Volume 26, Number 2: Summer 2025
ISSN: 1535-0975

Pre-Service Teacher Education in the Age of AI: Exploring Knowledge, Attitudes, and Classroom Integration Strategies

Dr. Jillian R. Powers
Florida Atlantic University
jrpowers@fau.edu

Dr. Ann Musgrove
Florida Atlantic University
musgrove@fau.edu

Dr. Mohammad Azhar
BMCC, CUNY
mazhar@bmcc.cuny.edu

Walter Milner, M.A., M.Ed.
Nova Southeastern University
wmilner@nova.edu

Abstract

This mixed-methods study investigates the impact of an instructional module that integrated artificial intelligence (AI) into pre-service teacher education. The study participants included 93 undergraduate teacher education students taking an introductory instructional technology course at a large university in Florida, United States. The study examined changes in pre-service teachers' (PSTs) knowledge and attitudes toward AI after participation in the instructional module. Also, it explores PSTs perceptions about using AI in their future classrooms and the strategies they propose for incorporating AI into teaching. Pre- and post-test surveys were utilized to collect the data, and paired t-tests confirmed significant changes in self-reported knowledge, attitudes, and comfort in using AI in future classrooms. Qualitative findings based on open-ended survey responses reveal that PSTs commonly explain AI as computers mimicking human intelligence, emphasizing machine learning, problem-solving, and recognizing AI as a classroom tool. The findings have implications for teacher practice, highlighting the importance of targeted educational interventions to enhance PSTs' understanding and preparedness to integrate AI into the academic landscape.

Keywords*: artificial intelligence, curriculum integration, instructional strategies, teacher education*.

Introduction

Artificial Intelligence (AI) is rapidly transforming education and has the potential to revolutionize teaching and learning practices. Research suggests AI has the potential to make a positive impact on students and teachers; for example, teachers can utilize AI to personalize the learning process, match it to students' needs and learning styles, simplify administrative tasks, save time to focus more on the creative and critical aspects, and provide real-time feedback on student performance (Younis, 2024). At the same time, AI is disrupting educational settings, making it almost

impossible to discern carefully constructed AI papers from student-created papers. As AI continues evolving and becoming an integral part of education, its influence sparks concerns and opportunities. Plagiarism is often a focus when discussing the use of AI in education. However, Spector (2023), using Stanford survey data, found no significant increase in student cheating since GenAI became widely available.

As educators strive to prepare students for the demands of the digital age, it becomes crucial for pre-service teachers (PSTs) to develop knowledge of AI and incorporate it into the classroom. However, the successful implementation of AI hinges upon educators' knowledge, readiness, and ability to leverage its potential effectively. This mixed-methods study investigated the impact of integrating AI into instruction on PSTs' knowledge, attitudes, and strategies related to AI in their future classrooms. PSTs, being at the threshold of their teaching careers, provide a unique perspective on incorporating AI into classroom practices. As such, the research presented here can help PST educators gain insights into the current state of AI literacy among PSTs and identify areas for instructional improvement.

Literature and Background

Artificial intelligence has served a dual role in education, one as a teaching/learning tool and another as a subject matter to be taught and experienced. Researchers and education technology advocates have long been speculating about how AI may shape the future of K-12 education, including ways AI may shape classroom instruction, the role of the teacher, and how students learn (Murphy, 2019). More recently, the introduction of freely available generative AI tools sparked widespread discussion over how AI will impact the future of teaching and learning. With the rapid expansion of available AI tools, teachers need to be educated on what they are and how to use these evolving tools themselves. In the following literature review, we discuss AI as a tool for teaching and learning, how it is being integrated into the K-12 curriculum, and AI in teacher education.

AI as a Tool for Teaching and Learning

Some of the earliest examples of using AI as an educational tool were intelligent tutoring systems (ITSs). These tutoring systems are a type of rule-based expert system that "mimic the decision-making ability of human experts" and can help teachers meet diverse student needs through individualized learning activities (Murphy, 2019, p. 3). Furthermore, Murphy noted that for subjects such as math, physics, language, and literacy, ITS-based instruction resulted in higher test scores than traditional learning formats and learning results similar to one-on-one tutoring and small-group instruction.

Robots are another example of how AI can be used as a teaching tool, as they offer the possibility for individualization and adaptation to student needs (Hrastinski et al., 2019). Specifically, educational robots have been successfully employed in classrooms to teach computational thinking (Powers et al., 2020) and AI concepts (Sklar et al., 2007). Sklar et al. also note that instructors have used robotics-inspired projects to teach AI and robotics courses.

In a study by Holstein et al. (2019), researchers used a participatory speed dating approach, where students and teachers were rapidly given hypothetical scenarios to respond to with immediate reactions. The researchers examined what teachers and students see as the role of human versus AI instruction (Holstein et al., 2019). The data was then synthesized from the transcriptions of the reactions. While the research looked both at what participants preferred and did not prefer in AI-enhanced classrooms, teachers showed a preference for AI capabilities such as real-time feedback to determine if their student comments were constructive, ranking students by a need for teacher help, and invisible hand raises, among others (Holstein et al., 2019).

Concerning the teacher's role, AI's goal is not to replace teachers but rather to help them do their jobs better and more efficiently (Bryant et al., 2020). The McKinsey Global Institute's 2018 Report suggests that 20 to 40% of teachers' time on activities can be automated using currently available technology (Bryant et al., 2020). Moreover, this research also showed that work hours have grown, yet teachers spend less time in direct instruction and have more time for preparation, evaluation, and administrative duties (Bryant et al., 2020). AI could enhance teacher productivity by taking on some of these activities, allowing them to focus more on student instruction. AI can also aid teachers in instruction by freeing them from the burden of possessing all knowledge and information, shifting to a support role, and guiding students in discussions and collaborative processes (Roll & Wylie, 2016).

