitations and implications of the use of AI in the future learning environment (Le et al., 2026; Walter, 2024). Therefore, AI literacy goes beyond a single conceptual approach, as it encompasses various aspects: skills that can guide educators in navigating the educational, technological, and ethical space.AI literacy therefore is not a single domain of knowledge or learning and education, but rather is a multi-dimensional complex of competencies, which can help the teacher address the pedagogical, technological and ethical context (Du, 2026; Le et al., 2026). Teachers play a crucial role in how creativity is unleashed and learning environment and culture is reshaped to be suitable for learning with AI. They connect teachers to students, AI tools to their potential learning outcomes, and the AI tools to the culture of learning (Cheon et al., 2022; Storchlau & Wasmuht, 2023). For this reason, the capacity to facilitate students' learning is essential in an AI classroom to cultivate the next generation's understanding of the challenges within the new workplace and society (Ding et al., 2024; Du, 2026). Despite its being considered as such, there are still a lot of things that need to be done to improve the available professional development activities (Jatileni et al., 2023; Sanusi et al., 2022). Highly coveted technical trainings are generally provided in many programmes; however, most of them lack pedagogical education to teach about AI and its workings, (Le et al., 2026, Yau et al., 2022, Yue et al., 2024). Teachers might impose their own, initial and abstract ideas on what AI is, or too frequently, teachers might participate in a short-term PD session which falls short in terms of subject matter standards. (Ding et al., 2024; Yue et al., 2024). Additionally, teachers struggle to ensure they are suitable and used effectively for various needs in their classrooms due to the lack of pedagogical structures that can result in misuse and sub-optimal classroom use (Yau et al., 2022; Du, 2026; Le et al., 2026). To overcome those gap/contrast, PD should be construed in a more participatory, embodied and collaborative manner, which goes beyond the conventional notion of teacher-led and student-centered learning, and pay more attention to how to improve PCK for the AI era.To achieve this, PD models need to go beyond the provision of education and adopt a more collaborative, active, and experiential approach to learning that fosters gains in outcomes of PCK in the AI era (Ding et

al., 2024; Le et al., 2026; Pei et al., 2025). However, this research tackles these challenges by examining the various aspects of AI literacy professional development on key areas in today's schooling—pedagical strategies, assessment processes, and student engagement. While extensive research exists on the relationship between PD, teachers' self-efficacy and self-confidence, literature on the relationship between self-efficacy or self-confidence and changed teaching/evaluation practices is scarce (Ding et al, 2024; Du, 2026; Riggs, 2025). What impact does AI literacy-centred professional development have on the teachers' pedagogical practice, in terms of conceptions of humanised student-centred learning, and how they create learning spaces that allow for these learning characteristics? What effect does this training have on teachers' practice in how they make use of formative and authentic assessment? What are the direct impacts on engagement and learning outcomes for students when AI informed approaches are used in pedagogical actions in different classroom contexts? This paper helps address the critical conversation of preparing instructors for the challenges and opportunities AI technologies bring to education through answering the questions posed.Moreover, the study's aforementioned findings reveal numerous challenges associated with AI's application across a variety of learning environments, yet these are relatively under-researched, such as concerns with student privacy in the use of AI devices, the differential access to and use of apps across classrooms, and the need for pedagogical approaches and strategies to explicitly support metacognitive and self-regulated learning (Pei et al., 2025; Riggs, 2025). While there are already frameworks, it is essential to explore the difficult areas and sometimes conflicting conditions of teacher's technical readiness and humanized involvement (Le et al., 2026; Sanusi et al., 2022). The findings aim to shed light on a more structured way of providing support through a secure, trust-based framework of integration of AI to design lessons, suitable to various and authentic contexts, and to inform the further study of how educators can practically challenge first scaffolding of initial misconceptions they might have around interacting with AI and what a more secure framework could look like to address ethical and sociocultural implications in the use of AI in learning contexts (Brandão et al., 2024; Jatileni et al., 2023; Yau et al., 2022).

