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Are they in or out? Exploring pre-service teachers' knowledge, perceptions, and experiences regarding artificial intelligence (AI) in teaching and learning

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Introduction: Artificial Intelligence (AI) continues to revolutionize the teaching and learning process. This study aimed to gather data on pre-service teachers' perceived knowledge, perceptions, and experiences in utilizing AI in education, such as ChatGPT, Quillbot, and Grammarly.
Methods: This mixed-method study involved 515 participants from state universities in Central Visayas, Philippines, selected via stratified random sampling. Quantitative data were collected through a survey, while qualitative insights were gathered from focus group discussions and analyzed using thematic analysis.
Results and discussion: Results showed that pre-service teachers' perceptions of AI revealed cautious optimism, with concerns about its limitations in handling complex tasks, bias, lack of originality, and the need for human oversight. They also recognized issues of factual inaccuracies, reliance on outdated data, and lack of contextual understanding, indicating a need for further education on AI's ethical and practical use. Four themes emerged from the qualitative data: the role of AI in teaching and learning; challenges and ethical implications; capacity training for AI integration; and the link between AI tools and critical thinking.
Conclusion: In conclusion, pre-service teachers recognize AI's limitations and emphasize the importance of training for its responsible and effective use.
Recommendation: It is recommended that AI use be integrated into the teacher education curriculum to prepare teachers for ethical and meaningful application in classrooms.

KEYWORDS

artificial intelligence, pre-service teachers, perception, knowledge, experiences

1 Introduction

Artificial intelligence (AI) is a field of computer science that blends natural language processing, algorithm creation, and machine learning (Igbokwe, 2023). Artificial intelligence has revolutionized teaching and learning. It has affected educational systems (Holmes and Tuomi, 2022) and workplaces (Lane et al., 2023). For instance, students at the university have used AI programs like Grammarly, Quilbot, and ChatGPT to complete coursework and research. Since they employ AI technologies in both their personal and professional lives, students from all academic fields must learn how to use them (Hornberger et al., 2023).

Artificial intelligence (AI) continues to transform teaching and learning. AI has fundamentally altered how teachers oversee instruction, learning, and evaluation. AI-powered platforms improve student engagement and offer tailored experiences. AI-powered intelligent

tutoring systems can offer prompt feedback and assistance, assisting students in understanding complex ideas at their own pace, thereby increasing engagement and knowledge retention (Kulik and Fletcher, 2016). Moreover, automated grading systems, powered by AI algorithms, can efficiently assess student assignments and examinations, providing timely feedback that is crucial for student growth (Brynjolfsson and McAfee, 2014). Additionally, by evaluating student data to find learning trends and customizing instructional materials to each student's needs, AI can help teachers differentiate training (Zawacki-Richter et al., 2019). Understanding how teachers might employ artificial intelligence to enhance learning outcomes is crucial, according to some academics (Wang, 2024).

In the AI-driven landscape, teachers and future teachers alike need to acquire the needed competencies to use AI tools effectively. Teachers who are knowledgeable about AI can create learning environments that are not only more adaptive but also more engaging, ultimately leading to improved academic outcomes for students (Luckin et al., 2016). In the digital age, educators can assist students in acquiring critical thinking abilities and an awareness of the ethical implications of AI by integrating AI-related content into the curriculum (Holmes et al., 2019; Reiss, 2021). On the other hand, teachers who are unfamiliar with AI might not be able to harness the potential of technology integration in teaching and learning. Teachers who lack AI knowledge may struggle to navigate the ethical challenges AI poses in education, such as student privacy, algorithmic bias, and the digital divide (Williamson and Eynon, 2020).

In the teacher education curriculum in the Philippines, courses are geared toward the development of professional teachers. With the dynamic and transformative landscape in education, future teachers need to be well-prepared to utilize AI-driven technologies effectively to enhance student learning outcomes. Improving pre-service teachers' knowledge and proficiency in AI could help future classrooms embrace AI-based instruction more successfully (Celik et al., 2022). However, courses that prepare teachers for emerging technological trends have to be enhanced in the teacher education curriculum.

