Paedagogi: Jurnal Kajian Ilmu Pendidikan (e-journal)
Volume 11, Issue 2, Pages 181–187 December 2025 e-ISSN: 2407-7445 p-ISSN: 2085-9880
https://jurnal.unimed.ac.id/2012/index.php/PAEDAGOGI/issue/view/3549
: *https://doi.org/10.24114/paedagogi.v11i2*

Artificial Intelligence as a Pedagogical Tool in Mathematics Courses: A Descriptive Study of Prospective Elementary School Teachers

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Keywords:
Artificial Intelligence,
Mathematics,
Prospective Teacher

Received: October 2025
Accepted: November 2025
Published: December 2025

Abstract

The rapid development of artificial intelligence has created new opportunities for enhancing mathematics learning, including in the preparation of prospective elementary school teachers. This study describes the use of artificial intelligence as a pedagogical tool in mathematics courses at the Primary School Teacher Education Program of Universitas Pendidikan Ganesha during the even semester of the 2024/2025 academic year. A descriptive quantitative approach was applied to 118 students enrolled in Elementary Algebra and Arithmetic, Elementary Numeracy, Measurement and Geometry, and Elementary Mathematics Teaching. Data were collected through an online questionnaire covering demographic characteristics, frequency of use, perceived usefulness, perceived ease of use, learning engagement, ethical awareness, and attitudes toward artificial intelligence. The results show high mean scores for perceived usefulness, perceived ease of use, learning engagement, and positive attitudes, while frequency of use and ethical awareness remain at moderate levels. ChatGPT emerged as the most frequently used platform, followed by Photomath, Perplexity, Gemini, QuillBot, Canva AI, and GeoGebra AI features, primarily for generating explanations, checking solutions, and designing instructional materials. These findings indicate that prospective elementary school teachers have developed favorable perceptions and a willingness to integrate artificial intelligence into mathematics learning, yet the moderate levels of usage frequency and ethical awareness highlight the need for structured training and explicit guidance to promote consistent and responsible application of artificial intelligence in mathematics education. Strengthening ethical understanding and providing systematic practice are essential to ensure that future teachers can leverage artificial intelligence effectively to improve mathematics learning in elementary schools.

DOI: https://doi.org/10.24114/paedagogi.v11i2.69279

INTRODUCTION

Rapid advances in digital technology have transformed the landscape of education, with artificial intelligence (AI) emerging as one of the most influential innovations in recent years. AI refers to computer systems that are capable of performing tasks that typically require human intelligence, such as problem solving, reasoning, and natural language processing (Kulkarni, 2024). In the field of education, AI applications have evolved from simple computer-assisted instruction to sophisticated intelligent tutoring systems, adaptive learning platforms, and automated feedback tools (Kabudi et al., 2021; Wang et al., 2024). These developments provide new opportunities for enriching teaching and learning processes, including the teaching of mathematics at the elementary level, where conceptual understanding and problem-solving skills are fundamental.

Mathematics courses within teacher education programs play a critical role in preparing prospective elementary school teachers to develop both content knowledge and pedagogical competence. Nevertheless, many pre-service teachers continue to experience challenges in mastering mathematical concepts and designing engaging learning experiences for young learners (Kaplan, 2024; Yılmaz & Gök, 2025). Previous studies highlight that mathematics anxiety, limited instructional resources, and insufficient exposure to innovative teaching methods can hinder their readiness to teach mathematics effectively (Pahmi et al., 2025). Integrating artificial intelligence (AI) offers a promising way to address these barriers by providing adaptive learning pathways, instant feedback, and personalized support (L. Y. Tan et al., 2025). Through AI-based applications such as intelligent tutoring systems or generative AI tools, pre-service teachers can access

immediate explanations, practice opportunities, and creative suggestions that enhance both their mathematical understanding and pedagogical strategies.

Despite the growing interest in AI, research on how prospective elementary school teachers actually utilize AI in mathematics courses remains limited, particularly in the Indonesian context where teacher education institutions are still exploring technology-enhanced learning models (Cheah et al., 2025; Rincón & Munárriz, 2025). Most existing studies focus on the effectiveness of AI-based learning in K–12 classrooms or on students' perceptions in general higher education settings, leaving a gap in understanding the specific experiences of pre-service teachers who are preparing to teach mathematics in primary schools (Lee & Kwon, 2024). Without empirical insights into the current state of AI adoption among this population, it is difficult to design targeted interventions, training programs, and policy guidelines that support ethical and meaningful AI integration.