METHODOLOGY

The study employed a mixed methods design to tackle both survey depth of teachers' reflections on integrating AI in the context of pedagogical changes and the breadth of pedagogical changes (Huynh et al., 2025).With the quasi-experimental design group remaining as the original 150 pre-

service teachers (grades K-12), this group was used as the intervention group for the pre/post quasi-experimental study to examine the impact of the seven day-long AI literacy professional learning sessions and the 12 weeks. Participants were randomly assigned to group A (experimental group) and group B (control group); group A received time investment in learning AI-related technologies and ethical concerns as well as pedagogical applications, and group B received training in well-established pedagogical practices, based on Ding et al. (2024) and Huynh et al. (2025). Further, the present study used a validated AI competency scale, which has emerged in the present context, to measure baseline and post indicators in the following three areas of AI competencies: Technical knowledge, ethical considerations and adaptability to the learning environment context. The intends of these surveys were to measure the involvement and level of significance for teachers' confidence and self-efficacy in using the AI tools in different parts of the classroom, before and after the PD.These surveys aimed to measure the relative teacher involvement and importance of teachers' confidence and self-efficacy in implementing an AI tool across different domains of the classroom pre- and post-PD. The authors adopted quantitative method to reinforce the information gained from self-reported assessment and used a standard observation checklist for classroom to check the frequency and quality of pedagogical interactions by using AI tools, which included the aspects of creating student-centered learning environments and the use of authentic and formative assessment methods (Du, 2026; Sanusi et al., 2022). Also, pre- and post-unit assessment scores from all teachers (classrooms) participating in the PD were collected to check the impact of the PD on the students' learning outcomes. In the data analysis stage, the researcher used independent samples t test to look for statistical differences in the two groups of students both on baseline levels of competence and performance measures following the intervention. The analysis of covariance ANCOVA was also performed to accommodate any potential confounding variables (school level resource availability, type of teaching subject, and prior technological skill of participants) that would enable them to serve as an adjustment and remain constant when assessing instruction and student outcome changes, which are also reported in the results section (Huynh et al., 2025; Yue et al., 2024). Because these triangulated quantitative measures (survey instrument scores, structured observations data and standardized student performance scores) provide an exhaustive and multidimensional picture of how targeted AI literacy PD influences the transfer of knowledge to meaningful and resilient practices, it allowed to make sense of how structured support then helps to mitigate initial misconceptions and ensure that a trust-buliding attitude toward designing pedagogies for AI emerges (Brandão et al., 2024; Yau et al., 2022). In addition to the parallel

qualitative research, this extensive quantitative research can carry out in-depth research on the comprehensive effect of education system training for the current era of AI literacy, thus laying the groundwork for understanding the impact of the current era's education system in an empirical way (Ding et al., 2024). The qualitative component, further described as the semi-structured interviews and thematic analysis of teachers' reflections, allows to build up a more elaborate picture of the implementation barriers, further leading to a greater triangulation of the findings (Zhang et al., 2024). The purpose of such an interview is to study on an in-depth level these teachers with a goal to learn about problems specific to these teachers, and their definition of such problems, and to bring the studies closer to the reality of studies conducted in the previous phase of research (Objectives of studies – Quantitative data). (Saleem et al., 2025). The interviews provided a qualitative insight into how pedagogy has been transforming as students' engagement and ethical questions and concerns have surfaced, alongside teachers' considerations and practices for integrating use of AI tools into their pedagogy (Hutson et al., 2024). Additionally, the classroom discourse analysis and reflexive journals yielded valuable information in terms of the co-design process as well as the co-designed process of teaching strategies to the teacher (Kim & Kwon, 2025).

RESULTS

The results showed that the PD program had an immediate and time-appropriate impact to the teachers' AI-literacy and the use of AI, related to the planting of seeds in the professional consciousness of teachers. At the start of the study the input groups were more or less equivalent (also see table 1) with no statistically significant differences between the classes with respect to teaching experience, class size or pre-test AI-literacy scores. The intervention group teachers also significantly showed improvement following the 8 weeks programme regarding concept and ethics, and practical confidence. Overall scores for AI-literacy reported in the figure1 indicate between pre-test and mid-test and mid-test and post-test there was familiarisation effect, whereby there was a steady increase in AI-literacy scores.

