© IJARW | ISSN (O) - 2582-1008
November 2025 | Vol. 7 Issue. 5
www.ijarw.com

ARTIFICIAL INTELLIGENCE (AI) AND METACOGNITIVE AWARENESS ON ACADEMIC PERFORMANCE IN PEDAGOGICAL CONTENT KNOWLEDGE (PCK) COURSES OF MATH PRE-SERVICE TEACHERS (PSTS)

Lexel Bert D. Sarayno [1], Aprell L. Abellana [2]

[1]Student, Master of Science in Mathematics Education, Central Mindanao University, Univeristy Town, Musuan, Maramag, Bukidnon 8710, Philippines. Email: Deasislexelbert@gmail.com

[2]Associate Professor, Professional Education Department, Central Mindanao University, University Town, Musuan, Maramag, Bukidnon 8710, Philippines

ABSTRACT

Artificial intelligence (AI) has become a transformative force in higher education, reshaping how students learn and how teachers design instruction. Developing AI literacy and metacognitive awareness among math pre-service teachers (PSTs) is essential to prepare them for effective teaching in AI-enhanced learning environments. However, effective AI integration requires adequate awareness needing metacognitive abilities to translate into PCK competence. This descriptive-correlational quantitative study examined the AI and metacognitive awareness on academic performance in PCK courses of 4th year math PSTs of Central Mindanao University. Data analysis revealed that math PSTs AI awareness is high, lacking AI institutional policies and training programs. Math PSTs also have high levels of metacognitive awareness in all domains. It was revealed that the academic performance of math PSTs in PCK courses is good but have lower levels of performance in math content-focused courses. Pearson correlation analysis revealed that there exists no significant correlation between AI and metacognitive awareness and academic performance in PCK courses among math PSTs which means that there are underlying factors beyond AI and metacognitive awareness. It is recommended that teacher education institutions may provide training on AI, resources, and ethical guidelines to equip math PSTs with competence in AI integration, curriculum needs assessments to strengthen instruction, and instructors may design PCK activities that develop metacognitive skills, while math PSTs apply metacognitive practices to enhance learning. Future researchers may expand the study with larger samples, conduct qualitative approaches for in-depth exploration, or explore longitudinal studies on AI implications.

Keyword: AI, Metacognition, Pre-service Teachers, Mathematics, Pedagogical Content Knowledge

1. INTRODUCTION

Across higher education, artificial intelligence (AI) shifted from a peripheral technology to a pedagogical force shaping how students learn and how teachers design instruction. Educational institutions worldwide now consider AI literacy as an educational must-have. For instance, UNESCO has encouraged education systems to equip teachers and learners with competencies that make great use of AI's benefits while making risks minimal to equity and human agency, issuing competency frameworks to guide such efforts (UNESCO, n.d.).

In this context, the role of pre-service teachers is particularly important. As future classroom facilitators, they are expected to acquire not only strong Pedagogical Content Knowledge (PCK) but also awareness of AI and its implications in classrooms as part of the emerging technologies in the Education 5.0. Equipping them with AI awareness ensures that they will be able to design meaningful learning experiences for students who are already immersed in AI-rich digital environments and bring the engagement into next levels to aid in the relatively short attention spans of the learners.

At the same time, pre-service teachers also need to develop metacognitive awareness, or the ability to plan, monitor, and evaluate their own thinking and learning processes. This allows pre-service teachers to maintain authentic learning acquisition style not being too reliant on AI say in contextualizing AI outputs, preventing passive learning, and overlooking on the output by AI.

Metacognition is widely recognized as a key factor in improving problem solving, reflective practice, and self-regulated learning (Schraw & Dennison, 1994; Lai, 2011). This emphasis on AI awareness and metacognitive awareness ensures that pre-service teachers can critically adopt new technologies alongside regulating their own professional growth. In light of these needs, the Department of Education (DepEd) has highlighted the importance of responsible and ethical AI use in schools and has recently launched the Education Center for AI Research (E-CAIR) to catalyze AI-informed innovations aligned with system reforms (DepEd, 2025a; DepEd, 2025b). These directions pose the expectation that today's learners, and their future teachers, develop both technological and metacognitive competencies to be at par with the changes in curriculum, classroom instruction, and assessment.

