The role of professional development in enhancing AI literacy competence development and participation in the Intelligence Age

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The role of professional development in enhancing AI literacy competence development in the Intelligence Age

Abstract

In the rapidly evolving digital landscape, Artificial Intelligence (AI) has become an essential tool for academic and professional growth. Over the past couple of years, the use of Generative Artificial Intelligence (GAI) in academia has been the subject of several debates, with discussions focusing on its ethical implications and how to use it to aid teaching and learning effectively. As GAI technologies become increasingly prevalent, raising awareness about their potential uses and establishing clear guidelines and best practices for their integration into academic settings is essential. Without proper understanding and frameworks in place, the misuse or over-reliance on these tools could undermine the educational goals they aim to support. Workshops and seminars play a critical role in addressing these concerns by not only informing educators and students about the capabilities and limitations of GAI but also equipping them to use these tools responsibly and effectively.

This paper reports on professional development efforts in AI literacy led by one of the authors. The findings from one of the series of workshops conducted across land-grant universities in the United States aimed at creating awareness and increasing student literacy on AI and its use in academia are presented. This study utilized a mixed-method evaluation design to assess the impact of professional development efforts for students in a land-grant, midwestern R1 US University. Data was collected using pre- and post-surveys for quantitative evaluation, and a Wilcoxon signed-rank test was performed. In addition, the post-survey contained open-ended questions designed to qualitatively explore the participants' perception of their experience during the workshop.

The author's professional development strategies for enhancing AI literacy and integrating AI into STEM education include AI panel conversations, workshop facilitation, webinars, and think tank conversations. The results from the mixed-method evaluation indicate that students who participated in the professional development initiatives experienced a significant increase in their knowledge of AI ethics and their self-efficacy in using AI tools. Overall, students expressed satisfaction with the workshops and reported greater awareness of AI tools for educational purposes. This study highlights the role of professional development as a sustainable model for improving the AI literacy of the current and future workforce.

Introduction

In this era of rapid technological advancements, Artificial Intelligence (AI) is transforming academic and professional landscapes, driving innovation across disciplines and sectors [1]. Engineering education, as a field that intersects deeply with technological evolution, stands at the forefront of integrating AI into pedagogy, research, and professional practice [2]. Generative AI (GAI) has emerged as a valuable tool, with the potential to enhance teaching and learning through automation, creativity, and personalized education [3]. However, the pervasive adoption of GAI technologies has also raised significant concerns regarding ethical implications, misuse, and the over-reliance on AI systems [4]. These challenges highlight the urgent need for fostering AI literacy among students and educators to ensure responsible and effective use of these technologies [5]. Despite widespread discussions about the promise of GAI, there remains a critical gap in practical frameworks and strategies for integrating AI literacy into engineering curricula [6]. Current approaches often lack the depth and structure required to address the dual objectives of ethical awareness and professional competence [7]. This paper addresses these gaps by reporting on professional development initiatives aimed at enhancing AI literacy through workshops and think tank discussions at land-grant universities in the United States [8]. By evaluating these initiatives using pre- and post-surveys, and participant reflections, the study provides actionable insights for designing equitable AI literacy resources [9], [10]. Studies like this have the potential to influence engineering education policies, bridge access gaps, and equip students and faculty with the skills needed to navigate the digital-intelligence transition [2], [11]. Additionally, this study contributes to the literature on the important role that professional development plays in the development of AI literacy skills in students. The following evaluation questions (EQ) were asked to assess the impact of the workshop:

> EQ1 (Quantitative Question) Do students' perceived AI ethic knowledge, self-efficacy, problem-solving with AI, and learning with AI improve as a result of participating in the professional development effort on AI?
>
> EQ2 (Qualitative Question) What are students' perceptions of the impact of the AI professional effort on their AI literacy skills?

Description of the AI Professional Development Effort

The professional development effort was a virtual symposium that was held for a student organization at a land-grant, midwestern R1 US University. The workshop titled "Intelligent Adoption of Generative Artificial Intelligence: Enhancing the Students' Competence for the Workforce" lasted for about 2 hours. The workshop focused on equipping students with the requisite AI literacy skills that can be leveraged to enhance their learning and research and, more importantly, prepare them for the workforce in this intelligent age. Students were introduced to numerous AI tools and how AI, when used as a tutor, enhances learning. They were discouraged from over-relying on AI tools and using AI tools just for getting results, as this may be harmful to their learning.