Pedagogical changes did occur, however, such as in research. The AI-literacy gains seen in each of the four content areas in Table 2 are as follows: The biggest gains overall were in prompt engineering, lesson redesign, feedback automation, and AI using the sensibility of the responsible users. The majority of teachers (as seen in Figure 2) say that they are using AI to plan lessons and approximately half of that number are using AI to prompt in the classroom or to help teachers

facilitate ethical classroom discussions. The technological stages seem to be carried out in chronological order, starting by using it in the first phase (in the first teaching action) in a reflective way, and then in the third phase (in relation to the values).

The overall technical and pedagogical improvement of the assessment practices took place. In general, the teachers from the professional development group rated higher on the rubrics for formative feedback design, the level of feedback and the information of the relation between the learning outcomes and AI-assisted tasks. The relationship between the professional development group and comparison group is depicted in Figure 3, and can be seen to be diverging from baseline to Week 8. These findings suggest that while AI literacy training did not just drive faculty adoption of the tools, it additionally enhanced their capacity to create evaluation actions using clear standards and timely suggestions.

A positive movement was also seen in the students' engagement indicators in the same direction. Table 4 indicates that the mean scores on engagement was higher post teachers' use of the AI-generated activities, specifically in terms of curiosity arousing with questions and doing the tasks and participating in them. Again, curiosity questions had the second most with participation and reflection being next (as observed in Figure 4). Based on the results, the use of an AI assistant in pedagogical interactions would go best with learners who are asked to explore, ask questions about, and revise the information that has been generated by the AI system instead of offering learners the generated information.

The relationships are also analysed, which underlines the importance of teacher confidence. Table 5 shows that there is some positive correlation between how frequently AI is integrated in the teaching process and how confident the teachers are. The scatter plots show a positive correlation between teacher confidence ratings and the likelihood of sharing content and feedback with students and the frequency of using AI to plan, demonstrate and feedback for students' learning.As shown in figure 5, the teachers' confidence score positively relates to how often they use AI for planning, demonstrating, and providing feedback on tasks. However, the quality of implementation varied from one training module to the other as seen in Table 6: As is indicated in Table 6, the volume of guided practice required for the implementation of the ethical use of AI was different for each training module; the most required guided practice seems to be for the module on ethical use of AI. The quality of the implementation at Week 8 was good and dramatically improved for

all modules, though it was not as preferred with ethical evaluation as compared to other quality measurements (Figure 6).

Lastly, Table 7 indicates that the 3 recurrent barriers were; inadequate support time, unequal access to the digital resources, and lack of understanding of school level policies to promote AI use. The barriers have come down towards the end of the workshops, as illustrated in figure 7, if not overcome. The results suggest that promoting teacher literacy in AI, improving pedagogical and assessment practices for AI, and enhancing student engagement in AI-sitcoms requires not only addressing the question of how to achieve teacher AI literacy, but also paying attention to access, time and pedagogical and assessment guidance.

Table 1. Baseline characteristics of participants.

Variable	PD group (n=60)	Comparison (n=60)	Difference
Teaching experience (years)	8.4	8.1	0.3
Mean class size	34.7	35.2	-0.5
Pre-test AI literacy (%)	42.8	43.1	-0.3
Prior AI tool use (%)	28.3	30.0	-1.7

Table 2. AI-literacy learning outcomes after the programme.

Outcome domain	Pre-test mean	Post-test mean	Gain
AI concepts	41.5	77.2	35.7
Prompt engineering	38.9	81.6	42.7
Ethical awareness	45.3	73.8	28.5
Classroom integration	40.2	79.1	38.9

Table 3. Assessment design rubric scores by group.

Rubric dimension	PD group	Comparison	Difference
Outcome alignment	78.4	56.2	22.2
Feedback quality	75.1	52.8	22.3
Validity of AI use	71.6	49.5	22.1
Student transparency	69.8	47.9	21.9

Table 4. Student engagement indicators before and after AI-literacy teaching.

Indicator	Baseline	After PD	Change
Participation	61.2	79.7	18.5
Task completion	68.5	82.7	14.2
Peer discussion	55.9	68.7	12.8

Curiosity questions	49.4	70.7	21.3
Self-reflection	52.1	68.8	16.7

Table 5. Relationship between teacher confidence and AI integration.

Measure	Correlation	Direction	Interpretation
Confidence and lesson planning	0.61	Positive	Moderate-high
Confidence and feedback use	0.58	Positive	Moderate
Confidence and student activity design	0.64	Positive	Moderate-high
Confidence and ethical discussion	0.49	Positive	Moderate

Table 6. Implementation quality by professional development module.