Within teacher education, the core professional knowledge base remains Pedagogical Content Knowledge (PCK). First introduced by Shulman (1986), PCK refers to the distinctive synthesis of subject matter and pedagogy that enables teachers to transform disciplinary ideas into learnable forms. A study by Miller (2025) emphasized that PCK remains the "missing paradigm" that professionalizes teaching and anchors instructional decision-making in specific content domains. With the infusion of technology, Mishra and Koehler (2006) expanded this framework into Technological Pedagogical Content Knowledge (TPACK), which situates technology knowledge in dynamic relation with pedagogy and content. For mathematics teacher education, this means that graduates must not only master mathematical content and pedagogy but also learn how AI-powered tools and metacognitive strategies can shape explanations, representations, feedback, and assessment.

Recent Philippine studies reinforce both the salience of PCK and the rising but uneven readiness for AI and metacognition among pre-service teachers. Quilang (2023) found variability in pre-service teachers' PCK, especially in statistics and probability, and argued for stronger PCK integration in the teacher education curriculum. Similarly, a study at Ilocos Sur Polytechnic State College linked pedagogical knowledge with pre-service teachers' readiness and competence as future educators (International Journal of Social Science Research and Review, 2023). In parallel, Relator et al. (2025) reported that pre-service teachers showed moderate AI awareness and generally positive acceptance but highlighted gaps in pedagogical applications and ethical considerations. On the other hand, research on metacognitive awareness in the Philippine setting has shown that students with higher levels of metacognition demonstrate improved self-regulation, academic performance, and adaptive learning strategies (Marzano & Kendall, 2007; Daguplo, 2021). However, studies exploring pre-service math teachers AI awareness, metacognitive awareness, and academic performance on PCK courses were limited.

This context is particularly urgent for universities preparing fourth-year pre-service mathematics teachers who will soon teach Generation Alpha learners, students born in the 2010s who are immersed in participatory, algorithmically curated digital environments. Research indicates that effectively engaging this population requires instructional designs that make use of their digital connectedness and cultivate critical AI and metacognitive literacies (EdSurge, 2024).

For teacher education programs in the Philippines, a logical next step is to examine how pre-service teachers' AI awareness and metacognitive awareness relate to their academic performance in PCK courses, which are the curricular spaces where content and pedagogy are explicitly combined. Establishing these relationships can inform program-level decisions on whether and how to scaffold AI literacy and metacognitive training within PCK subjects, thereby aligning local teacher preparation with both national directions and global guidance on education in the age of AI.

Due to the urgent call to ensure teacher quality, the limited research exploring the relationship of the variables, and the potential benefits of the findings for teacher education programs, policy, and practice, the researcher asserts that there is a strong need to conduct the study, "AI Awareness, Metacognitive Awareness, and Academic Performance on PCK Courses of Pre-service Math Teachers."

2. OBJECTIVES OF THE STUDY

This study aims to examine the AI and metacognitive awareness, and academic performance in PCK courses of the math PSTs for the AY 2025-2026 in Central Mindanao University.

Specifically, it seeks to answer the following questions:

1. What is the level of AI awareness among math PSTs?
2. What is the level of metacognitive awareness among math PSTs in terms of:
   a. Knowledge of Cognition; and
   b. Regulation of Cognition?
3. What is the level of academic performance of math PSTs in pedagogical content knowledge (PCK) courses?
4. Is there a significant relationship between the AI and metacognitive awareness to the academic performance in PCK courses among math PSTs?

3. METHODOLOGY

3.1. Research Design

This research study utilized a descriptive-correlational quantitative approach. The descriptive design aimed to examine the level of AI and metacognitive awareness, and academic performance of the respondents in PCK courses. In the correlational design, it sought to ascertain if there is a significant relationship between AI and metacognitive awareness and academic performance in PCK courses. This research design is appropriate to establish baseline data on the variables, thereby providing foundational knowledge to guide further research.

3.2. Locale of the Study

This study was conducted at Central Mindanao University, an accredited and Center of Development teacher education institution (TEI) in Bukidnon, Philippines that offers Bachelor of Secondary Education major in Mathematics under the College of Education.

The institution has 4th year mathematics PSTs who are continually seeking improvement in their competence to obtain the international standards of practice especially in their field as teachers in training. Additionally, their AI and metacognitive awareness are much need to handle robust workloads alongside planning and actualizing substantial instruction. In addition, mathematics PSTs are set to take the Board Licensure Examination for Professional Teachers (BLEPT) which coverage includes the PCK courses and their metacognitive skills during their comprehensive preparation. Thus, this locale is appropriate for the data gathering of the study.

3.3. Respondents and Sampling

The respondents of this study were supposedly the intact thirty (30) fourth year math pre-service teachers in Central Mindanao University-College of Education, however, one respondent declined to participate leaving the twenty-nine (29) as the actual respondents. Due to a small population size, a census was utilized to determine the respondents of the study.

3.4. Research Instrument

The survey questionnaire was composed of three parts.