An important framework for analyzing the integration of AI into teacher preparation is the Technological Pedagogical Content Knowledge (TPACK) model (X. Tan et al., 2025b). TPACK describes the complex interplay between teachers' knowledge of content (CK), pedagogy (PK), and technology (TK), emphasizing that effective technology integration requires more than technical proficiency. For mathematics education, pre-service teachers must not only understand mathematical concepts and how children learn them but also develop the ability to select, adapt, and evaluate digital tools that enhance learning outcomes (Ersozlu, 2024; Kandemir & Eryilmaz, 2025). AI applications—ranging from automated problem generators to adaptive feedback systems—demand a sophisticated blend of these knowledge domains to ensure that technology use is pedagogically sound and aligned with curricular goals.

Within the TPACK framework, AI can serve as a catalyst for innovative teaching practices when pre-service teachers are guided to integrate technology with appropriate pedagogical approaches and content-specific strategies. For example, AI-driven platforms that provide real-time diagnostic feedback can help prospective teachers identify students' misconceptions, allowing them to design targeted interventions that build deeper conceptual understanding (Pangestu, 2024; X. Tan et al., 2025a). However, without adequate training, there is a risk that AI will be used merely as a substitute for traditional methods rather than as a transformative tool that promotes higher-order thinking and active learning. Therefore, understanding how pre-service elementary teachers perceive and utilize AI within the TPACK framework is essential for informing curriculum design and professional development in teacher education programs.

The present study seeks to fill this gap by describing the utilization of AI as a pedagogical tool in mathematics courses for prospective elementary school teachers. Specifically, this research aims to (1) portray the extent to which pre-service teachers use AI applications to support their mathematics learning, (2) identify the perceived benefits and challenges associated with such usage, and (3) explore their attitudes toward AI-based pedagogical support. By providing a comprehensive description of AI practices in teacher education, the findings are expected to inform curriculum designers, teacher educators, and policy makers in promoting responsible and effective AI integration in mathematics instruction at the elementary level.

RESEARCH METHODS

This study employed a descriptive quantitative design to portray the utilization of artificial intelligence (AI) as a pedagogical tool in mathematics courses for prospective elementary school teachers. The research was conducted in the Primary School Teacher Education (PGSD) Program at Universitas Pendidikan Ganesha (Undiksha), Bali, during the even semester of the 2024/2025 academic year.

The subjects comprised 118 prospective elementary school teachers who were enrolled in mathematics-related courses, namely *Aljabar dan Aritmatika SD* (Elementary Algebra and Arithmetic), *Numerasi SD* (Elementary Numeracy), *Pengukuran dan Geometri SD* (Elementary Measurement and Geometry), and *Pembelajaran Matematika SD* (Elementary Mathematics Teaching). Participants were selected using a purposive sampling technique, focusing on students who had completed at least one semester of mathematics coursework and had experience using digital learning tools.

Data were collected using an online questionnaire developed by the researchers. The instrument consisted of three sections: (1) demographic information, (2) AI utilization scale, and (3) perception and attitude scale. Items measured key variables such as frequency of AI use, perceived usefulness, perceived ease of use, learning engagement, and ethical awareness. The blueprint of the questionnaire, including aspects, indicators, and number of items for each indicator, is presented in Table 1.

Table 1. Instrument blueprint

Aspect	Indicator	Number of Items
Frequency of AI Use	Frequency of AI utilization per week in mathematics courses Duration of AI use per session	2
Perceived Usefulness	AI helps understand mathematical concepts AI improves the quality of mathematical problem solving	3

	AI supports preparation of teaching materials	
Perceived Ease of Use	Ease of accessing AI platforms Clarity of AI interface and instructions Simplicity in applying AI-generated feedback	3
Learning Engagement	AI increases motivation to study mathematics AI encourages independent practice and exploration	2
Ethical Awareness	Awareness of academic honesty when using AI Ability to verify AI-generated answers	2
Attitude toward AI	Positive perception of AI as a pedagogical tool Willingness to integrate AI in future teaching	2

Responses were recorded on a five-point Likert scale ranging from "strongly disagree" to "strongly agree." Prior to administration, the questionnaire underwent expert validation and pilot testing to ensure clarity and reliability. It was then distributed electronically through class groups and could be accessed via mobile devices or computers. Participation was voluntary, and informed consent was obtained before data collection.

Descriptive statistics (including mean, standard deviation, and percentage) were used to summarize participants' AI usage patterns, perceptions, and attitudes. Cross-tabulations were applied to compare AI usage frequency across demographic categories such as semester level and prior technology training. Reliability of the instrument was assessed using Cronbach's alpha to ensure internal consistency, but no complex statistical modeling was employed in order to maintain the focus on descriptive findings.