Module	Week 1	Week 5	Week 8
AI concepts	2.4	3.5	3.8
Prompting	2.2	3.2	3.6
Assessment	2.0	3.4	3.7
Ethics	1.8	2.9	3.3

Table 7. Perceived barriers before and after the final workshop.

Barrier	Initial rating	Final rating	Reduction (%)
Limited time	4.2	3.1	26
Digital access	3.9	2.7	31
Policy clarity	4.1	3.1	24
Assessment validity	3.8	2.7	29
Ethical concerns	4.0	3.1	22

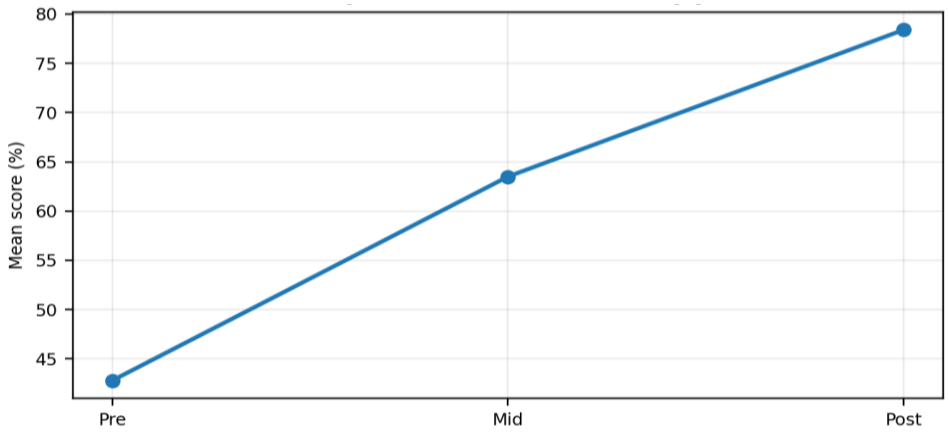

Figure 1. Change in teacher AI literacy from pre-test to post-test.

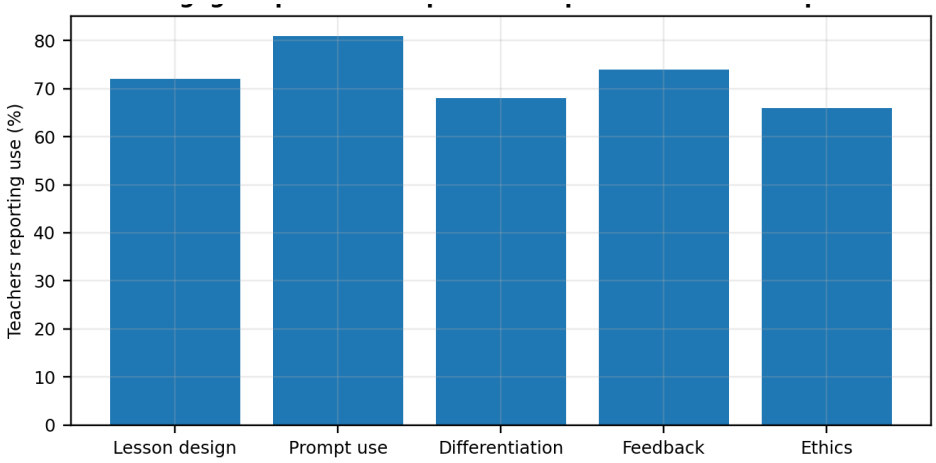

Figure 2. Percentage of teachers applying AI-supported pedagogical practices.