It has been observed that pre-service teachers have varying levels of knowledge about artificial intelligence in education, such as Grammarly, Quilbot, and ChatGPT. Their understanding typically ranges from basic awareness of AI concepts to more advanced insights into how AI can be integrated into the classroom. Some are familiar with AI's potential to personalize learning and provide instant feedback, yet future teachers' practical experience with these technologies may be limited. This gap in practical knowledge is often due to a lack of exposure to AI tools, together with the rapid development of AI, which cannot be captured by the existing curricula.

It is therefore important to look into the pre-service teachers' knowledge and perceptions of AI in education. Understanding their current knowledge base can help in designing more targeted and comprehensive capacity-building programs for future teachers. Investigating this topic can uncover potential barriers and facilitators to the adoption of AI in classrooms, providing insights for educators and technology developers.

2 Statement of the problem

This study aimed to gather data on the pre-service teachers' perceived knowledge, perceptions, and experiences in utilizing AI in education, such as ChatGPT, Quilbot, and Grammarly. Specifically, it sought to answer the following questions:

a What is the extent to which pre-service teachers perceive the challenges and ethical concerns of using generative AI tools?
b What is the extent of the pre-service teachers' knowledge of generative AI in teaching and learning?
c What emerging themes can be developed based on the pre-service teachers' experiences with the use of AI-driven tools?

3 Methodology

3.1 Research design

The study employed the mixed-methods approach, integrating quantitative and qualitative techniques to obtain a thorough grasp of pre-service teachers' understanding and perspectives regarding artificial intelligence in education. To gather the quantitative data, a survey questionnaire was used. Through the use of a survey, data from a sizable sample were collected, offering a comprehensive picture of participants' opinions and knowledge. The qualitative data involved an in-depth focus group discussion (FGD) through a semi-structured interview guide.

3.2 Research respondents and environment

A total of 515 pre-service teachers from different state universities in Region 7, Central Visayas, Philippines, participated in the study. All respondents were students enrolled in the College of Teacher Education. The study employed a probabilistic sampling strategy, specifically stratified random sampling, to ensure representation across participating higher education institutions. The student population in each university was divided into strata (by year level and institution), after which respondents were randomly selected proportionally from each stratum. This method was used to minimize sampling bias and increase the generalizability of the results.

The sample size of 515 was determined based on Slovin's formula at a 95% confidence level and a 5% margin of error, using an estimated population of approximately N pre-service education students in Region 7. This calculation yielded a minimum required sample size of about n respondents; however, the study exceeded this minimum, thereby strengthening the reliability of the findings. In line with ethical protocols, respondents were informed of their voluntary participation and assured that they could withdraw at any time. Anonymity and confidentiality of responses were strictly maintained.

3.3 Research instrument

The study used a survey instrument adapted from the study of Chan and Hu (2023). It is composed of 20 Likert-scale statements that measure pre-service teachers' perceptions and knowledge of generative AI technologies, focusing on their limitations, capabilities, and ethical concerns. The items examined areas such as handling of complex tasks, potential biases, accuracy,

originality, reliance on user input, and the necessity of human oversight and judgment. For the qualitative data, a semi-structured interview guide was used, and the content was validated by three research experts to ensure that the phenomenon was fully covered.

3.4 Limitations

This study is limited to pre-service teachers from state universities in Central Visayas, which may affect the generalizability of the findings. It also focused only on three AI tools such as ChatGPT, Quillbot, and Grammarly, so perceptions of other educational technologies were not captured. In addition, the qualitative phase involved a smaller number of participants, offering depth but not broad representation.

3.5 Data gathering procedure

Before data collection, the study secured institutional ethics clearance and informed consent from all participants. The survey questionnaire was administered online via Google Forms, allowing broad accessibility while maintaining confidentiality of responses. Out of the 515 survey respondents, 20 were purposively chosen for the Focus Group Discussion (FGD). The qualitative subsample was selected to reflect diversity in gender, institution, and year level, ensuring varied perspectives. The FGDs were audio-recorded with permission, transcribed verbatim, and stored securely.