RESULTS AND DISCUSSION

Demographic Characteristics of Participants

A total of 118 prospective elementary school teachers participated in this study. The demographic characteristics of participants is presented in Table 2.

Table 2. Demographic characteristics of participants

Variable	Category	Frequency (f)	Percentage (%)
Gender	Female	97	82.2
	Male	21	17.8
Semester	2nd	31	26.3
	4th	43	36.4
	6th	44	37.3
Mathematics Courses Enrolled*	Elementary Algebra and Arithmetic	96	81.4
	Elementary Numeracy	78	66.1
	Elementary Measurement and Geometry	88	74.6
	Elementary Mathematics Teaching	102	86.4

*Multiple responses allowed because students may enroll in more than one course.

The demographic data in Table 2 show that the majority of respondents were female (82.2%), reflecting the typical gender distribution of students in the PGSD program. Male participants comprised only 17.8% of the sample. Most students were in the middle to upper semesters, with 36.4% in the fourth semester and 37.3% in the sixth semester, while 26.3% were second-semester students. Enrollment patterns also reveal that the Elementary Mathematics Teaching course had the highest participation rate (86.4%), followed by Elementary Algebra and Arithmetic (81.4%), Measurement and Geometry (74.6%), and Elementary Numeracy (66.1%). This distribution indicates that respondents represented a diverse range of mathematics learning experiences, ensuring a comprehensive overview of AI utilization across different mathematics course contexts.

Types of AI Applications Used

The distribution of AI applications employed by students to support their mathematics learning is illustrated in Figure 1. This figure presents the relative proportion of each platform reported by the participants, highlighting the most and least frequently utilized tools.

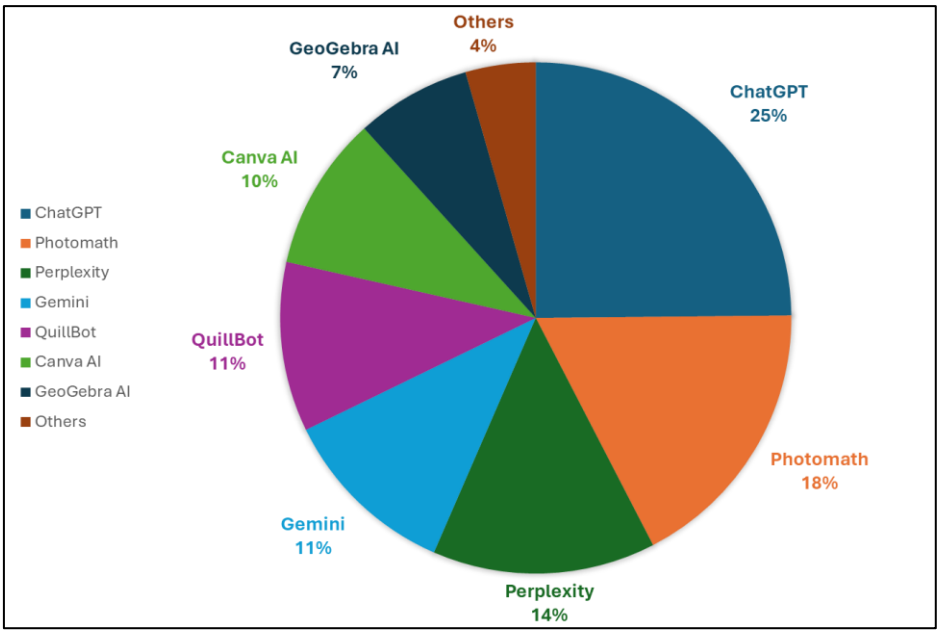

Figure 1. Types of AI Application Used

Figure 1 illustrates that ChatGPT was by far the most frequently used application, representing approximately 25% of all responses. This dominance reflects its popularity for generating explanations, solving sample problems, and providing step-by-step reasoning. Photomath followed with about 18%, indicating strong use for checking algebraic and arithmetic calculations. Perplexity (14%) and Gemini (11%) were also notable, often employed for quick information retrieval and alternative solution strategies. Other creative tools such as QuillBot (11%) and Canva AI (10%) were primarily utilized to rephrase mathematical explanations or design teaching materials, while GeoGebra AI features (7%) supported dynamic visualization of geometric concepts. A small proportion of students (4%) mentioned using other emerging AI applications.