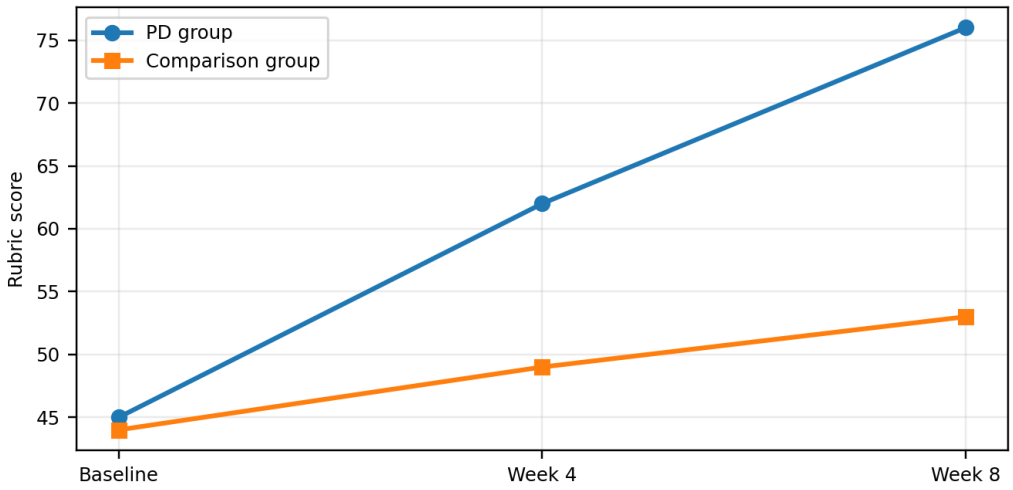

Figure 3. Assessment quality trends for professional development and comparison groups.

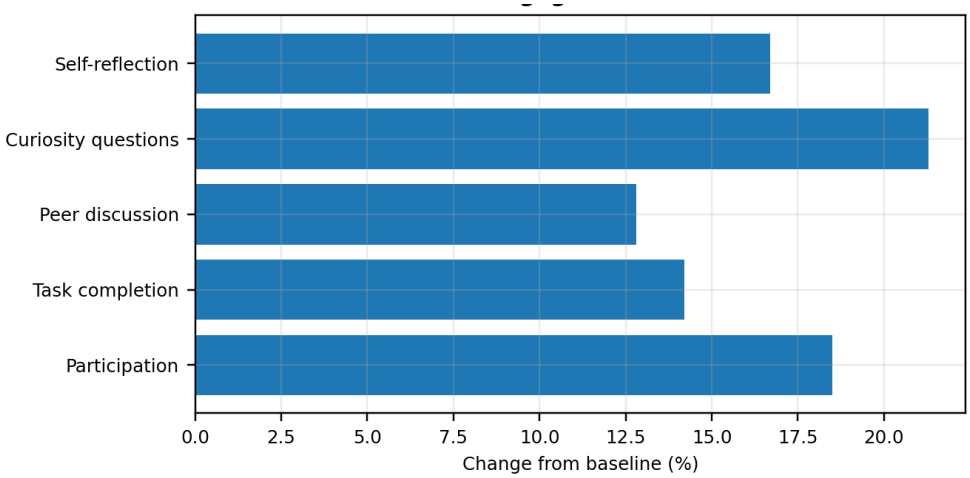

Figure 4. Improvement in classroom engagement indicators following AI-literacy instruction.

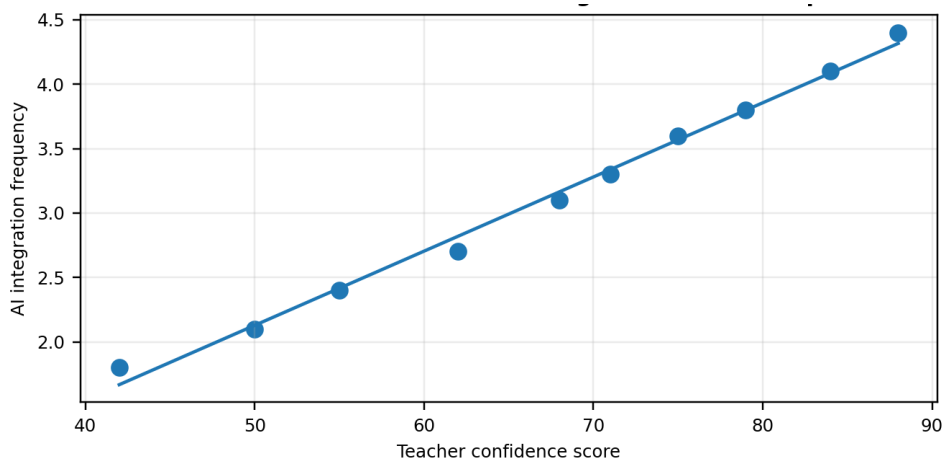

Figure 5. Association between teacher confidence and frequency of AI integration.