At a symposium hosted by Mid Sweden University, teachers expressed various concerns and attitudes about their evolving roles in K-12 classrooms amidst the integration of AI in education (Hrastinski et al., 2019). These included teachers' concerns about their future roles in the K-12 classroom. At the same time, teachers expected that AI education would make individualized teaching easier, function as a digital assistant, and be a resource to provide opportunities for students who need more information at school. Teachers also saw the potential for AI education to simplify the work in the classroom. Regarding educational robots, a key focus of the discussions was the relationship between educational robots, teachers, and students (Hrastinski et al., 2019).

AI in the Curriculum

Globally, efforts to expand computer science education, including teaching AI concepts in K-12 education, are quickly growing (Touretzky et al., 2019). China, for example, has mandated that all high school students learn about artificial intelligence (Jing, 2018). In Australia, AI researchers have collaborated with K-6 teachers to provide a curriculum covering basic AI concepts and vocabulary (Heinze et al., 2010). In the United States, private companies and various associations and organizations have supported and encouraged students to learn computer science throughout their K-12 education (Touretzky et al., 2019). In 2018, the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA), along with the nonprofit AI4ALL, developed a joint initiative called "AI for K-12" led by Professor David Touretsky to create national guidelines for teaching K-12 students about AI, machine learning, and robotics based on CSTA's national standards for K-12 computing education AI4ALL Team, 2018). The group is also working to provide online resources for teachers to find materials, software, and lesson plans and to deliver free workshops directly to teachers (AI4ALL Team, 2018; AAAI, 2018).

The International Society for Technology in Education [ISTE] is known for creating educational standards for teacher educators. In 2023, ISTE merged with the Association for Supervision and Curriculum Development (ASCD) to form a new education nonprofit organization. Consequently, the ISTE standards were updated to incorporate AI, and the question of how best to combine the strengths of human and AI instruction received increased attention. The white paper Evolving Teacher Education in an AI World (ISTE, 2024a) stresses the urgency and importance of integrating AI into the current classroom and teacher preparation programs. ISTE also offers many curricular resources for using AI in education (ISTE, 2024b). These resources include lesson ideas, videos, podcasts, blogs, and online courses.

In articulating what every child should know about AI, Touretzky et al. (2019) suggested teaching five "big ideas" about AI to K-12 students, with increasing levels of complexity based on grade level. These big ideas are:

1. Computers perceive the world using sensors. Students should understand that computers "see" and "hear" information. They should know how to interact, modify, create, and show the limitations of voice-based and vision-based computer applications.
2. Agents maintain models/representations of the world and use them for reasoning. Students should understand that computers construct representations using data. They should know how to examine and create these representations with increasing levels of complexity as they progress through the grade levels.
3. Computers can learn from data. Students should understand that "machine learning is a kind of statistical inference that finds patterns in data" (Touretzky et al., 2019, p. 9797). They should experience, modify, measure, and code machine-learning applications.
4. Making agents interact comfortably with humans is a substantial challenge for AI developers. Students should understand that it is difficult for computers to understand and interact with humans at even a child's level (Touretzky et al., 2019, p. 9798). They should recognize these challenges in creating and understanding language and eventually learn to work with language processing and sentiment analysis tools.
5. AI applications can impact society in both positive and negative ways. Students should understand how AI contributes to their lives, identify the ethical and societal impacts of AI, and be able to evaluate the impact of AI applications critically.

In summary, these five "big ideas" provide a comprehensive framework for introducing K-12 students to the fundamental concepts of AI, paving the way for a more AI-literate generation.

Companies such as Google and Microsoft have also aided the expansion of AI curricula (Touretzky et al., 2019). For example, ISTE and General Motors partnered to develop AI guides for elementary, secondary, elective, and computer science educators and an AI ethics guide (ISTE, 2024b). AI4ALL has received a large grant from Google to develop an AI curriculum (AI4ALL Team, 2018). Further, various AI software tools have been developed and made available to younger students (Touretzky et al., 2019). There are also nonprofits such as Code.org, which is supported by various corporations and provides K-12 computer science curriculum to schools while increasing diversity and access to computer science education (Code.org, 2024). Other

curricula expose students to robotics as a component of AI and machine learning and prepare them for the future (Zimmerman, 2018). The term "robot" can cover different phenomena, from software expert systems to autonomous physical robots (Serholt et al., 2017). LEGO robotics, for example, has been used to improve students' computational thinking skills (Shute et al., 2017). The representation of code through robotics helps students understand abstraction, an important component of computational thinking (Adler & Beck, 2020). Working with educational robots can also help enhance students' cognitive and social skills (Ioannou & Makridou, 2018). As educational applications of AI in the classroom continue to grow, researchers are investigating how AI and ChatGPT may be utilized in educational settings to help teachers and students while ensuring responsible and ethical use (Adiguzel et al., 2023).

Few efforts have been made to involve teachers as AI curricula designers (Zhou et al., 2020). Implementing technology and software and training teachers to adapt to it can be difficult (Bryant et al., 2020). Information garnered from group discussions at the symposium on Digitalization, Education, and Design: The Role of the Teacher reflects some of these concerns. One of the most common themes in the discussions about AI education was teacher knowledge and professional development (Hrastinski et al., 2019). Comments focused on the need for knowledge about AI education and how to use AI education in the K -12 classroom (Hrastinski et al., 2019).

AI in Teacher Education

Research suggests a substantial need for professional development if AI education is to be integrated into K-12 classrooms for teaching and learning (Hrastinski et al., 2019). Many teachers need help to imagine how to use AI education in the classroom because they express a limited understanding of AI (Hrastinski et al., 2019). This may be attributed to the limited curriculum for teaching AI literacy and the fact that teachers often need more experience teaching AI (Zhou et al., 2020). There is also a need for more robotics teaching materials for K-12 educators (Mataric, 2004). Teachers know little about what AI is, what educational robots are, or how they can be used in the classroom (Hrastinski et al., 2019). More K-12 teachers need to be trained in computer science or computational thinking, which could be helped with effective pre-service training (Mason & Rich, 2019). A lack of knowledge in content, technology, or pedagogy could lead to barriers to teachers' understanding of computing concepts (Mason & Rich, 2019), and there is a need for more knowledge about digital technologies and how they may be used (Hrastinski et al., 2019).