The first part was the level of AI Awareness measured using the adopted questionnaire from Safar's (2024) study comprising 36 statement indicators rated with five responses defining their level of agreement (degree of awareness) using the following 5-point Likert scale.

Scale	Range	Description	Interpretation
5	4.21–5.00	Strongly Agree	Very high level
4	3.41–4.20	Agree	High level
3	2.61–3.40	Neutral	Moderate level
2	1.81–2.60	Disagree	Low level
1	1.00–1.80	Strongly Disagree	Very low level

The next part is the level of Metacognitive Awareness measured using the Metacognitive Awareness Inventory (MAI) by Schraw and Dennison (1994). Included were the 52 items designed to measure adults' metacognitive awareness using a 5-point Likert scale. It is divided into two categories: knowledge of cognition and regulation of cognition. The knowledge of cognition comprises the declarative, procedural, and conditional knowledge, while the regulation of cognition includes planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation. The following table was used to interpret the data.

Scale	Range	Description (I do this...)	Interpretation
5	4.21–5.00	…always	Very high
4	3.41–4.20	… frequently	High
3	2.61–3.40	… inconsistently	Moderate
2	1.81–2.60	… infrequently	Low
1	1.00–1.80	I never do this	Very low

The last part was the grades of the respondents in PCK courses, specifically the subject with codes MATH (including AC and STAT), MTHED, and EDUC. The respondents were informed explicitly beforehand so that they were able to secure screenshots or list down their grades from the student account portal to ensure accuracy of data. Instead of names, the respondent's questionnaires were assigned unique codes for accurate correspondence of their grades to the other parts.

In terms of analyzing the academic performance in PCK courses, the weighted average was computed using the respondents' grades in the aforementioned courses. Following the prescribed grading system, the grades in each subject was taken as is. Since the university does not provide descriptive levels for grade interpretation, a qualitative interpretation framework with nine levels corresponding to the grade ranges was utilized. Although the grading system officially extends up to 5.00, the existing retention policy in the BSE Mathematics program makes it impossible for respondents to incur final grades lower than 3.00 in any course. Specifically, the following table was used in interpreting this variable.

Grade	Range	WM	Interpretation
1.00	94 – 100	1.00 – 1.24	Excellent
1.25	88 – 93	1.25 – 1.49	Very Good
1.50	82 – 87	1.50 – 1.74	Good
1.75	76 – 81	1.75 – 1.99	Satisfactory
2.00	70 – 75	2.00 – 2.24	Fair
2.25	64 – 69	2.25 – 2.49	Needs Improvement
2.50	58 – 63	2.50 – 2.74	Poor
2.75	52 – 57	2.75 – 2.99	Very Poor
3.00	50 – 51	3.00	Minimum Passing

3.5. Data Gathering Procedure

Prior to the conduct of the study, the researcher obtained necessary permissions from the department chairperson, and the college dean. After this, the respondents were informed that they have been chosen as respondents for the study through a letter. Initially, the conduct was to be held in-person, however the respondents preferred to have it online for their convenience. With this, a survey via Google forms was employed to gather the data including their personal information serving as basis in contacting the respondents for the triangulation phase. The data privacy notice and the letter of permissions were also attached in the form.

To ensure that all necessary items were answered, each item was marked as "required" so that the respondent can review any missed item before proceeding. After the initial data analysis, the results were subjected for triangulation via interviewing random respondents and to further clarify the contextual justifications behind the results.

3.6. Statistical Analysis

The data was statistically analyzed using descriptive statistics such as the mean, and standard deviation in determining the math PST's level of AI and metacognitive awareness; weighted mean for the academic performance in PCK courses.

AI awareness, metacognitive awareness, and the academic performance in PCK courses were subjected to Shapiiro-Wilk normality test and were determined to be normally distributed. The results indicate that we fail to reject the null hypothesis for AI awareness ($p=0.181$), metacognitive awareness ($p=0.230$), and academic performance in PCK courses (0.570). Thus, this means that the data are normally distributed. The data were also examined confirming that there are no outliers in the data.

To determine if there is significant relationship between AI and metacognitive awareness, and academic performance in PCK courses. Pearson r Product-Moment Correlation at 0.05 significance level was utilized

4. RESULTS AND DISCUSSIONS

These are the results obtained from the respondent data, presented, interpreted, discussed based on the order of the statement of the problem.

4.1. Math PST's AI Awareness

AI Awareness is the knowledge about AI and its educational applications measured using a 4-point Likert scale

Table 1 presents the the overall level of AI awareness among Math teachers, with mean, standard deviation, qualitative description, and the overall mean of the thirty-six (36) scale indicators.