During the workshop, participants explored how generative AI can transform learning experiences when applied ethically and responsibly [12]. The facilitator emphasized key considerations such as bias, fairness, privacy, transparency, and accountability. Participants were instructed to pay

consider ethics, academic integrity, convergence, and data on which current generative AI tools are trained when using the tool. Some questions were posed to encourage critical thinking, such as examining the data used for AI training, the reliability of AI outputs, and strategies for fine-tuning AI tools. This reflective process aimed to help participants balance human judgment with AI assistance effectively.

Furthermore, the participants were introduced to Bloom's taxonomy as a framework for developing AI literacy [13], progressing from foundational knowledge acquisition to the creation of original work (See Figure 1). Practical sessions involved the use of resources like ChatGPT, Scholarly, Elicit, and Consensus as AI as a tutor and for aiding literature reviews and syntheses. Similar AI workshops have been held by the facilitator at his home institution and on a national level for the American Association for the Advancement of Science-Improving Undergraduate STEM Education Initiative AAAS-IUSE [14]. Other professional development mechanisms used by the author to enhance AI literacy and integrate AI into STEM education include AI panel conversations, webinars, and think tank conversations on achieving equitable AI education for all.

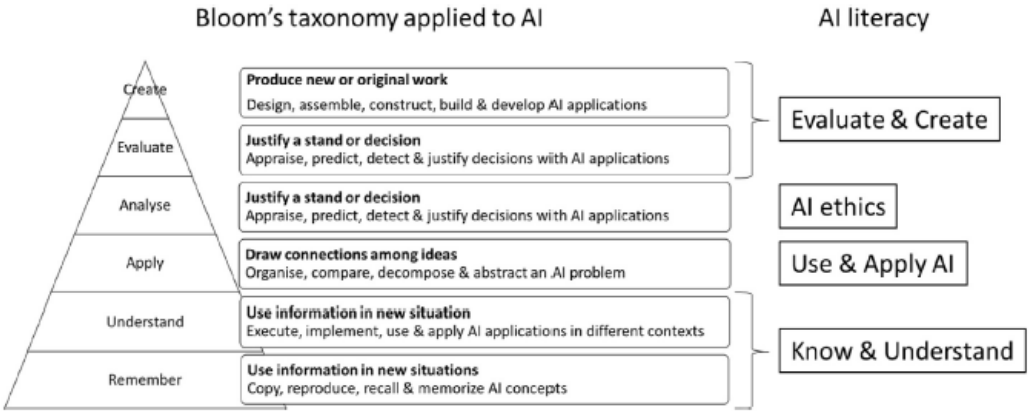

Figure 1: Bloom taxonomy framework for AI learning [13], [15]

Literature Review

The literature review section examines the current state of research on AI literacy and its integration into engineering education, emphasizing both its opportunities and challenges. It provides an overview of foundational concepts, explores the role of professional development programs in fostering AI literacy, and highlights key gaps in existing studies. By synthesizing insights from prior research, this review lays the groundwork for understanding how AI literacy initiatives can be effectively implemented in engineering education, with a focus on balancing technical proficiency with ethical awareness. The subsections that follow will discuss the significance of AI literacy, analyze professional development strategies, identify critical gaps in the literature, and conclude with the unique contributions of this study.

AI Literacy and Its Role in Engineering Education

AI literacy refers to the ability to understand, use, and evaluate AI tools effectively, as well as to critically assess their societal and ethical implications. Engineering education has increasingly

recognized the importance of AI literacy as a foundational skill, particularly in response to the rising demand for AI-integrated solutions in industry and academia. However, research indicates that many engineering programs lag in equipping students with the interdisciplinary knowledge required to apply AI responsibly [6], [16], [17], [18]. Initiatives such as workshops and professional development programs have shown promise in addressing this gap, but their effectiveness often depends on the depth of content and contextual relevance to participants' professional roles [2], [7].

Professional Development in AI Literacy

Professional development programs aimed at enhancing AI literacy typically include workshops, webinars, and panel discussions that focus on introducing participants to AI tools and their applications. Existing literature highlights the importance of tailoring these programs to address both technical and ethical dimensions of AI [5], [16], [19]. However, many initiatives lack mechanisms for assessing participants' growth in key areas such as AI ethics knowledge and self-efficacy skills. Moreover, there is limited research on how such programs can be scaled across diverse educational and geographic contexts, particularly in engineering disciplines where students must navigate complex ethical dilemmas related to technology deployment [7], [8]. The workshops reported in this study advance the existing body of work by not only focusing on technical competency but also emphasizing the ethical use of AI in academia. Unlike conventional training programs, these workshops incorporate think tank-style discussions and participant reflections, enabling deeper engagement with the societal implications of AI [20].