Digital competencies can provide teachers with a practical framework for learning how to use digital technologies in a way that seamlessly connects technology, pedagogy, and content (Hrastinski et al., 2019). One of the foundational concepts of technology integration is the Technological, Pedagogical, and Content Knowledge (TPACK) framework. TPACK is an extension of Shulman's (1987) concept that pedagogical content knowledge should be integrated with technology into the practice of teaching. TPACK describes "an understanding that emerges from an interaction of content, pedagogy, and technology" (Koehler & Mishra, 2009, p.17). Recent studies have focused on applying the TPACK Model to AI. Mishra et al. (2023) highlight the qualities of generative AI that make it like other digital technologies, which are often protean, opaque, and unstable. However, they also note that it is revolutionary because it is generative and

socially based. These researchers go on to discuss how generative AI changes many basic educational elements, including basic assessments.

Recently, a few studies have examined the integration of AI education in teacher training for both in-service and pre-service educators. Regarding AI knowledge, research indicates that both pre-service and in-service teachers often possess a limited amount, which can impede their ability to integrate AI into their instructional practices effectively (Ayanwale et al., 2024; Celik, 2023; Yue et al., 2024). This knowledge gap exists in both the theoretical understanding of AI and its practical applications within the classroom. Some studies have demonstrated that specific AI instructional interventions can enhance PSTs' AI literacy and knowledge. Ayanwale et al. (2024) explored AI literacy among PSTs, finding that a profound understanding of AI predicts positive outcomes in AI use. Celik (2023) also emphasized the importance of teachers' AI-specific technological and pedagogical knowledge for effective AI integration.

Regarding PSTs' attitudes toward AI, some research suggests that it can significantly influence their intentions to use AI-based educational applications (Ayanwale et al., 2024; Zhang et al., 2023). Factors such as perceived usefulness, perceived ease of use, and AI anxiety play a role in their acceptance of AI (Zhang et al., 2023). Other research suggests that PSTs recognize AI as a potential classroom tool and propose strategies for its incorporation, such as using computers in lesson plans (David & Maroma, 2025; Guan et al., 2025; Sun et al., 2024). For example, David and Maroma (2025) explored the integration of ChatGPT in PST education. Guan et al. (2025) investigated PSTs' perceptions and capabilities for AI-integrated education. Studies emphasize the importance of preparing pre-service teachers to integrate AI into their future classrooms. In another study, Sun et al. (2024) found that factors such as Technological Pedagogical Content Knowledge (TPACK), Perceived Usefulness (PU), Perceived Ease of Use (PE), and Self-Efficacy (SE) influence pre-service STEM teachers' willingness to integrate AI into STEM education. The current study adds to the body of research by extending it to the infusion of AI education into teacher preparation coursework.

Methodology

This mixed-methods study had two overarching objectives. First, we added a module that integrated AI into instruction to explore how PSTs' knowledge and attitudes toward AI might change. Next, we explored participants' perceived comfort in using AI in their future classrooms and the strategies participants described that could be used to incorporate AI into their teaching.

In doing so, the following research questions were asked:

1. Is there a significant change in PSTs' knowledge and attitudes toward AI?
2. Is there a significant change in PSTs' comfort in using AI in their future classrooms?
3. How do PSTs explain the concepts of AI after participating in the lesson?
4. What strategies do PSTs describe that could be used to incorporate AI into their future classroom teaching?

In order to answer the questions, an explanatory mixed methods design was utilized, as described by Fraenkel et al. (2012). Following up the quantitative analysis with qualitative inquiry, the researchers gained a deeper insight into the qualitative findings by painting a picture of PSTs' understanding of AI and its integration into classroom instruction.

Description of the Lesson

In the fall of 2019, two instructional technology faculty members from the site of this study collaborated with a computer science professor from another university to develop the learning module. The instruction was delivered via distance learning during the spring, summer, and fall semesters of 2020 at a large public university in Florida. Two instructors were teaching the course using the same Canvas course materials, one of whom was a research team member.

The AI lesson in this study was embedded in a module named Solving Problems & Designing Solutions through Coding, Makerspaces & Serious Games (Plugged in CS Activities). This module also includes resources and assignments on computational thinking and robotics. AI is introduced with a series of resources from ISTE. The students then explored Code.org and were given two assignments named "AI for Oceans" and “Computational Thinking, Artificial Intelligence, and Robotics Integration Lesson." These activities allowed the PSTs to experience an AI curriculum that could be integrated into their future classrooms.

Data Collection

Data for this study were collected using a pre-and post-test survey designed and delivered through Qualtrics software. The survey contained 16 items, though not all were used in this analysis. Items included demographic and background information about the participants. Also, items adapted from the instrument Yadav et al. (2014) used to assess perceived knowledge and attitudes toward AI in four categories: Definition, Comfort, Interest, and Use in the classroom. These items were measured on a scale of 1 to 7 with endpoints "strongly disagree" to "strongly agree." Finally, a few open-ended items were included to gather qualitative data. A summary of the survey is presented in Appendix A.

After gaining institutional review board approval, the surveys were administered electronically within the course through the Canvas learning management system. This was accomplished by providing students with a link to the pre-test survey in the course before the AI instructional module and the post-test survey after the instruction. All of the students in the course were directed to complete the surveys as part of the coursework, but participation in the research was voluntary. Therefore, only those students who consented to participate in the research were included.