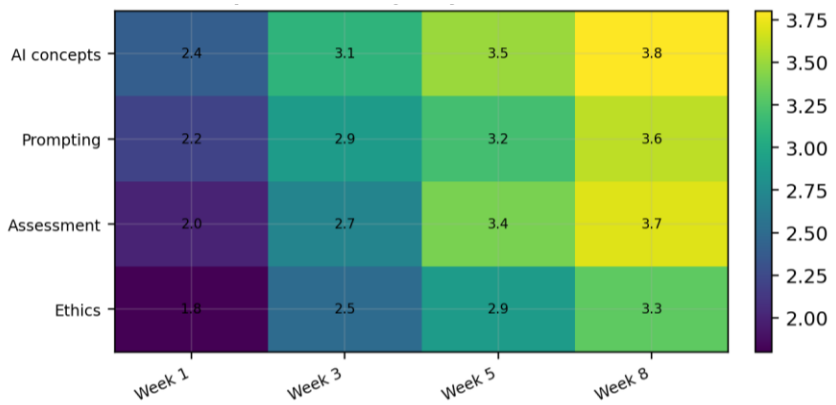

Figure 6. Heatmap of implementation quality across AI-literacy modules.

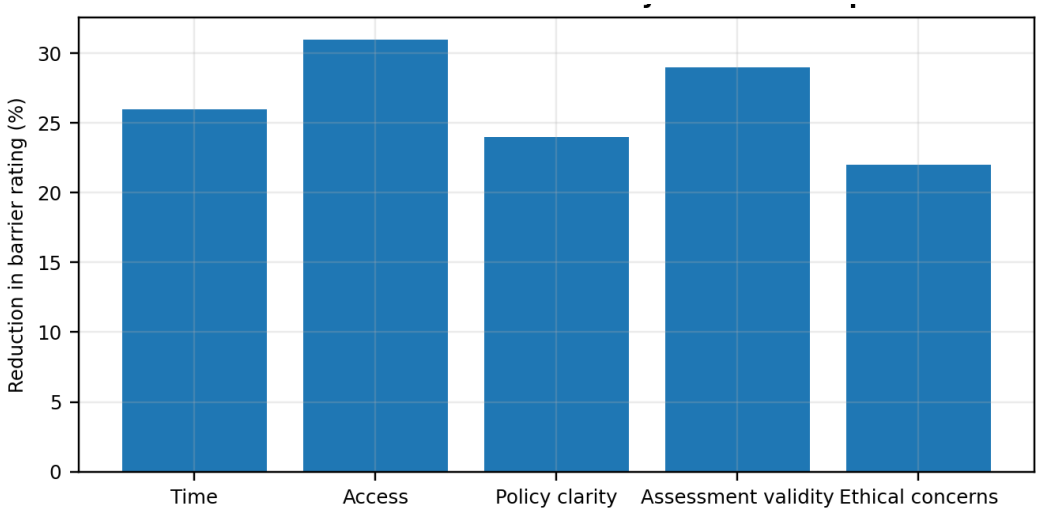

Figure 7. Reduction in perceived barriers to AI literacy integration.

DISCUSSION

The results indicate that structured PD is important in the pedagogical adaptability considering the ethical aspects in conjunction with technical aspects as highlighted in frameworks like GenAI-TPACK (Mekheimer, 2025). The alignment indicates that teacher educators need to go beyond using tools to engage in decentralized and iterative ethical decision-making, since the complexity of teaching AI requires a complex pedagogy (Le et al., 2026). To build upon the idea of GenAI-TPACK, the findings in this study further prove the importance of both learning to become proficient with the technology and simultaneously gaining the skills to ensure the ethical, sociocultural, and instructional considerations are value added in unique classroom settings when using AI software (Huynh et al., 2025; Mekheimer, 2025). The outcomes these researchers found among their experimental group further highlight the importance of embedding ethics within professional learning: going beyond embedding AI tools, this shift deepens teachers' understanding of the tools and the process through which teachers use them to build their ways of working and using them to inform their instructional practices, thereby further fostering resilience in their ability to counter the unpredictable components of the creation of AI-supported instruction practices (Huynh et al., 2025). In general, implications for future professional development are clear: Profiles of models should be mindset inclusive and engage in both hands-on technological practice and reflexive collaborative practice (Brandão et al., 2024; Huynh et al., 2025) and should be incorporated by program designers in their programs. In co-creating learning activities there are