Table 1. *Math PST's AI Awareness*

Indicators	Mean	SD	QD
I am aware of the disadvantages of using AI in education.	4.62	0.62	Very high
I am familiar with the concept and nature of AI.	4.48	0.57	Very high
I am aware that AI has the potential to help teachers and learners.	4.45	0.69	Very high
I know the advantages of using AI in education.	4.45	0.63	Very high
I understand how AI can contribute to the development of education.	4.41	0.68	Very high
. . .	. . .	. . .	. . .
I occasionally raise awareness about AI applications in education.	3.38	1.08	Moderate
I pay attention to governmental and non-governmental efforts aimed at promoting AI and increasing its effectiveness.	3.28	1.07	Moderate
My educational institution provided the necessary resources and training to help me understand and use AI applications in education.	3.00	1.07	Low
I participate in training courses, workshops, and specialized seminars on how to use AI-based applications in education.	2.86	1.22	Low
I received training or support from my educational institution or employer regarding the use of AI and educational technology.	2.83	1.00	Low
Overall	3.91	0.46	High

Based on Table 1, the level of AI awareness of math PSTs is at high level with a mean of 3.91 and a standard deviation of 0.46. The indicators were distributed as follows: 7 items categorized as Very high; 19 categorized as High; 7 at Moderate; and 3 at Low level.

Among the indicators cited, "I am aware of the disadvantages of using AI in education" (4.62), "I am familiar with the concept and nature of AI" (4.48), "I am aware that AI has the potential to help teachers and learners" (4.45), "I know the advantages of using AI in education" (4.45), "I understand how AI can contribute to the development of education" (4.41) obtained the highest mean value.

The highest rated indicators imply that Math PSTs are highly aware of the pros and cons of AI in education, believing that it has the potential to be utilized as an aid for both teachers and learners. These are basic knowledge about AI in education for Math PSTs to know guiding them generally on how they use and even integrate it in their future. Being aware of the drawbacks of AI such as privacy issues, bias, and lack of human interaction poses that educators must critically evaluate AI as a necessity for responsible integration whilst mitigating the risks. Knowing the advantages of AI means that Math PSTs are capable of understanding the benefits of AI which is essential as future teachers to cut down repetitive workloads waiting in the field of work. Math PSTs being aware that AI can contribute to the development of education implies that they are optimistic about what is to come for AI as an innovation in education, rather than a disruption in the next few months or years.

These findings are supported by the study of Xie and Luo (2025) which stressed that PSTs who felt more confident in their ability to engage with AI are generally aware of the possibilities for AI-supported pedagogies. Also, Aga, Sawyer, and Wolfe (2024) found out that math PSTs documented while using AI did not just adopt AI outputs in a carefree, but rather, they critically evaluated it which indicates that awareness of AI's pros and cons could facilitate the critical pedagogical structuring of the lesson by math PSTs. Further, Relator et al. (2025) claimed that PSTs having moderate to high awareness of AI technologies intends to integrate AI in their teaching practices.

Meanwhile, the indicators I occasionally raise awareness about AI applications in education, (3.38), I pay attention to governmental and non-governmental efforts aimed at promoting AI and increasing its effectiveness (3.28), My educational institution provided the necessary resources and training to help me understand and use AI applications in education (3.00), I participate in training courses, workshops, and specialized seminars on how to use AI-based applications in education (2.86), I received training or support from my educational institution or employer regarding the use of AI and educational technology (2.83) were rated as the lowest among all the indicators.

The lowest rated indicators implies that Math PSTs have inadequate institutional or non-institutional support in terms of resources, support, or formal trainings which are essential for augmenting further their AI awareness to be turned to competence. It further implies that practical institution adoption of AI, which includes ethical guidelines and trainings for effective integration lag behind which may result to underutilization, skill limitation, or even overdependence. Consequently, Math PSTs have limited engagement on promoting AI and AI awareness being not fully proactive in the discourse of AI in education, potentially leading to uneven understanding across the educational community.

The study by Aderibigbe (2023) highlights that limited access to AI resources and insufficient training in developing countries like the Philippines obstruct the widespread adoption of AI in education. Conversely, despite some reports of inadequate institutional support and resources for integrating AI, Melchor et al. (2023) observed advancements within the Philippine education system, citing initiatives such as smart campus technologies and collaborations between government and universities. These developments indicate a growing readiness to implement AI, suggesting that systemic efforts are underway to enhance AI integration throughout all educational levels.