Participants

The study involved 93 students enrolled in an undergraduate instructional technology course at a Florida, United States university. The majority of participants (N=79) identified as female, while 14 identified as male, which is typical in education courses. Most participants fell within the 18-22 age range, which is typical for traditional college students (86%). The remaining 13.4% of participants were aged between 23 to 32 years old, with 3.2% being over 30. Additionally, a large

proportion of the students (83.8%) were pursuing degrees in education, including majors such as early childhood, elementary, chemistry, English, mathematics, social studies, and exceptional student education, as shown in Table 1.

Table 1

Participants by Degree Program

Degree Program	N	%
Bachelor in Early Child Care and Education	18	19.4
Bachelor of Arts in Exceptional Student Education	9	9.7
Bachelor in Chemistry Education	1	1.1
Bachelor in Elementary Education	31	33.3
Bachelor in English Education	7	7.5
Bachelor in Math Education	2	2.2
Bachelor in Social Science Education	10	10.8
Pursuing a different degree or course of study	15	16.2
Total	93	100

As is common among education courses, the majority of the participants were female at 86.4% (N=51), seven were male (11.9%), and one participant preferred not to answer the survey item regarding gender (1.7%). The age distribution of the participants indicated that most fell within the 18 to 22 age bracket (62.7%), and some belonged to higher age ranges, including 23 to 27 (30.3%), 28 to 32 (11.9%), and 30 years or older (5.1%).

Quantitative Analysis

The quantitative data were entered into SPSS® 27 software for analysis. The survey items regarding knowledge, attitudes, and future classroom use of AI were summarized by calculating descriptive statistics. Next, a one-sample paired t-test was conducted to determine whether there was a statistically significant difference between participants' self-reported ratings of each knowledge, attitudes, and future classroom use of AI survey item between the pre-test and post-test. Furthermore, the differences in means of the paired values were calculated and plotted on histograms to assess the validity of the paired t-test results. An examination of the histograms showed that the values were roughly bell-shaped, satisfying the assumption that the values are normally distributed for one-sample paired t-test validity. Finally, the effect size of any statistically significant findings was evaluated by examining Cohen's d. Walker (2008) noted that determining the difference between the means of two samples d is calculated by dividing the difference in means by the average of their standard deviations. SPSS® 27 generates this value automatically when a paired t-test is run. An effect size of 1 indicates that the means differ by one standard deviation; a d of 0.2 can be categorized as a small effect size, 0.5 as a medium effect size, and 0.8 as a large effect size, as per Walker's (2008) recommendations for effect size assessment.

Qualitative Analysis

Qualitative analysis seeks to uncover categories, themes, and patterns that appear in qualitative data (Patton, 1980). In this study, qualitative methods were used to analyze open-ended survey items that were organized into tables in electronic word processing software and coded by two researchers. A list of a priori codes that relate to the research questions was used as a starting point. Later, the code list was adapted to accommodate unexpected findings. In doing so, additional coding categories were developed by reading over all of the data and searching for regularities, patterns, and topics the data covered, and then writing down words and phrases that represented the topics and patterns that were not included in the initial set of codes (Bogdan & Biklen, 2007). The researchers then systematically sorted the data into the final set of coding categories (Bogdan & Biklen, 2007). Finally, the researchers examined the categorized data to identify any overarching themes or thematic findings (Bogdan & Biklen, 2007; Merriam, 1998). A list of the a priori and additional codes is presented in Table 2.

Table 2

Code List

A Priori Codes	Additional Codes
AI as teacher helper (TH)	Machine that completes tasks for/normally done by humans (CT)
AI Tools (Alexa, chatbots, etc.) (AIT)	Teaching Aide (TA)
Computer with human intelligence (CHI)	
Machine learning (ML)	
Online apps and websites (AOW)	
Problem-solving machine (PS)	
Robot design (RD)	

Results

Quantitative Results

Descriptive Statistics

Nine survey items were used to measure PSTs' reported AI knowledge, attitudes, and future classroom use on both the pre-and post-test surveys. Descriptive statistics for these items, as measured on a scale from 1 (strongly disagree) to 7 (strongly agree), are summarized in Table 3.