Significance of the Study

Several gaps in the current literature hinder the development of comprehensive AI literacy programs in engineering education. First, there is a lack of empirical studies assessing the impact of professional development efforts on participants' ethical reasoning and AI self-efficacy. While studies have explored the integration of AI into broader STEM education [2], [11], [16], few have examined its specific implications for engineering curricula. Second, existing frameworks often neglect the equity dimension [6]. Third, while the importance of AI ethics is widely acknowledged, there is insufficient focus on practical strategies for embedding ethical principles into the engineering design and problem-solving processes [5], [7]. The study contributes to the engineering education community by providing exemplary practice for evaluating professional development efforts. They also provide an educational opportunity for faculty and students who want to develop their AI literacy skills or hold similar professional development efforts in AI. Furthermore, it emphasizes the need for professional development efforts in preparing our workforce to be AI- competent users who can handle the tool responsibly and ethically.

Theoretical Framework: Technological Pedagogical Content Knowledge (TPACK) Framework

In framing this study, the Technological Pedagogical Content Knowledge (TPACK) Framework proposed by Mishra & Koehler [21] was utilized. This framework underscores the need for a balanced integration of technology, pedagogy, and content knowledge, crucial for fostering AI literacy among educators and students in the intelligence age [21]. When applied to AI literacy, it

expands to include AI ethics and AI self-efficacy as essential components for professional development, ensuring educators can critically evaluate and teach the societal implications of AI technologies [2]. It is important that faculty and students who use AI be aware of the ethical implications of using the tool [7].

Using TPACK as a framework for professional development on AI allows workshop facilitators to focus on preparing workshop activities to recognize biases in AI algorithms and ethical dilemmas regarding AI use while developing competency in the effective and responsible use of AI tools for educational purposes. It provides a framework for enhancing participants' self-efficacy as they engage in hands-on experiences with using AI tools for educational purposes and engage in reflective discussions on their capabilities and limitations [5], [16]. TPACK framework recommends that educators and students be prepared to use AI tools effectively and ethically. By fostering self-efficacy and ethical reasoning, the framework addresses both cognitive and affective dimensions of AI literacy, supporting technical competence, ethical awareness, and inclusivity in professional development programs aligned with the demands of the Intelligence Age.

Methodology

To evaluate the impact of the workshop on participants' AI literacy skill sets, a mixed-method evaluation design was utilized [22]. Specifically, a mixed-method survey containing both quantitative and qualitative questions was distributed before and after the workshop. The workshop lasted for about two hours. Twelve participants completed the pre- and post-surveys. Table 1 shows the survey questions that were administered during the survey. It should be noted that the AI literacy scale that was administered is a reliable and validated survey [13]. Also, not all sub-scales on the AI literacy scale were utilized. Only AI ethics and AI self-efficacy (AI problem solving and learning as sub-scales) were investigated. The survey is a 5-point Likert scale survey from "strongly disagree" to "strongly agree." For the qualitative section of the survey, the participants were asked three open-ended questions, including "What are your major takeaways from this professional development? What is one thing that you will do differently as a result of this workshop? Any feedback for the workshop facilitator? Evaluating the impact of professional development efforts has been recommended as best practice when undertaking professional development efforts [23].

Data Analysis and Result

Quantitative result

To quantitatively evaluate the impact of the AI professional development effort on the AI literacy skills of attendees, the Wilcoxon Signed Rank Test was conducted. The AI literacy skills that were evaluated are AI ethics knowledge and AI self-efficacy (see Table 1). The impact of the two sub-scales of the AI self-efficacy skill: problem-solving skills with AI and learning about AI, was also analyzed. We also conducted a normality test and descriptive analysis of our dataset.