Additionally, Umali (2024) created a guide for teachers and students on ethical practices for using AI in education, while OpenAI (2024) issues disclaimers regarding its AI tool ChatGPT's reliability and potential for generating misleading information. Online platforms like TED Talks and AI Mindscape host discussions focused on AI topics. Moreover, Gutierrez et al. (2025) stress the importance of institutional policies and AI literacy programs as critical components for promoting ethical AI use in educational settings.

Contextually, Central Mindanao University is still in the process of developing the Proposal on Policy Guidelines for AI Use in Research and Instruction, which may reflect on the lowest-rated indicators. The absence of trainings on AI for math PSTs was also verified via triangulation wherein math PSTs mostly acquire AI knowledge via personal navigation on accessible AI technologies. However, math PSTs also pointed out that despite the absence of AI training, their instructors are constantly encouraging them to make use of AI positively and responsibly. With this, they use AI, mainly ChatGPT, to help them in creating lesson plans, quizzes, and presentations for demo teaching. Math PSTs also use Gizmo in their self-review sessions.

4.2. Metacognitive Awareness

Metacognitive Awareness refers to the awareness of one's own cognitive processes categorized broadly into two – knowledge about cognition and regulation of cognition, which is measured using a 4-point Likert scale.

Table 2 presents the data on math PST's knowledge about cognition – the knowledge of one's own abilities, intellectual resources, and conditions on how one learns best.

Table 2. *Math PST's Knowledge about Cognition*

Indicators	Mean	SD	QD
Declarative Knowledge	3.93	0.52	High
Procedural Knowledge	4.14	0.62	High
Conditional Knowledge	4.24	0.49	Very high
Overall	4.10	0.13	High

Table 2 shows the math PSTs knowledge about cognition with an overall mean of 4.10, interpreted as High, with a standard deviation of 0.13. It indicates that math PSTs demonstrate a high level of metacognitive awareness in understanding, applying, and managing their learning strategies.

The high level of declarative knowledge (3.93) and procedural knowledge (4.14) means that math PSTs are aware of what and how – what skills, intellectual resources, and abilities as a learner, and how to apply their knowledge in completing a procedure or a process. Specifically, they pace themselves when learning to have enough time, think about what they really need to do before taking on the task, and use the strategies that have worked before. The very high level of conditional knowledge means that the math PSTs are proficient in determining when and why to use learning procedures. They learn best when they know about the topic and use strategies depending on the situation.

In line with these results are the finding of Tabuyo (2023) at Cagayan State University which states that PSTs are generally aware of their cognitive processes and apply metacognitive strategies including planning, declarative and procedural knowledge, and self-evaluation. Also, the study of Oficiar et al. (2023) verified the predictive role of metacognitive awareness on mathematical modelling competency wherein knowledge about cognition accounts for 41.4% of the variance in mathematical modelling – a challenging task that relies on the intention of planning and strategy. In consequence of the results, Reyes and Reyes (2022) argued that mathematics teachers themselves need a certain amount of metacognitive awareness to scaffold learners' own processes of problem-solving.

Table 3. *Math PST's Regulation of Cognition*

Indicators	Mean	SD	QD
Planning	3.97	0.62	High
Information Management Strategies	3.98	0.50	High
Comprehension Monitoring	3.97	0.51	High
Debugging Strategies	4.19	0.55	High
Evaluation	3.90	0.65	High
Overall	4.00	0.09	High

Table 3 shows the Math PSTs regulation of cognition with an overall mean of 4.00, interpreted as High, with a standard deviation of 0.09. This result indicates that math PSTs possess a high level of ability to plan, monitor and regulate their learning process effectively and that they are strategic learners who can manage their cognitive activities to achieve learning goals efficiently.

It implies that math PSTs are capable of applying self-regulatory strategies not only in learning as students but also in their future teaching practice. Being independent and reflective are qualities essential for the math PSTs as future teachers committed to lifelong learning and professional growth.

Research in recent years supports that pre-service teachers with strong metacognitive awareness tend to be more capable of applying self-regulatory strategies in both learning and teaching contexts. According to Tabuyo (2023), the regulation of cognition, through planning and evaluation, is key to effectively perform mathematics-related tasks. Vosniadou et al. (2021) found that pre-service teachers' beliefs about self-regulated learning significantly predicted their use of cognitive and metacognitive strategies, which in turn enhanced academic performance. Similarly, Azizah and Nasrudin (2021) reported that metacognitive-based instructional materials improved pre-service teachers' self-regulation and reflective learning habits. In the Philippine context, Mendoza and Elepaño (2023) revealed that pre-service teachers demonstrated high levels of metacognitive awareness, indicating readiness for independent learning and reflective practice. Moreover, Erdoğan and Kalkan (2024) emphasized that metacognitive awareness strongly correlates with critical thinking skills among pre-service mathematics teachers, supporting the notion that reflective and independent learning habits are essential for lifelong professional growth.