3.6 Data analysis

The study employed descriptive statistics to analyze the perceptions of pre-service teachers regarding the use of generative AI technologies such as ChatGPT, Quillbot, and Grammarly. Participant responses were summarized and presented using percentages and frequency counts for each statement across five Likert-scale categories: strongly agree, agree, neutral, disagree, and strongly disagree. For the qualitative aspect, transcribed data were analyzed using the thematic analysis process of Braun and Clarke (2006) with the following steps: (1) familiarization of data; (2) generation of codes; (3) combining codes into themes; (4) reviewing themes; (5) determine the significance of themes; and (6) reporting of findings.

4 Findings

The study explored the pre-service teachers' perceptions and experiences with generative AI tools, specifically focusing on their awareness of ethical concerns, challenges, and limitations in teaching and learning. It examined the extent to which they recognized issues such as biases, originality, and the need for human oversight, alongside their experiences on the capabilities and potential impact of these technologies in teaching and learning. The following results offer insights into pre-service teachers' understanding and perspectives, with useful implications for integrating AI into teacher education.

4.1 Perceptions of pre-service teachers on the use of AI

Pre-service teachers have a cautious yet optimistic outlook on AI in education, acknowledging its promise while pointing out ethical issues. According to Chan and Hu (2023), by understanding how students view technology, pre-service teachers can adapt AI technologies to address needs and concerns while promoting good learning outcomes (see Supplementary Table 1).

The perception questions in Supplementary Table 1 highlight pre-service teachers' attitudes toward the challenges and ethical concerns related to generative AI tools. AI's limitations in handling complex tasks were widely acknowledged, with 34% strongly agreeing and 28.3% agreeing that these tools struggle with more intricate or higher-order cognitive tasks. Respondents generally recognized that AI may not yet be equipped to fully replicate the nuanced thinking required for certain teaching situations.

Concerns about AI bias and unfairness were also prevalent, with 33.6% agreeing and 18.3% strongly agreeing that generative AI tools could exhibit biases in their outputs. Respondents expressed concern that biased AI content could affect teaching outcomes, showing awareness of ethical issues in education. Similarly, the lack of originality in AI-generated content, largely due to reliance on pre-existing data, was a concern for the 33.4% of respondents. This indicates that future educators are cautious about the potential for AI to produce formulaic or uncreative content that may not engage students fully. Another notable finding was the widespread belief (31.5%) that AI works best when complemented by human judgment. This illustrates a fair assessment of AI as an aid rather than a substitute for teachers. Pre-service instructors are aware of AI's limitations and the value of human monitoring, even if they acknowledge its potential.

The responses in this table show that pre-service teachers mentioned ethical issues when considering AI use in educational settings. Teacher education programs should build on this awareness by incorporating discussions about AI ethics, particularly bias and fairness in AI outputs. Educators should also be trained to collaborate with AI rather than rely solely on it, making sure that AI is used as a tool to complement their learning rather than replace human interaction. Developing guidelines and best practices for using AI in the classroom can help pre-service teachers integrate technology thoughtfully and responsibly.

4.2 Pre-service teachers' knowledge of artificial intelligence

The term "knowledge of AI" refers to pre-service teachers' comprehension of its principles, resources, and uses in the classrooms as well as their capacity to incorporate it into efficient instruction. Ali (2020) and Kemp et al. (2019) believe that students' familiarity with AI technologies impacts learning outcomes and procedures by shaping their engagement with digital tools, adaptation to new methods, and use of technology for personalized learning (see Supplementary Table 2).

Supplementary Table 2 shows the pre-service teachers' knowledge of the use of AI-driven tools and their limitations. There was a common understanding among preservice teachers who agreed (34%) and strongly agreed (21.7%) on the potential of AI-driven tools in

generating factually inaccurate content. Respondents agreed that AI tools like ChatGPT and Grammarly sometimes produce inaccurate content, showing awareness of their shortcomings. Since pre-service teachers' views about artificial intelligence (AI)-based educational technology may impact their future students' learning outcomes, it is imperative to understand more about these attitudes (Zhang et al., 2023; Al Kurdi et al., 2020; Sumalinog, 2018). Respondents mentioned the need for training on how to use AI tools effectively and ethically.