Table 3

Descriptive Statistics of Pre- and Post-Test Survey Items

	Pre-Test	Post-Test

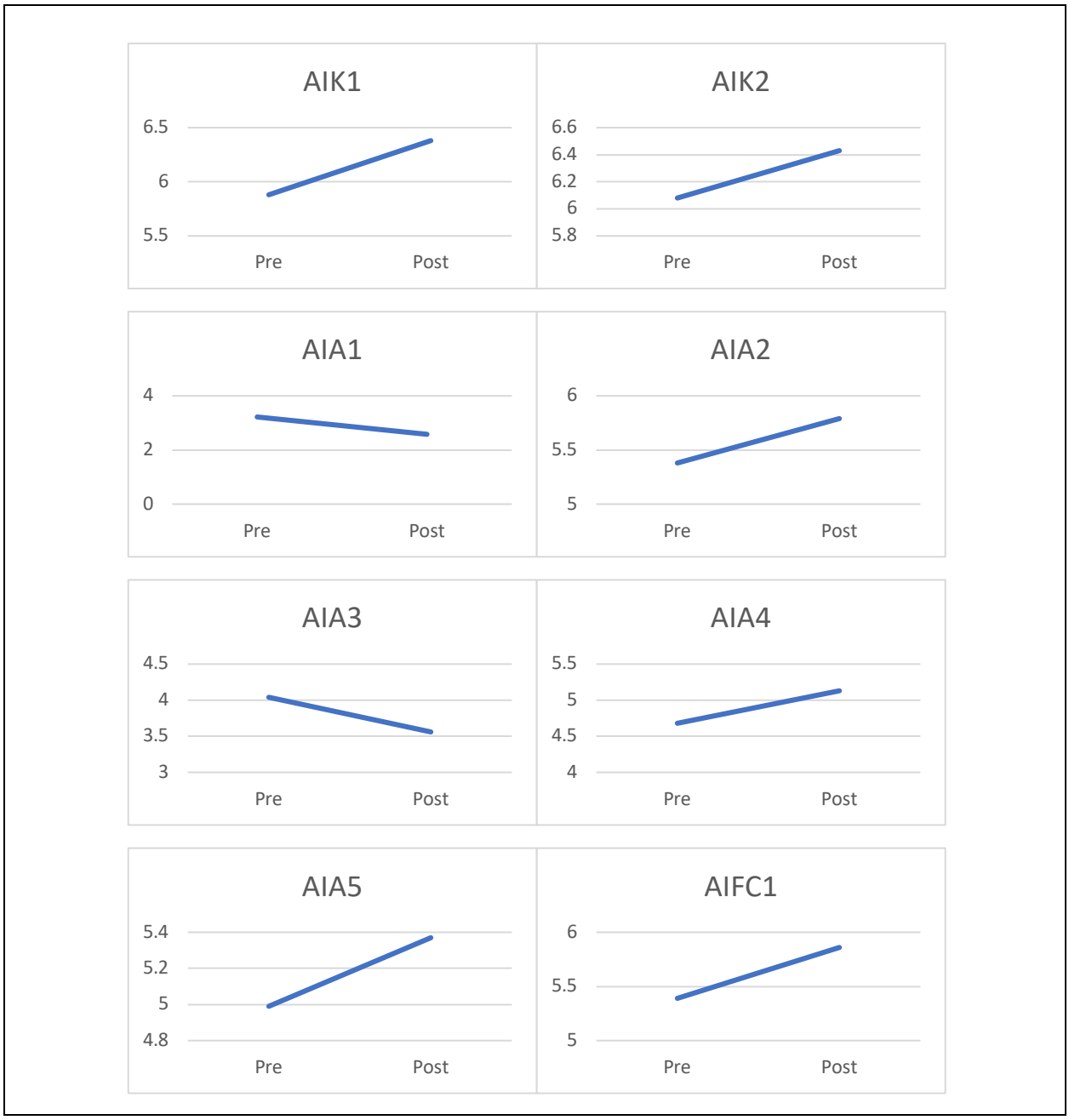
	Mean	Std. Deviation	Mean	Std. Deviation
AI involves designing machines that can perform tasks commonly associated with intelligent beings (AIK1)	5.88	1.058	6.38	.881
AI involves designing machines that have the ability to interpret data, learn from such data, and use the information to achieve specific goals through adaptation (AIK2)	6.08	.902	6.43	.780
I do not think I can apply knowledge of AI to interact with machines that can adapt and learn (AIA1)	3.22	1.527	2.58	1.499
I can learn to understand AI concepts (AIA2)	5.38	1.241	5.79	1.204
I do not use AI skills in my daily life (AIA3)	4.04	1.722	3.56	1.716
The challenge of interacting with machines that can adapt and learn using AI appeals to me (AIA4)	4.68	1.564	5.13	1.400
I think AI is interesting (AIA5)	4.99	1.503	5.37	1.426
AI can be incorporated in the classroom by using computers in the lesson plan (AIFC1)	5.39	1.215	5.86	.104
AI can be incorporated in the classroom by allowing students to design robots (AIFC2)	5.47	1.153	6.06	.976

As shown in the table above, the level of agreement for most of the items was higher on the post-test than on the pre-test. For instance, the item "AI can be incorporated in the classroom by allowing students to design robots" (AIFC2) yielded a mean of 5.47 on the pre-test survey and 6.06 on the post-test. These suggested participants tended to agree with this statement before the AI instruction but agreed even more strongly after. It should be noted that a few of the items were measured on a reverse scale (AKA1 and AKA3) and yielded lower ratings on the post-test, which was promising because this indicated the participants generally did not agree with these statements as much after participating in the lesson. For instance, the item "I do not use AI skills in my daily life" went from 4.04 down to 3.56, a relatively small decrease but representing a shift from the neutral "neither agree nor disagree" to somewhat in disagreement with this statement.

To provide a visual representation of the changes in means from pre- to post-test surveys, a series of line graphs depicting the change for each item is presented in Figure 1.

Figure 1

Line Graphs of Pre- and Post-Test Survey Items



AI Knowledge and Attitudes

Research question 1 asked, "Is there a significant change in the PSTs' knowledge and attitudes toward AI?" The results of the paired t-test for PSTs' self-reported level of knowledge and attitudes toward AI are presented in Table 4.

Table 4

Results of Paired T-Test of Knowledge Towards AI

					95% Confidence Interval					
	Item	Mean	SD	SEM	Lower	Upper	t	df	Sig.	Cohen's d
Knowledge	AIK1	.500	1.192	.126	.250	.750	3.979	89	.000 *	.419
	AIK2	.356	.998	.105	.147	.565	3.380	89	.001 *	-.374
Attitudes	AIA1	-.644	1.724	.182	-1.006	-.283	-3.546	89	.001 *	-.374
	AIA2	.411	1.315	.139	.136	.686	2.967	89	.004 *	.313
	AIA3	-.489	2.068	.218	-.922	-.056	-2.243	89	.027 *	-.236
	AIA4	.456	1.677	.177	.104	.807	2.577	89	.012 *	.272
	AIA5	.378	1.362	.144	.092	.663	2.631	89	.010 *	.277

Note: $^{*}p < .05$

The results indicate that two AI knowledge items and all five AI attitude items yielded significant differences ($p < .05$). As knowledge toward AI was measured on a scale of 1 to 7, on average, participants' post-test self-reported levels of the knowledge items increased by 0.500 (AIK1) and 0.356 (AIK2). Regarding AI attitudes, the two survey items that were worded in the negative (i.e., "I do not think I can apply knowledge of AI" or "I do not use AI") decreased, while levels of the items that were positively worded increased as shown in Table 4 above. However, the effect sizes for all of the dimensions of AI knowledge and attitudes were relatively small, as indicated by Cohen's d values lower than 0.050.