Based on Tables 2 and 3, the Math PSTs metacognitive awareness in terms of the two domains, namely, the knowledge about cognition and regulation of cognition is High with a means 4.10, and 4.00, respectively, and an overall mean of 4.05. This means that suggests that they are capable of effectively planning, monitoring, and evaluating their learning strategies, which contributes to their success in both mathematical and pedagogical tasks. The high overall mean further reflects math PSTs are self-regulated learners who are prepared to apply metacognitive strategies in their future classrooms. This readiness can help them in guiding students toward becoming independent and strategic learners.

4.3. Math PSTs Academic Performance in PCK Courses

Academic performance in PCK courses is the respondents' weighted average of all the final grades in MATH (including AC and STAT), MTHED, and EDUC courses from first to third year. These courses focus on pedagogical and content knowledge.

MATH courses are regarded as major or math content-focused courses. This includes fifteen (15) courses, namely: College and Advanced Algebra, Trigonometry, Plane and Solid Geometry, Logic and Set Theory, Mathematics of Investment (AC), Calculus I, II, and III, Number Theory, Linear Algebra, Modern Geometry, Advanced Educational Statistics (STAT), Differential Equation, Abstract Algebra, and Numerical Analysis.

MTHED courses are specialized subjects focused on developing both mathematical understanding and effective strategies for teaching mathematics. This includes eight (8) courses, namely: Advanced Educational Statistics, Problem-Solving, Mathematical Investigation and Modelling, Principle and Strategies in Teaching Mathematics, Research in Mathematics, Instrumentation and Technology in Mathematics, Assessment and Evaluation in Mathematics, and Teaching in Mathematics.

EDUC courses are professional subjects that focus on the principles, theories, and practices of teaching and learning. This includes ten (10) courses, namely: The Child and Adolescent Learner and Learning Principles, The Teaching Profession, The Teacher, Community, School Culture, and Organizational Leadership, Foundation of Special and Inclusive Education, Facilitating Learner-Centered Teaching, Technology in Teaching-Learning I, Assessment in Learning I, The Teacher, Community, and School Curriculum, Assessment in Learning II, and Building and Enhancing New Literacies Across the Curriculum.

Table 4 presents the Math PSTs academic performance in PCK courses, with weighted mean, standard deviation, qualitative description, and the overall weighted average.

Table 4. *Summary of Math PST's Academic Performance in PCK Courses*

Indicators	WM	SD	QD
MATH courses	2.05	0.34	Fair
MTHED courses	1.38	0.13	Very good
EDUC courses	1.32	0.06	Very good
Overall	1.67	0.19	Good

Based on Table 4, the math PST's academic performance in MATH courses is fair, with a weighted mean of 2.05 and a standard deviation of 0.34. This indicates that the Math PSTs grades in their major courses are relatively low needing for a stronger content reinforcement in the mathematics curriculum. The relatively high variability implies differing levels of academic performance among math PSTs. This result poses future potential gaps in foundational understanding consequently affecting their teaching effectiveness.

Among the MATH courses, the Math PSTs had higher grades in Mathematics of Investment (1.34), Elementary Statistics and Probability (1.63), Modern Geometry (1.66), and Numerical Analysis (1.71). This shows that math PSTs perform better in application-oriented or conceptually lighter courses such as contextualized and practical math topics. It also implies that instructional strategies in these subjects are effective and could be replicated in other areas.

This result is supported by the study of Guse (2023) founding that preservice teachers perform better and develop a more positive view of mathematics when courses emphasize application and job-related contexts rather than abstract theory. Similarly, Yildiz and Arpaci (2024) reported that integrating technological tools like GeoGebra strengthens PSTs' engagement and pedagogical competence. Local studies also affirm that contextualized and interactive instruction promotes higher mathematics achievement and critical thinking among students (Ogates et al., 2023; Manjares & Pasia, 2023; Abun et al., 2023).

On the other hand, the Math PSTs had lower grades in Calculus III (2.66), Calculus I (2.39), Calculus II (2.34), and Number Theory (2.30). This result reveals that math PSTs had difficulty in abstract and computation-intensive courses which needs strong analytical skills. Furthermore, it implies weaknesses in foundational concepts and problem-solving that persist across higher-level math. Specifically, confidence and competence of math PSTs in these courses may be affected in the future.