Table 1: Some subscales of AI Literacy Scale [13]

Construct	Scale Items	Citation
AI Ethics	I can weigh the consequences of using AI for society. I can incorporate ethical considerations when deciding whether to use data provided by an AI. I can analyze AI-based applications for their ethical implications.	[24]
AI Self-efficacy		
AI Problem solving	I can rely on my skills in difficult situations when using AI. I can handle most problems in dealing with artificial intelligence well on my own. I can also usually solve strenuous and complicated tasks when working with artificial intelligence well.	[25]
Learning	I can keep up with the latest innovations in AI applications. Despite the rapid changes in the field of artificial intelligence, I can always keep up to date. Although there are often new AI applications, I manage to always be 'up-to-date.'	[13], [26], [27]

Normality

To check if our data fulfilled the normality assumption or not, we ran the Shapiro-Wilk test. In interpreting Shapiro-Wilk's results, a p-value greater than 0.05 indicates that our data fulfilled the normality assumption. Table 2 shows that all the data collected during the pre-survey on all the constructs: AI Ethics, AI Self -efficacy, AI problem-solving, and AI learning fulfilled normality assumptions. However, most of the data collected on our construct during the post-survey did not fulfill normality assumptions since their Shapiro-Wilk test p-values were less than 0.05. Only AI learning fulfilled the normality assumption with a p-value > 0.05. Based on our small sample size and most of our post-survey data being non-normal, we decided to take the more conservative approach of conducting non-parametric analysis for this study. Hence, the Wilcoxon Rank test was conducted. It should be noted that the author also conducted the parametric paired sample t-test; the interpretation of the outcome was the same for the non-parametric analysis conducted.

Descriptive

The results from the pre- and post-surveys demonstrate an increase in the average participants' perceptions across all AI-related constructs. Figure 2 summarizes the comparative results across the four constructs. Figure 2 and Table 2 show that there was an overall positive increase in students' perception of their AI ethics skills from before the AI professional development workshop (M = 9.25, SD = 3.52) to after the professional development effort (M = 13.67, SD = 1.30). Also, there was a positive increase in students' perception of their AI self-efficacy skills from before participating in the AI professional development workshop (M = 17.58, SD = 8.06) to after the professional development effort (M = 24.33, SD = 4.66). In addition, there was a positive

increase in students' perception of their problem-solving skills with AI from before participating in the AI professional development workshop (M = 8.58, SD = 4.46) to after the professional development effort (M = 12.50, SD = 2.11). Lastly, there was a positive increase in students' perception of their ability to learn about AI tools before participating in the AI professional development workshop from (M = 9.00, SD = 4.09), to after the professional development effort (M = 11.83, SD = 2.86).

Wilcoxon Signed Rank Test

The result of the Wilcoxon signed-rank test in Table 3 shows that there was a statistically significant increase in the students' AI ethics skills as a result of participating in the AI professional development efforts, z = 2.79, p = 0.005. The median score on AI ethics increased from (Md = 9.00) before the professional development effort to (Md = 14.00) after the professional development. The effect size (r = 0.57) shows that participating in the AI workshop largely improved students' perception of their AI ethics knowledge.

Also, the result of the Wilcoxon signed-rank test in Table 3 shows that there was a statistically significant increase in the students' AI self-efficacy because of participating in the AI professional development efforts, z = 2.28, p = 0.023. The median score on AI self-efficacy increased from (Md = 16.50) before the professional development effort to (Md = 25.00) after the professional development. The effect size (r = 0.47) shows that participating in the AI workshop largely improved students' perception of their AI self-efficacy.

Additionally, our analysis recorded a statistically significant increase in the students' AI problem-solving skills because of participating in the AI professional development efforts, z = 2.41, p = 0.016. The median score on AI problem solving increased from (Md = 8.00) before the professional development effort to (Md = 13.00) after professional development. The effect size (r = 0.49) shows that participating in the AI workshop largely improved students' perception of their AI problem-solving skillset.

Lastly, the result revealed a statistically significant increase in the students' perception of their ability to learn about AI tools because of participating in the AI professional development efforts, z = 1.96, p = 0.050. The median score on students' perception of their ability to learn about AI tools increased from (Md = 8.00) before the professional development effort to (Md = 12.00) after professional development. The effect size (r = 0.40) shows that participating in the AI workshop moderately improved students' perception of their ability to learn about AI tools.