These findings suggest that while text-based conversational AI dominates usage patterns, students also explore a variety of specialized AI tools for both conceptual understanding and instructional design, indicating a diverse and adaptive approach to AI integration in mathematics courses.

Descriptive Analysis of AI Utilization

The overall pattern of AI utilization across aspects is presented in Table 3 and visualized in the radar chart in Figure 2.

Table 3. Descriptive analysis of AI utilization

Aspect	Mean	SD	Category*
Frequency of AI Use	3.42	0.76	Moderate
Perceived Usefulness	4.05	0.58	High
Perceived Ease of Use	3.89	0.62	High
Learning Engagement	3.78	0.64	High
Ethical Awareness	3.51	0.71	Moderate
Attitude toward AI	4.12	0.55	High

*Category based on mean score intervals: 1.00–2.49 = Low, 2.50–3.49 = Moderate, 3.50–5.00 = High.

The frequency of AI use showed a moderate mean score (M = 3.42, SD = 0.76), indicating that students typically accessed AI applications two to three times per week for mathematics-related tasks. Perceived usefulness was consistently high (M = 4.05, SD = 0.58), demonstrating that students found AI valuable for clarifying mathematical concepts, improving problem-solving accuracy, and preparing teaching materials. Ease of use (M = 3.89, SD = 0.62) and learning engagement (M = 3.78, SD = 0.64) also received high ratings, reflecting the accessibility of AI platforms and their ability to encourage independent exploration.

However, ethical awareness remained at a moderate level (M = 3.51, SD = 0.71). While most respondents acknowledged the importance of verifying AI-generated answers, several admitted occasional use of AI outputs without proper citation. Despite this, the overall attitude toward AI was strongly positive (M = 4.12, SD = 0.55), with many students expressing willingness to integrate AI into their future mathematics teaching.

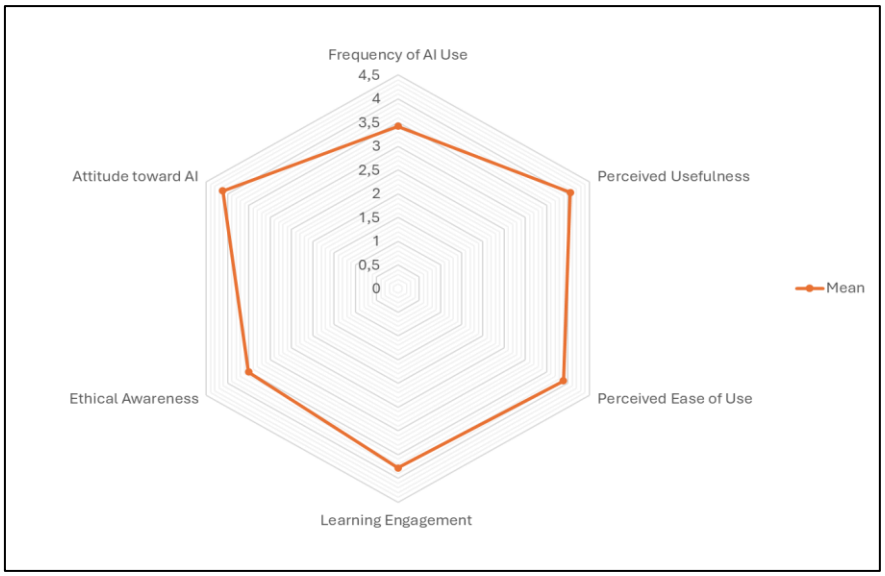

Figure 2. Radar chart of AI Utilization

Figure 2 reveals a balanced but slightly uneven profile. The highest scores appear on Attitude toward AI and Perceived Usefulness, indicating that most students view AI positively and consider it highly beneficial for understanding mathematical concepts and preparing teaching materials. Perceived Ease of Use and Learning Engagement also show strong results, suggesting that AI tools are generally accessible and encourage students to practice and explore mathematics more actively. In contrast, Frequency of AI Use and Ethical Awareness occupy the inner area of the radar chart, reflecting moderate levels. This means that although students value AI, they do not yet use it consistently in every learning session, and their awareness of responsible or ethical AI practices (such as verifying answers and citing AI assistance) remains an area for improvement.