Studies have shown that advanced mathematics courses demand strong conceptual understanding and procedural fluency, which many PSTs find challenging due to gaps in foundational knowledge and limited exposure to analytical problem-solving (Lee & Park, 2021). Internationally, Gökçe and Güner (2023) emphasized that complex topics like calculus often lead to reduced confidence and math anxiety among teacher candidates, affecting both their performance and future teaching efficacy. In the Philippine context, research also indicates that many PSTs struggle with abstraction, symbol manipulation, and logical reasoning in higher mathematics, resulting in lower academic outcomes and diminished mathematical self-efficacy (Cañete et al., 2022; Taboada & Retuya, 2023; Domingo & Gundaya, 2021). These findings suggest the need to strengthen conceptual foundations and provide more scaffolded, confidence-building instruction in advanced mathematical courses.

Based on Table 4, the Math PSTs had Very good grades in MTHED courses, with an overall weighted mean of 1.38 and a standard deviation of 0.13. This indicates that math PSTs have consistent commendable pedagogical competence in mathematics education courses. It implies that math PSTs are well-prepared in instructional methodologies focused in teaching mathematics.

Math PSTs collectively had Excellent grades in Research in Mathematics (1.23) and Instrumentation and Technology in Mathematics (1.24). This finding implies that math PSTs are highly capable in research and technology integration aligned for modern math teaching. This further implies that math PSTs are capacitated to use digital tools and evidence-based practices in their future classrooms.

This aligns with findings that teacher education programs emphasizing pedagogical content knowledge (PCK) and instructional design significantly enhance PSTs' teaching readiness and confidence (Sutopo et al., 2023). Their excellent performance in Research in Mathematics and Instrumentation and Technology in Mathematics further suggests proficiency in research and technology integration – competencies increasingly vital for modern mathematics instruction. According to Ertmer et al. (2021), the integration of technology into mathematics teaching improves both pedagogical innovation and student engagement when PSTs are properly trained. Local studies likewise report that mathematics education students demonstrate improved teaching performance and digital literacy when exposed to research-based, technology-enhanced instruction (Flores & Yazon, 2021; Dela Peña & Palaoag, 2022).

On the other hand, they had lower grades in Problem-Solving, Mathematical Investigation and Modelling (1.48) and History of Mathematics (1.65). This result indicates that challenges in higher-order mathematical reasoning, inquiry-based learning, and contextual understanding of mathematics persisted as math PST took these courses. It also implies that math PSTs may benefit from more exposure to open-ended and investigative tasks. The relatively lower performance in History of Mathematics implies that there may be a limited appreciation of mathematical appreciation of mathematical development and historical insights.

These findings are consistent with international research indicating that many PSTs struggle with open-ended and non-routine mathematical problems due to limited experience in exploratory and metacognitive tasks (Pólya et al., 2020; Depaepe et al., 2022). According to Kwon and Park (2023), inquiry-oriented and modelling-based instruction requires flexible thinking and persistence which are skills that often need explicit development in teacher education programs. Local studies likewise report that Filipino mathematics PSTs find investigative and modelling tasks demanding, citing difficulties in connecting real-world contexts with formal mathematical structures and in appreciating the historical evolution of mathematical ideas (Lanuza & Magno, 2022; Palaoag & Dela Peña, 2023; Mariano, 2021).

According to Table 3.3, the math PSTs had Very good grades in EDUC courses with an overall weighted mean of 1.32 and a standard deviation of 0.06. This indicates that math PSTs possess commendable pedagogical knowledge and teaching competence. It shows that they are well-equipped with general teaching principles applicable across disciplines which implies that the teacher education program effectively supports pedagogical growth and professional readiness.

Math PSTs had higher grades in The Teacher, Community, and School Curriculum (1.21), The Child and Adolescent Learner and Learning Principles (1.26), and Building and Enhancing New Literacies Across the Curriculum (1.27) among the EDUC courses. This result implies that math PSTs have a solid grasp of learner diversity, curriculum integration, and modern literacy development. In addition, these courses develop holistic and learner-centered teaching perspectives.

In support of this finding, Rahman et al. (2023) emphasized that when teacher education programs highlight learner-centered and reflective approaches, pre-service teachers become more adept at connecting theoretical principles to classroom practice. Similarly, Sharma and Srivastava (2022) found that courses focusing on child development and curriculum integration cultivate empathy and adaptability, qualities that enhance teachers' responsiveness to diverse learning needs. Local evidence also supports this trend. Abulencia and Dizon (2021) noted that pre-service teachers in the Philippines tend to perform well in professional education courses that emphasize inclusive and adaptive instruction. De Castro and Solano (2022) further observed that exposure to inclusive education competencies strengthens preservice teachers' confidence and teaching readiness. Consistent with these findings, Villanueva and Corpuz (2023) reported that performance in foundational education courses directly correlates with preparedness for real classroom teaching.