Furthermore, AI's reliance on statistical models and large datasets was identified as a potential limitation by 37% of the respondents. This suggests that while many understand that AI's data-driven nature can lead to issues such as outdated or irrelevant information, some may lack full awareness of how this affects the quality of outputs. The respondents further agreed (33.4%) that due to reliance on existing data, the content generated by AI tools may lack originality. Additionally, there was the recognition that AI tools struggled with real-time adaptation and contextual understanding, as reflected by the neutral responses (37.3%). Neutral responses reflected some uncertainty among pre-service teachers, suggesting limited practical experience with AI tools.

Regarding the need for educators to keep an eye on AI-generated content, there was broad agreement among respondents (36.9%). This shows that, despite its potential, AI still needs human judgment to guarantee that the outputs are suitable and accurate. Pre-service teachers appear to broadly agree with the notion that AI technologies should not function independently, based on the minimum disagreement (2.9%). The majority of pre-service teachers strongly agreed (31.5%) and agreed (29.5%) that AI-powered technologies work best when combined with human judgment and experience.

Moreover, the preservice teachers agreed (31.3%) and strongly agreed (17.3%) that AI tools do not possess awareness of the context in which they are used. This points to the limitation of AI tools like ChatGPT, which generate responses purely on patterns in the data they were trained on without anchoring on the real situation. For instance, a student teacher can request that ChatGPT create a lesson plan for a specific subject. Although ChatGPT is capable of doing so, the results could not provide enough information about the unique requirements of the students or the cultural setting in which the lesson plan is developed. Generative AI can assist educators in developing instructional content, but it cannot account for unique classroom dynamics, which require a teacher's contextual understanding (Hao et al., 2024; Burke and Akhtar, 2023).

The results showed that participants recognized AI's limitations, such as accuracy, bias, and lack of contextual understanding, given the limitations of using AI-driven tools as demonstrated by the respondents' responses. More hands-on experience and exposure to AI applications in real-world scenarios could bridge the gap in understanding and help alleviate uncertainty. Emphasizing critical thinking and ethical considerations when using AI in classrooms is very important for future educators.

4.3 Pre-service teachers' perceptions and knowledge of the use of AI

Pre-service teachers' perceptions and knowledge of AI encompass their understanding of its tools and applications, their attitudes toward its integration in education, and their awareness of its potential benefits and challenges in teaching and learning. For Sanusi et al. (2020), gaining insight into pre-service teachers' opinions and knowledge regarding AI use could help develop instructional AI programs for educators. Similarly, one background aspect to consider when examining students' behavior towards AI is their literacy and their knowledge (Chai et al., 2020; Dai et al., 2020) (see Supplementary Table 3).

The table summarizes pre-service teachers' responses to their perceptions and knowledge of AI technologies. In terms of knowledge, the majority (59.4%) either strongly agreed or agreed that they possessed adequate knowledge of AI, while 31.5% remained neutral, indicating moderate understanding or uncertainty. A small proportion (9.3%) disagreed, suggesting limited knowledge among some respondents. Regarding perceptions, 61.1% hold positive views, with 29.5% strongly agreeing and 31.6% agreeing on the benefits of AI in education. Meanwhile, 30.2% remained neutral, reflecting ambivalence or lack of strong opinion, and only 9.6% expressed negative perceptions.

Most participants reported favorable perceptions and moderate knowledge of AI technologies, while a notable group gave neutral responses, pointing to the need for enhanced training and exposure to the use of AI in education. The previous paragraph highlights the significance of understanding their perceptions and knowledge of AI, as these factors significantly influence their willingness to adopt AI-powered educational technologies, which in turn may affect the learning outcomes of students (Turan et al., 2022; Ndlovu et al., 2020). Although many pre-service teachers viewed AI as useful, they also mentioned challenges such as limited knowledge and practical experience (Karatas and Yuce, 2024). To guarantee the successful integration of AI in education and optimize its potential advantages for both educators and students, these problems must be resolved.