AI in Future Classroom

The second research question posed in this study was, "Is there a significant change in PSTs' comfort in using AI in their future classrooms?" The results of the paired t-test for PSTs' self-reported levels of future classroom use of AI are presented in Table 5.

Table 5

Results of Paired T-Test of Future Classroom AI

	Item	Mean	SD	SEM	95% Confidence Interval Lower	Upper	t	df	Sig.	Cohen's d
Future Classroom	AIFC1	.467	1.220	.129	.211	.722	3.630	89	.000 *	.383
	AIFC2	.589	1.235	.130	.330	.848	4.523	89	.000 *	.381

Note: *p <.05

For two items regarding future classroom use of AI, significant differences were found (p <.05). Participants' levels of self-reported future classroom use of AI items increased by 0.467 (AIFC1) and 0.356 (AIFC2). As indicated by Cohen's d values below 0.050, effect sizes were relatively small for both items.

Qualitative Results

This study's qualitative findings are categorized according to research questions and themes and are supported by the input obtained from open-ended survey responses and student reflection.

How do PSTs Explain the Concept of AI?

Research question 3 inquired, "How do PSTs explain the concepts of AI after participating in the lesson?" The analysis of the open-ended survey items unveiled the most common explanations provided by the respondents.

The most prevalent response centered around the notion of computers possessing human intelligence. Respondents described computers as "mimicking," "developing," or "simulating" human thinking, among other similar terms. Following closely after was the concept of machine learning. These responses emphasized computers' ability to "interpret data" and "learn" in order to independently "make decisions," for instance. Slightly less frequent than machine learning was the idea that AI involves machines performing tasks that are typically done by humans. Additionally, some respondents expressed the notion that AI is about solving problems or "making things easier." Several participants also acknowledged AI as a tool to assist in the classroom.

Overall, these qualitative findings shed light on PSTs' explanations of AI concepts, highlighting their understanding of computers imitating human intelligence, machine learning capabilities, task automation, problem-solving, and the potential of AI as a classroom tool.

Future Classroom Strategies

Research question 4 asked, "What strategies do PSTs describe that could be used to incorporate AI into their future classroom teaching?" The analysis of responses revealed the most frequently mentioned strategies.

The strategy that emerged with the highest frequency was the utilization of AI as a teacher assistant or helper. Respondents highlighted tasks such as grading papers and assessments, providing expertise, and assisting in lesson planning. Many of these respondents emphasized the potential for individualized tutoring using AI. The next most common strategy mentioned was related to robot design. Respondents expressed interest in incorporating robots into their classrooms, potentially as educational tools or aids for various tasks. Closely following robot design, the use of online websites and apps was suggested as a strategy for incorporating AI. Respondents recognized the value of AI-powered online resources and applications in enhancing student learning experiences. While several respondents mentioned AI tools as potential strategies, a larger number of participants indicated that they either needed to learn or were unsure how to effectively utilize AI in their future classrooms. In summary, these qualitative findings indicate that PSTs described strategies such as utilizing AI as a teacher assistant, exploring robot design, incorporating online websites and apps, and utilizing AI tools in their future classroom teaching. However, it is worth noting that several respondents expressed uncertainty regarding implementing AI in their teaching practices.

Limitations

Like any research, this study has limitations that affect the generalizability of its findings. First, students were required to complete the instructional module in this study as part of regular coursework. While consent for participation in the research was optional, this could introduce potential bias, as students might have felt obligated to consent, impacting their responses. Also, the findings could have differed if additional data samples were collected from other universities. The external validity of this study is limited, as it concentrated solely on PSTs at one university. This issue highlights the need to recognize that the findings may not be generalizable across populations or settings. Future research focusing on integrating AI into instructional contexts could benefit from examining larger and more diverse sample sizes. Another limitation is the participants who engaged in the instruction may have different educational backgrounds and varying levels of exposure to AI concepts and the online learning modality in general. Therefore, some participants might have had more background or experience that influenced students' ability to build on prior knowledge of AI or navigate an online course effectively. Lastly, it is important to note that one of the four researchers on this project also served as an instructor in the courses examined. This dual role influenced how students responded to the survey items, potentially causing response bias.

Discussion

This mixed-methods study explored the impact of an instructional module that integrated AI into PSTs' education, focusing on their knowledge, attitudes, comfort levels, and strategies for incorporating AI into future classrooms. The study's findings have several implications that can guide teacher education practices related to integrating AI into teacher education.

Changing Knowledge and Attitudes Towards AI

This study found significant differences in PSTs' self-reported levels of knowledge and attitudes toward AI after participating in the instructional module. PSTs reported feeling more knowledgeable about AI concepts after the instruction and were more willing to apply AI knowledge. These findings suggest that integrating AI education into teacher education can enhance PSTs' understanding of AI and its potential applications in education. This finding supports Roll and Wylie (2016) and Hrastinski et al. (2019), who found that teachers felt they would benefit from more knowledge of AI. However, it's important to note that the effect sizes were relatively small, indicating that while there was improvement, it might not be substantial. This highlights the need for continued, in-depth AI education for future teachers.

Comfort in Using AI in Future Classrooms

This study also found a significant increase in PSTs' comfort levels when using AI in their future classrooms. It is important to note this outcome because teachers' comfort and confidence with AI tools are essential for effective integration. The fact that PSTs reported greater ease with using AI in their classrooms after instruction suggests that exposure to AI concepts and practical applications can positively influence their readiness to embrace AI as an educational tool.

Explanations of AI Concepts

The qualitative analysis shed light on how PSTs explain AI concepts. The most common explanation of AI centered on computers mimicking human intelligence. This perception aligns with the traditional notion of AI as machines that exhibit human-like cognitive abilities, as noted by Murphy (2019). The findings also indicate that PSTs may see AI as a tool that can make tasks easier and enhance problem-solving.