Table 2: Descriptive and Normality Test

	Pre-survey				Post-survey			
	M	**Md**	**SD**	**Shapiro-Wilk (P)**	**M**	**Md**	**SD**	**Shapiro-Wilk (P)**
AI Ethics	9.25	9.00	3.52	0.980	13.67	14.00	1.30	0.006
AI Self-efficacy	17.58	16.50	8.06	0.498	24.33	25.00	4.66	0.038
AI Problem Solving	8.58	8.00	4.46	0.232	12.50	13.00	2.11	0.031
AI Learning	9.00	8.00	4.09	0.282	11.83	12.00	2.86	0.055

Table 3: Wilcoxon Signed Rank Test Summary T-test

	Test Statistic	**Standard Error**	**Standardized Test Statistic (Z)**	**P Value (2-sided test)**	**Effect Size (r)**
AI Ethics	74.50	12.72	2.79	0.005	0.57
AI Self-Efficacy	68.00	12.72	2.28	0.023	0.47
AI Problem Solving	60.00	11.23	2.41	0.016	0.49
AI Learning	64.00	12.73	1.96	0.050	0.40

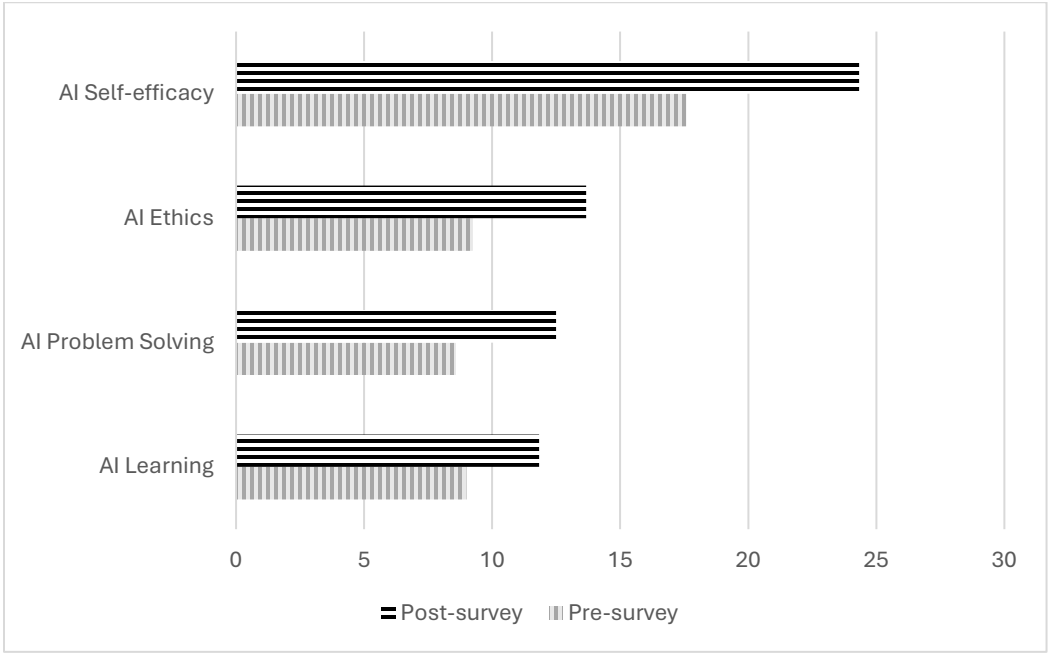

Figure 2: Comparison of pre-survey and post-survey scores across AI constructs: AI Self-efficacy, AI Ethics, AI Problem Solving, and AI Learning.

Qualitative result

Participants' responses to the open-ended items on the survey were thematically analyzed. The themes from the participants' responses are as follows:

1. **Increased Awareness about Available AI tools**

   About half of the participants noted that their awareness of the various AI tools that are available for educational purposes increased as a result of the professional development effort. One student mentioned, *"By attending this workshop, I gained insights into available AI tools."* Another said, *"Understanding the vast artificial intelligence AI resources available is key."*. Another participant noted, *"There are numerous AI tools available at our disposal, and it's better to jump on the train than be left behind."*

2. **Ethical and responsible use of AI**

   The majority of the participants in the AI professional development workshop emphasized how the workshop positioned them to better use AI tools responsibly and ethically. One participant noted, *"I think AI will improve the workplace, but we have to be careful about how we use it. We need to make sure that AI is used ethically and responsibly."* When asked, what is one thing that you will do differently because of this workshop? About three of the 12 participants responded verbatim that they will use AI more ethically going forward. Quoting one of them, *"I'll use AI tools more ethically."*

3. **Effective and personalized use of AI tools**

   Participants' responses showed that they were equipped with skills in the effective utilization of AI for educational purposes. One participant responded, *"I now know how to better use AI to learn in my field."* One student said, "AI can make me work smarter...while still maintaining originality." Another related *"I will be more personal in my use of AI and train my AI to work for me."* In addition, students appreciated that the workshop was eye-opening for them as regards the limitations of AI tools, especially with their tendency to converge. One student noted, *"I am aware of the limitation of AI in research as AI may be convergent in nature."* Other students related that since they are now aware of the limitations of AI for research, they would overcome this limitation by exploring more deeply and making more conscious effort in maintaining a divergent view when conducting research. *"I will be more divergent in my AI use, taking note of how convergent it may be."* Another student noted "I will be doing research better as I know more options now.