4.4 Emerging themes on the use of AI in teaching and learning

An interview was undertaken to substantiate the quantitative data gathered. The respondents' narrative remarks and experiences were analyzed and organized into emerging themes.

4.4.1 Theme the role of AI in teaching and learning

The role of AI in improving teaching and learning is multifaceted, providing various advantages at the same time challenges. As culled from the narratives of the respondents, AI-driven tools lessen the work of teachers and future teachers by automating repetitive tasks like grading and lesson planning. This increased efficiency enables teachers to spend more time enhancing instruction and fostering relationships with students. Furthermore, AI systems provide useful insights into student performance, allowing teachers to discover areas where students may be struggling and adjust their teaching strategies as needed. AI tools also give suggestions on lesson planning and how to make teaching more engaging through varied activities.

> *"AI technologies automate tasks like grading to lessen the work of the teacher. Through this, AI helps teachers to create amazing outputs to give to their learners to make their activities more exciting and collaborative" (P2)*

> *AI tools create engaging activities that capture young learners' interest and encourage participation. (P1)*
>
> *AI, as I have discerned, has incredible potential to improve our teaching, but it can also come with significant risks if it is misused or it will not managed carefully. (P9)*
>
> *The capabilities of AI technologies in the classroom are that it's very easy to use with just one click, and you will have all the ideas you want to know. For instance, it will help you craft a lesson plan. It makes your work lighter because the AI will provide you with information, and all you have to do is rephrase or get some of it and apply it in your classroom. But it's still important to be very mindful when using this. (P7)*

Pre-service teachers understand that although AI is user-friendly and offers helpful assistance, its use or inadequate management can result in serious ethical implications. As a result, to maximize the potential benefits of AI tools in education, they emphasize the importance of using them cautiously and wisely. AI-driven educational platforms, for example, can review student performance data to identify learning gaps and give tailored learning pathways, increasing the efficacy of pre-service teacher training programs (Chauke et al., 2024; Igbokwe, 2023).

Furthermore, AI has played an important role in improving the learning experience for pre-service teachers by giving them access to a variety of material and interactive tools that help them understand complicated concepts more deeply. AI assists students in developing problem-solving abilities through simulations and scenarios that mimic real-world issues, allowing them to apply theoretical knowledge in practical settings. Furthermore, AI fosters collaboration by supporting teamwork in the classroom, offering platforms and applications that encourage group projects, peer-to-peer interaction, and collective decision-making, all of which are essential for effective teaching practices (Al-Shammari and El-Enezi, 2024; Ali, 2020).

4.4.2 Theme challenges and ethical implications of AI use in education

While AI offers efficiencies and novelty, challenges, including inaccuracy, technology dependency, and ethical considerations like privacy issues and equity, need to be addressed. Among these are: (1) bias risk in AI algorithms, (2) accessibility gaps and digital divides, and (3) maintaining the human element in teaching. Below are some of their narratives:

> *When thinking of the ethical consideration of AI, I see it as, you know, it is a balancing act between innovation and responsibility because AI, as we have discerned, has incredible potential to improve lives, but it can also come with significant risks if it will be misused or it will not be managed carefully (P 4).*
>
> *And for me, ethical consideration just reminds me that while AI can be powerful, yes, it's true that AI can be an innovative tool that we can use. However, the design and use it reflects our values and priorities (P 5)*

Indeed, many studies have emphasized the promising benefits of AI; however, there are so many questions remaining about how best to tackle ethical, technological, and societal questions about AI use. According to Farooqi et al. (2024), some ethical issues on the use of AI include data privacy (Amado et al., 2024). These issues have not received much attention in the educational setting (Gaonkar et al., 2020; Nassar and Kamal, 2021).

Pre-service teachers support the need to balance humanistic elements of education with AI efficiency and the significance of integrating ethical considerations that support the relational nature of teaching and represent shared values. To overcome these obstacles, educational stakeholders may take a multifaceted strategy in the future, promoting an AI-enhanced learning environment that places high priority on accountability, inclusivity, and human-centered values.