Strategies for Incorporating AI in Future Classrooms

PSTs in this study provided several strategies for incorporating AI into their future classrooms. The most prevalent strategy was the utilization of AI as a teacher assistant, which aligns with the idea of AI supporting educators rather than replacing them. This finding is consistent with Bryant et al. (2020), who asserted that the goal of AI is not to replace teachers but to help them in doing their jobs. Robot design emerged as a strategy PSTs would use to implement AI in their future classroom, and the mention of online websites and apps suggests that PSTs recognize the value of AI-powered resources for creating interactive and engaging learning experiences. However, not all PSTs were sure how to use AI in their future classrooms, as many expressed uncertainties about effectively integrating AI into their teaching practices.

Conclusion

While AI is becoming a highly discussed and studied topic, more needs to be researched on how we can effectively prepare current and future teachers to incorporate it into their classrooms. Many teachers have difficulty imagining using AI in their classrooms because of their limited understanding of it (Hrastinski et al., 2019). This study adds to research on AI by demonstrating that exposing future educators changes their knowledge, attitudes, and teaching strategies. As future teachers are trained to go into classrooms, it is necessary for them to develop their knowledge of AI so that they can leverage its potential effectively. However, future research is needed and welcomed to expand upon this study in light of the recent releases of open-access

generative AI tools and ongoing discussion about the benefits and concerns regarding AI in education.

References

AAAI (2018). *AAAI Launches "AI for K-12" initiative in collaboration with the Computer Science Teachers Association (CSTA) and AI4All*. https://aaai.org/aaai-launches-ai-for-k-12-initiative-in-collaboration-with-the-computer-science-teachers-association-csta-and-ai4all/

Adiguzel, T., Kaya, M. H., & Cansu, F. K. (2023). Revolutionizing education with AI: Exploring the transformative potential of ChatGPT. *Contemporary Educational Technology, 15*(3).

Adler, R.F. & Beck, K. (2020). Developing an introductory computer science course for pre-service teachers. *Journal of Technology and Teacher Education*, 28(3), 519-541. https://www.learntechlib.org/primary/p/214351/

AI4ALL Team (2018). *AI4ALL Open Learning brings free and approachable AI education online with the support of Google.org*. https://medium.com/ai4allorg/ai4all-open-learning-brings-free-and-accessible-ai-education-online-with-the-support-of-google-org-3a6360c135c9

Ayanwale, M. A., Adelana, O. P., Molefi, R. R., Adeeko, O., & Ishola, A. M. (2024). Examining artificial intelligence literacy among pre-service teachers for future classrooms. *Computers and education open*, *6*. https://doi.org/10.1016/j.caeo.2024.100179

Bogdan, R., & Biklen, S. (2007). *Qualitative research for education: An introduction to theory and methods* (5th ed.). Allyn and Bacon.

Bryant, J., Heitz, C., Sanghvi, S., & Wagle, D. (2020). *How artificial intelligence will impact K-12 teachers*. McKinsey & Company. https://www.mckinsey.com/industries/education/our-insights/how-artificial-intelligence-will-impact-k-12-teachers

Celik, I. (2023). Towards Intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education. *Computers in human behavior*, *138*. https://doi.org/10.1016/j.chb.2022.107468

Code.org. (2024). *About us*. https://code.org/about

David, R. M. T., & Maroma, A. P. (2025). Exploring the Integration of ChatGPT in Pre-Service Teacher Education: Benefits, Challenges and Pedagogical Implications. *International Journal of Multidisciplinary: Applied Business and Education Research*, *6*(3), 1333-1342. 10.11594/ijmaber.06.03.24

Fraenkel, J., Wallen, N., & Hyun, H. (2012). *How to design and evaluate research in education* (8th ed.). McGraw Hill.

Guan, L., Zhang, Y., & Gu, M. M. (2025). Pre-service teachers preparedness for AI-integrated education: An investigation from perceptions, capabilities, and teachers' identity changes. *Computers and Education: Artificial Intelligence*, 8. https://doi.org/10.1016/j.caeai.2024.100341

Heinze, C., Haase, J., & Higgins, H. (2010, July). An action research report from a multi-year approach to teaching artificial intelligence at the k-6 level. In *Proceedings of the AAAI Conference on Artificial Intelligence* (Vol. 24, No. 3, pp. 1890-1895). https://doi.org/10.1609/aaai.v24i3.18830

Holstein, K., McLaren, B. M., & Aleven, V. (2019). Designing for complementarity: Teacher and student needs for orchestration support in AI-enhanced classrooms. *Lecture Notes in Computer Science*, 157–171. https://doi.org/10.1007/978-3-030-23204-7_14

Hrastinski, S., Olofsson, A. D., Arkenback, C., Ekström, S., Ericsson, E., Fransson, G., & Utterberg, M. (2019). Critical imaginaries and reflections on artificial intelligence and robots in postdigital K-12 education. *Postdigital Science and Education*, *1*, 427-445. https://doi.org/10.1007/s42438-019-00046-x

International Society for Technology in Education (2024a). Evolving Teacher Education in an AI World. https://info.iste.org/openai-white-paper

International Society for Technology in Education (2024b). Artificial Intelligence in Education. https://iste.org/ai

Ioannou, A., & Makridou, E. (2018). Exploring the potentials of educational roboticsin the development of computational thinking: A summary of current research and practical proposal for future work. *Education and Information Technologies, 23*(6), 2531–2544. https://doi.org/10.1007/s10639-018-9729-z

Jing, M. (2018, May 3). China looks to school kids to win the global AI race. *South China Morning Post*. https://www.scmp.com/tech/china-tech/article/2144396/china-looks-school-kids-win-global-ai-race

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70. https://doi.org/10.3390/educsci8010011

Mason, S. L., & Rich, P. J. (2019). Preparing elementary school teachers to teach computing, coding, and computational thinking. Contemporary Issues in Technology and Teacher Education, 19(4), 790–824. https://www.learntechlib.org/primary/p/184723/

Mataric, M. J. (2004, March). Robotics education for all ages. In *Proc. AAAI Spring Symposium on Accessible, Hands-on AI and Robotics Education* (pp. 22-24). https://cdn.aaai.org/Symposia/Spring/2004/SS-04-01/SS04-01-004.pdf

Merriam, S. B. (1998). *Qualitative research and case study applications in education.* Jossey-Bass.