The findings of this study provide a comprehensive picture of how prospective elementary school teachers at PGSD Undiksha utilize artificial intelligence (AI) as a pedagogical tool in mathematics courses. Overall, the results demonstrate a positive orientation toward AI adoption, with high scores for perceived usefulness, ease of use, learning engagement, and attitude toward AI. These outcomes are consistent with earlier research indicating that technology-enhanced learning environments can improve conceptual understanding and motivation in mathematics (Haleem et al., 2022; Sabrun, 2025). The strong perception of AI as both beneficial and easy to operate suggests that pre-service teachers recognize the potential of AI to support mathematical problem solving and lesson preparation, aligning with global trends in technology-integrated teacher education (Funa & Gabay, 2025).

The moderate frequency of AI use indicates that, despite positive perceptions, students do not yet employ AI on a regular basis in their coursework. Similar patterns have been reported by Emon & Khan (2025), who noted that favorable attitudes toward technology do not always translate into consistent practice. Several factors may contribute to this gap, including time constraints, variability in course requirements, and limited guidance from instructors on how to incorporate AI tools effectively. This finding underscores the need for structured opportunities within mathematics courses to model and practice AI-supported learning, thereby encouraging more habitual and purposeful use.

Another noteworthy result is the moderate level of ethical awareness. Although participants acknowledged the importance of verifying AI-generated answers and maintaining academic integrity, some admitted occasional reliance on AI outputs without proper citation. This mirrors concerns raised in recent literature regarding the ethical and critical use of AI in educational settings (Ali et al., 2024; Raharjo & Rohmadi, 2025). Without explicit instruction on ethical practices, there is a risk that students may misuse AI or develop a superficial understanding of mathematical reasoning. Teacher education programs must therefore integrate explicit guidelines and reflective activities to cultivate responsible AI usage, including verification of solutions, acknowledgment of AI assistance, and awareness of potential biases in AI-generated content.

The results also have important implications when viewed through the Technological Pedagogical Content Knowledge (TPACK) framework (Schmid et al., 2024; X. Tan et al., 2025b). High scores in perceived usefulness and ease of use suggest that students possess a growing level of technological knowledge (TK), while positive attitudes and learning engagement indicate readiness to combine technology with pedagogy (TPK). However, the moderate frequency of use and ethical awareness imply that the integration of technology with mathematical content knowledge (TCK) is still developing. To achieve balanced TPACK competence, teacher educators should design assignments that explicitly require students to integrate AI tools with mathematical concepts and pedagogical strategies, rather than treating AI as an optional supplement.

The demographic data further enrich the interpretation of these findings. The dominance of female students and the strong representation of middle- to upper-semester participants suggest that AI integration is being explored across a range of mathematics courses and student experiences. The wide variety of AI applications reported (such as ChatGPT, Photomath, Perplexity, Gemini, QuillBot, and GeoGebra AI) reflects both the versatility of AI and the creativity of students in applying different tools for problem solving, explanation, and instructional design. These patterns indicate that pre-service teachers are not only consumers of AI-generated answers but also experimenters who seek to combine multiple tools for diverse learning purposes.

Taken together, these findings highlight both promising opportunities and critical challenges for AI adoption in teacher education. On the one hand, pre-service teachers exhibit strong motivation and recognize the pedagogical value of AI, which can serve as a foundation for deeper integration in mathematics instruction. On the other hand, the moderate frequency of use and limited ethical awareness point to the need for systematic training, curriculum integration, and policy development. Embedding AI-related competencies within mathematics education courses—through workshops, guided practice, and reflective assessments—will be essential to ensure that future teachers can leverage AI responsibly to enhance mathematical understanding and foster critical thinking in their own classrooms.

Finally, this study contributes to the growing body of literature on AI in teacher education by providing context-specific evidence from Indonesia, a setting where AI adoption in higher education is still emerging. By documenting current practices and perceptions among PGSD students, the findings offer practical insights for curriculum developers, teacher educators, and policymakers who aim to prepare future teachers for an AI-rich educational landscape.

CONCLUSION

This study concludes that prospective elementary school teachers demonstrate a generally positive and constructive engagement with artificial intelligence as a pedagogical tool in mathematics courses. The findings show that students perceive AI to be highly useful and easy to operate, and they express strong motivation and favorable attitudes toward integrating AI into their learning and future teaching practices. Despite these positive perceptions, the frequency of AI use remains at a moderate level, indicating that AI has not yet become a routine component of their mathematics coursework. Ethical awareness is also moderate, reflecting the need for clearer guidance on verifying AI-generated outputs and maintaining academic integrity. These results indicate that while students recognize the pedagogical value of AI and are open to its adoption, sustained training, structured learning opportunities, and explicit ethical guidelines are necessary to strengthen regular usage and ensure responsible application of AI in mathematics education.

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