4.4.3 Theme: capacity training of teachers for AI integration

Familiarity with AI tools, their limitations, and mindful application are crucial for successful implementation. Subtopics include (1) training programs for educators, (2) balancing AI use with traditional methods, and (3) building confidence and proficiency in AI tools.

> *As a future early childhood educator, I recognize several challenges in AI use. Preparing ourselves for AI integration is very important. Over-reliance on technology may limit personal interaction between educators and learners. Another challenge is ensuring that AI tools are age-appropriate and safe for young learners (P6)*
>
> *I believe that training is very important. Thus, we must undergo training on integrating AI into learning. (P10)*

The successful training and capacity building on the integration of AI-based tools in teacher education among preservice teachers and, further, their classroom instruction hinges on their awareness of technology, pedagogy, and content, as well as how all of these interact overall (Levenberg et al., 2024). In addition, for the effective implementation of the educational process by school instructors within the modern electronic information-educational environment integrating elements of artificial intelligence, there is a need for focused training of school instructors in AI and its applications in education (Vlasova et al., 2019).

This indicates that education programs for pre-service teachers should put top priority on opportunities for professional development focused on integrating AI into education. There is a necessity to prepare the pre-service teacher to blend old ways of teaching with AI-enriched teaching methods. For a pre-service teacher to develop their confidence in AI tool use, they need specific guidance. In addition, preservice teachers need support to improve their confidence and enhance their capacity to use AI tools in teaching and learning.

4.4.4 Theme: the use of AI tools and critical thinking

While generative AI tools facilitate learning, pre-service teachers believed that critical thinking skills should not be sacrificed. Overdependence on AI tools may diminish the students' ability to think independently and be creative. A student needs to evaluate the validity and relevance of information provided by AI. All AI-generated content is not true or appropriate at all times; thus, the learners need to evaluate sources critically. Students should utilize AI as an aid and

not a crutch. Reduced dependence on technology promotes more meaningful interactions with content and creates a more active learning space.

> *I always cross-check the facts and assess the credibility of the sources. (P3)*
>
> *It's important to question the validity of AI-generated responses. (P14)*
>
> *I believe we should use technology to enhance learning, not as a substitute for critical thinking. (P19)*
>
> *AI can sometimes present a skewed view of a topic, and we must identify those biases. (P9)*
>
> *When we use AI, I always remind my students not to take everything at face value. (P12)*

Pre-service teachers always cross-check facts and assess the credibility of sources, recognizing the importance of questioning the validity of AI-generated responses. AI sometimes presents a skewed view of a topic, so it emphasizes the need to identify potential biases and ensure that critical thinking remains a central part of the learning process. In a survey conducted by Szmyd and Mitera (2024), the majority of the pre-service teachers rank their critical thinking ability as high or moderate. However, up to 83% of respondents were concerned that leaning too much on artificial intelligence may limit their ability to think independently and make responsible decisions. Similarly, AI technology can increase academic performance, tailor learning, and better prepare students for global careers (Hao et al., 2024). However, the findings emphasize the ethical and pedagogical challenges raised by AI, such as its potential to worsen educational inequities and undermine critical thinking skills.

5 Discussion

The results of this study highlight pre-service teachers' ambivalent yet thoughtful stance on generative AI. Quantitative data revealed broad recognition of AI's potential, with more than 61% affirming its value in supporting instruction, but respondents also acknowledged limitations such as bias, lack of originality, and contextual insensitivity (Zhang et al., 2023; Hao et al., 2024). These concerns were echoed in qualitative interviews, where participants described AI as useful for automating repetitive tasks like grading and lesson planning while simultaneously enhancing classroom interaction and collaboration (Chauke et al., 2024; Ali, 2020). Taken together, these findings suggest that pre-service teachers are approaching AI with cautious optimism, recognizing its ability to complement teaching but not replace the irreplaceable human dimension of education. The identified themes resonate with existing frameworks such as TPACK, which emphasizes the integration of technology, pedagogy, and content knowledge in teacher preparation (Levenberg et al., 2024; Vlasova et al., 2019). Similarly, the concerns about bias, accuracy, and the need for critical thinking align with AI literacy perspectives that stress ethical awareness and responsible engagement with AI tools in education (Chan and Hu, 2023; Szmyd and Mitera, 2024).