Mishra, P., Warr, M., & Islam, R. (2023). TPACK in the age of ChatGPT and Generative AI. *Journal of Digital Learning in Teacher Education*, *39*(4), 235-251. https://doi.org/10.1080/21532974.2023.2247480

Murphy*, R. F. (2019). Artificial intelligence applications to support K-12 teachers and teaching.* RAND Corporation. https://www.jstor.org/stable/resrep19907

Patton, M. Q. (1980). Qualitative evaluation methods. Sage.

Powers, J. & Azhar, M. (2020). Preparing teachers to engage students in computational thinking through an introductory robot design activity. *Journal of Computers in Mathematics and Science Teaching*, 39(1), 49-70. https://www.learntechlib.org/p/213891/

Roll, I., & Wylie, R. (2016). Evolution and revolution in artificial intelligence in education. *International Journal of Artificial Intelligence in Education*, 26(2), 582–599. https://doi.org/10.1007/s40593-016-0110-3

Serholt, S., Barendregt, W., Vasalou, A., Alves-Oliveira, P., Jones, A., Petisca, S., & Paiva, A. (2017). The case of classroom robots: teachers' deliberations on the ethical tensions. *AI & Society, 32*(4), 613–631. https://doi.org/10.1007/s00146-016-0667-2

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1-23. https://doi.org/10.17763/haer.57.1.j463w79r56455411

Shute, V. J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying computational thinking. *Educational Research Review*, 22, 142–158. https://doi.org/10.1016/j.edurev.2017.09.00

Sklar, E., Parsons, S., & Azhar, M. Q. (2007, March). Robotics across the curriculum. In *AAAI spring symposium: semantic scientific knowledge integration* (pp. 142-147). https://cdn.aaai.org/Symposia/Spring/2007/SS-07-09/SS07-09-032.pdf

Spector, C. (2023, October 31). What do AI chatbots really mean for students and cheating? *Stanford Graduate School of Education*. https://ed.stanford.edu/news/what-do-ai-chatbots-really-mean-students-and-cheating

Sun, F., Tian, P., Sun, D., Fan, Y., & Yang, Y. (2024). Pre-service teachers' inclination to integrate AI into STEM education: Analysis of influencing factors. *British Journal of Educational Technology*, 55. https://doi.org/10.1111/bjet.13469

Touretzky, D., Gardner-McCune, C., Martin, F., & Seehorn, D. (2019). Envisioning AI for K-12: What should every child know about AI? *Proceedings of the AAAI Conference on Artificial Intelligence*, *33*, 9795–9799. https://doi.org/10.1609/aaai.v33i01.33019795

Walker, I. (2008). Null hypothesis and effect sizes. Statistics for Psychology: Making Sense of Our World through Analysis. https://people.bath.ac.uk/pssiw/stats2/page2/page14/page14.html

Yadav, A., Mayfield, C., Zhou, N., Hambrusch, S., & Korb, J. T. (2014). Computational thinking in elementary and secondary teacher education. *ACM Transactions on Computing Education, 14*(1). https://doi.org/10.1145/2576872

Younis, B. (2024). Effectiveness of a professional development program based on the instructional design framework for AI literacy in developing AI literacy skills among pre-service teachers, Journal of Digital Learning in Teacher Education, 40:3, 142-158, DOI: https://doi.org/10.1080/21532974.2024.2365663

Yue, M., Jong, M. S. Y., & Ng, D. T. K. (2024). Understanding K-12 teachers' technological pedagogical content knowledge readiness and attitudes toward artificial intelligence education. *Education and Information Technologies*, https://doi.org/29. 10.1111/bjet.13469

Zhang, C., Schießl, J., Plößl, L. (2025). *A*cceptance of artificial intelligence among pre-service teachers: a multigroup analysis. *International Journal of Technology in Higher Education, 20,* 49. https://doi.org/10.1186/s41239-023-00420-7

Zhou, X., Van Brummelen, J., & Lin, P. (2020). Designing AI learning experiences for K-12: Emerging works, future opportunities and a design framework. *arXiv preprint arXiv:2009.10228*. https://doi.org/10.48550/arXiv.2009.10228

Zimmerman, M. R. (2018). Zimmerman, M. (2018). *Teaching AI: exploring new frontiers for learning*. International Society for Technology in Education.

Appendix A

AI Survey Questions

Demographic and background information

1. Consent
2. Gender
3. Age group
4. Degree enrollment
5. Progress toward a degree

Please rate your attitudes regarding each of the statements about AI using the following scale: Strongly agree (1), Agree (2), Somewhat agree (3), Neither agree nor disagree (4), Somewhat disagree (5), Disagree (6), Strongly disagree (7).

6. AI involves designing machines that can perform tasks commonly associated with intelligent beings.
7. AI involves designing machines that have the ability to interpret data, learn from such data, and use the information to achieve specific goals through adaptation.
8. I do not think I can apply knowledge of AI to interact with machines that can adapt and learn.
9. I can learn to understand AI concepts.
10. I do not use AI skills in my daily life.
11. The challenge of interacting with machines that can adapt and learn using AI appeals to me.
12. I think AI is interesting.
13. AI can be incorporated in the classroom by using computers in the lesson plan.
14. AI can be incorporated in the classroom by allowing students to design robots.

Open-ended Questions

15. How would you explain the concepts of AI?
16. Describe the strategies you can use to incorporate AI into your future classroom teaching.