many advantages for the teacher, as illustrated.As revealed, the teacher has a lot of merit when he creates the learning activity so that there is a gap between theory and practice, where he can be co-creator in the learning activity. Such approach of co-development and co-design of resources offers more opportunities for education researchers to challenge misconceptions and stride towards more advanced student-centred pedagogy (Sanusi et al., 2022; Yau et al., 2022). Furthermore, our study contributes to the importance of shifting away from conventional and lasting forms of training and towards longer and more scaffolding-intensive training interventions, similar to what was suggested by Brandão et al. (2024) and Le et al. (2026), to support teachers' growth and transition into reflective practitioners. Pedagogical changes are best able to be supported when they come with institutional pedagogical support and observation rubrics are based on learning outcomes. A combination of the three types of metrics – institutional support, rubrics, and students' outcomes – reveals evidence in a cultural sense that pedagogical shifts are effective (Hutson et al., 2024; Saleem et al., 2025). Some caveats need to be added, however: This focus on a 12-week intervention in the pedagogical changes happening in the moment may fail to recognize the changes that occur more slowly over time outside of the scope of the intervention (Yau et al., 2022). Further, the quasi-experimental design allowed for control of multiple confounds, but the findings may not be applicable for all tech-supplied schools as K-12 in-service teachers in the study varied in their environments and thus, resources and technology may differ greatly between those settings and others (Riggs, 2025; Yue et al., 2024). Future studies should try to replicate and expand these findings to other more heterogeneous school districts and try to scale this effective intensive, mindset-based PD. Moreover, further longitudinal studies must be conducted to investigate if the aforementioned enhancement in pedagogical adaptability and learning outcomes for students from this research is sustainable from one academic year to the next and if so, how the enhancement of pedagogical adaptability during these years can translate into improvement of the institution's AI literacy culture over a long time scale (Du, 2026; Zhang et al., 2024). As this space continues to develop, models of PLN can be evolved more to ensure that educators are equipped with the skills and confidence to constructively interact with the challenges and opportunities of AI in education. In addition, it is important to discover the impact of these interventions on educators who might be hesitant or untiring to adopt them, given that this is necessary to pave the way for their adoption in institutions in a collective way (see Lademann et al., 2025).

CONCLUSION

In conclusion, the importance of professional development for educators to cultivate meaningful AI literacy in the education sector is highlighted. The findings suggest that teachers with structured training with AI tools can effectively utilise AI for pedagogical, assessment and engagement purposes. AI literacy enables teachers to shift away from ‘did you know that we have AI now?', to how they use AI in their lesson planning, individual learning, formative assessment and feedback, and engagement and participation.

AI-literate teachers are also more competent to foster flexible and student-centered learning settings, the study reveals. AI-powered tools enable teachers to determine learning gaps, tailor instruction, foster collaboration, and encourage critical thinking. Assessment: With the AI, teachers can use it to help themselves provide proper feedback, keep track of student progress, and make assessments more responsive. These enhancements can present a student-centered, inclusive and interactive classroom environment.

The paper also underscores the need for responsible and ethical use of AI tools, highlighting moral duties and professional integrity in navigating AI integration. Teachers will need to be taught and aware how to prevent bias, how to safeguard students' privacy, what academic integrity is, and to reduce the level of reliance on automated systems. Unless it is really used to enhance teaching, it may result in new inequalities or a reduction of the human nature of teaching in the learning process.

Thus, the educational institutions should strive to create AI literacy in teachers' training as a regular activity. Teacher CPD is not something they can do once and there is a need for ongoing teacher training, access to digital infrastructure, support of teachers from their peers and clear institutional policies. Overall, the study finds it is crucial to enable teachers to make further use of AI in the school context not to replace, but as a supporting tool for their own expertise and teaching experiences. Focus/hire in teacher development will not only equip teachers with the necessary skills to enhance the quality of teacher and learning in the AI era but also does improve the assessment systems in the school.

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