Ethical and pedagogical issues emerged strongly across both strands of data. Survey responses indicated a widespread belief that AI outputs require constant human oversight to prevent factual inaccuracies and biased content (Chan and Hu, 2023; Burke and Akhtar, 2023). Narratives similarly underscored the danger of overdependence, warning that uncritical reliance may undermine critical thinking and creativity, potentially reproducing inequities within education (Szmyd and Mitera, 2024; Farooqi et al., 2024). These results reveal that while pre-service teachers acknowledge the efficiencies of AI, they also see the risks of its unchecked use, positioning ethics and human judgment as indispensable to its responsible integration in classrooms. The need for guidelines and best practices for classroom AI use can be considered in the discussion of these findings.

A further pattern concerns the gap between knowledge and practical application. While nearly 60% of participants reported having sufficient knowledge of AI, a significant proportion expressed uncertainty, reflecting ambivalence in their actual readiness (Sanusi et al., 2020; Karatas and Yuce, 2024). This gap was reinforced in the qualitative accounts, where pre-service teachers pointed to the need for structured training and professional development to build competence and confidence (Levenberg et al., 2024; Vlasova et al., 2019). Such findings indicate that exposure to AI tools alone is insufficient; rather, pre-service teachers need guided opportunities to integrate technology with pedagogical practice, ensuring that their engagement is both ethical and effective. The relatively high proportion of "neutral" responses suggests uncertainty or limited confidence in applying AI tools, which may stem from a lack of hands-on experience or formal training. This highlights the need for teacher education programs to provide more practical exposure and capacity-building activities to strengthen pre-service teachers' readiness for AI integration. Participants recognized both the potential advantages of AI and the challenges that still need to be addressed.

Overall, the convergence of quantitative and qualitative findings paints a portrait of pre-service teachers as both pragmatic and reflective in their engagement with AI. They see its promise in promoting efficiency and personalized learning, yet they remain vigilant about its risks to equity, originality, and independent thought. These results point to several implications for practice: teacher education curricula should integrate explicit training on AI tools, including their ethical and technical limitations; professional development programs must equip pre-service teachers with strategies to blend traditional and AI-driven pedagogies; and institutional guidelines should reinforce accountability and human-centered values to ensure that AI complements rather than undermines critical thinking and inclusivity in education.

6 Conclusion

Pre-service teachers are aware of the ethical implications and challenges posed by generative AI, including biases in output, the need for human oversight, and data privacy concerns. While they recognize the efficiency and innovative potential of AI tools in automating tasks like lesson planning and grading, they also emphasize the risks of over-reliance and the importance of balancing AI use with ethical responsibility. Additionally, participants demonstrate an understanding of AI's limitations, acknowledging its reliance on large datasets and statistical models, which can lead to inaccuracies, a lack of contextual

understanding, and limited adaptability. Although pre-service teachers appreciate the ways AI can streamline processes and enhance teaching efficiency, they stress the need for training and capacity building to effectively integrate AI in teaching and learning. They advocate for using AI as a supplement to, rather than a replacement for, the time-tested teaching methods, ensuring that critical thinking and human interaction remain central to the educational process. To prepare future educators to effectively navigate with AI tools, the teacher education curricular offerings need to integrate the concept of artificial intelligence, focusing on AI ethics, practical applications, and critical evaluation of AI outputs, fostering a balanced approach to leveraging AI while upholding educational values and standards.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Ethics Review Committee - Cebu Normal University. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

FD: Conceptualization, Funding acquisition, Writing – original draft. HB: Investigation, Methodology, Writing – review & editing. GS: Formal analysis, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2025.1665205/full#supplementary-material

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