4. **Overall Satisfaction and Positive Feedback**

   Overall, the participants noted the workshop had an overall positive impact on their AI literacy skill development. The survey showed they were satisfied with the workshop. Below are some of their responses:

   "The facilitator demonstrated adequate knowledge on the subject matter, and this was the most engaging virtual symposium I'd ever been on, he sure is an instructor to instructors like he said." "Super interactive session. Great job." "Love that it was very interactive."

   "The symposium was very engaging. I also learnt about new tools I didn't know existed. Thank you for sharing."

Discussion

This study highlights the important role that professional development workshops play in enhancing students' AI literacy. These workshops helped students better understand, use, and evaluate AI tools effectively, while also enabling them to assess the societal and ethical implications of these technologies critically. AI can be daunting given the evolving number of AI tools in the marketplace. The professional development program helped students broaden their awareness of AI tools and their abilities to use them in educational programs. This resulted in an overall positive increase in students' perceptions of their ability to learn about AI tools and students' AI self-efficacy. This is valuable, since AI is evolving, there is a need for students to engage with continuing professional development about AI, and its use in their education during and beyond undergraduate studies. With a higher self-efficacy in AI and their ability to learn, students are more likely to engage in lifelong learning in AI [28].

This study also shows that professional development programs significantly improve students' problem-solving skills with AI. Problem-solving is a key skill required in engineering (ABET) [29], and having a tool to assist engineers in solving problems in various contexts can aid undergraduates in being successful not only during their studies but also in their careers as engineers [28]. Ethics is known to be a critical aspect that is not only required in the engineering profession internationally [30] but also defines the landscape for using AI. The professional development program has improved student perceptions of AI ethics knowledge and skills. This improvement helps students better understand how AI is used and also assists them to become more aware of the ethical implications of using AI. This also contributes to the larger conversation of AI and ethics in the context of engineering education and engineering practice [31], [32].

Implication of research to engineering education (Make this part of discussion).

The implications of this study are multifaceted, highlighting the need for a comprehensive approach to integrating AI literacy into engineering education. Firstly, the significant improvements in students' AI ethics knowledge and self-efficacy suggest that professional development programs should be prioritized in the higher institutions of learning. Such effort ensures that both educators and students are equipped with the necessary skills to navigate ethical dilemmas associated with AI technologies. Secondly, the findings advocate for the incorporation of hands-on workshops and reflective discussions within educational frameworks, fostering an environment where students can critically engage with AI tools while understanding their societal impacts. Finally, it is recommended that the educational institutions prioritize AI literacy development of their students. This ultimately will result in AI competency development in better preparing students for the workforce.

Limitation

The data analysis for this study is based on self-reported data from twelve students. We acknowledge that the limited number of participants who completed both the pre- and post-surveys may constrain the statistical power of the study, thereby reducing its ability to detect significant

differences. However, to mitigate this sample size limitation, a non-parametric test was conducted. It should be noted that despite this small sample, and using a more conservative non-parametric approach, we were still able to detect a significant difference between pre- and post-test scores on all our constructs. Despite this limitation, this study provides us with insights into the importance of professional development in AI competence development.

Conclusion

This paper shows the important role that professional development plays in the effort to prepare a workforce that possesses the requisite AI literacy and competent skills to drive the industry and economic force of the United States. The study underscores the critical importance of professional development in enhancing AI literacy among students in higher education. By implementing targeted workshops and discussions, participants demonstrated significant improvements in their understanding of AI ethics, self-efficacy, problem-solving skills, and overall ability to learn about AI tools. The significant outcome observed in this study suggests that theory-driven professional development efforts can lead to a meaningful increase in students' AI competencies. These findings highlight the necessity for ongoing professional development initiatives that not only equip students with technical AI competencies but also foster ethical awareness and responsible use of AI technologies. As the landscape of AI continues to evolve, such educational efforts are essential in preparing students to meet the challenges and opportunities presented by artificial intelligence. This work lays the groundwork for scaling such professional development efforts and provides a replicable model that can inform national and global efforts to increase AI literacy in higher education.

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