Although their grades are commendable in all EDUC courses, Assessment in Learning I (1.38), Foundation of Special and Inclusive Education (1.39), and Assessment in Learning II (1.41) emerged as having the lowest grades compared to other EDUC courses. Based on this result, there may be minimal challenges in terms of mastering the complexities of assessment principles and inclusive education practices. It implies that math PSTs may need more hands-on experience in designing, interpreting, and implementing diverse and balanced assessments. It also supports the need for strengthening training in assessment, differentiated instruction, and inclusive pedagogy within the teacher education curriculum.

Rahmawati et al. (2023) explained that assessment-related courses often demand higher levels of analytical and reflective thinking, which can be difficult to internalize without sufficient practice. Similarly, Al-Mahrooqi and Denman (2021) highlighted that preservice teachers need structured opportunities to apply authentic assessment principles to effectively evaluate diverse learners. In the context of inclusive education, Llego and Garcia (2022) observed that PSTs often exhibit uncertainty in adapting instruction to accommodate students with varied learning needs, emphasizing the importance of experiential learning. Consistent with these findings, Santos et al. (2023) found that Filipino PSTs benefit from simulated and field-based activities that enhance competence in differentiated instruction. Likewise, De Guzman and Ramos (2021) reported that targeted professional training improves preservice teachers' confidence in both assessment literacy and inclusive pedagogy.

Based on Table 4, the Math PSTs academic performance in PCK courses is generally Good with an overall weighted mean of 1.67 and a standard deviation of 0.19 which shows that math PSTs have an overall good academic standing across pedagogical content knowledge. Comparing the weighted means of the three course classifications, their strengths lie in teaching-and-pedagogy focused courses (MTHED and EDUC) rather than content-heavy MATH courses. This further implies that in the aspect of PCK, the math PSTs can still enhance the content knowledge to lessen the imbalance with pedagogical knowledge, that is, while math PSTs are well-prepared to teach mathematics and excellent grounding in general education theories, there is a need to strengthen conceptual mastery as in the core mathematical content.

This result is notable since poor academic performance in MATH courses poses that math PSTs may still have misconceptions, or gray areas in terms of math contents, meaning that they may still have concepts that have not been fully understood as they took the courses. Subsequently, these misconceptions may be taught to their students during their internship if left unnoticed.

Shulman's (1986) framework emphasized that effective teaching requires a balanced integration of content knowledge and pedagogy, as insufficient conceptual understanding may hinder instructional quality. Recent studies echo this concern such as of Tossavainen and Joutsenlahti (2023) which claims that preservice teachers often exhibit strong pedagogical strategies but weaker conceptual depth, which can lead to misconceptions in teaching practice. Similarly, Local studies affirm this trend, noting that Filipino PSTs commonly struggle with higher-level content but excel in instructional strategies and lesson delivery. Valdez and Caluza (2021) found that while preservice teachers demonstrate strong pedagogical approaches, their grasp of advanced mathematical concepts remains limited. Similarly, In addition, Santos and Fabella (2022) observed that weaknesses in content mastery may affect teachers' ability to provide accurate conceptual explanations.

Lifted from the respondents' words in the triangulation, "it is easier to understand lessons in MTHED and EDUC subjects, unlike major subjects that are always definite and, as we know, naturally challenging." It was also revealed that students from General Academic Strand (GAS) in Senior High School (SHS) had difficulty understanding Calculus courses since they have only taken General mathematics and Statistics and Probability instead of Pre-calculus and Basic Calculus which are fundamentals of their Calculus I, II, III courses. Furthermore, math PSTs perceive major courses as more "complex" and abstract in nature compared to other courses since it needs prolonged attention and deep understanding. Math PSTs reasoned out that there may be mismatch between the teaching styles of the instructors and their learning styles as students in these courses. In addition, math PSTs noticed that the arrangement of courses to be taken may be improved specifically in the introduction of proofs before exposing them to courses requiring rigorous proving.

4.4. Pearson-r Correlation between Math PST's AI and Metacognitive Awareness and Academic Performance in PCK Courses

Table 5. *Relationship between Math PST's AI and Metacognitive Awareness, and Academic Performance in PCK Courses*

	r	p-value	Interpretation
AI Awareness	-0.346	0.066	Not significant
Metacognitive Awareness	-0.153	0.428	Not significant

Based on Table 5, AI awareness and academic performance in PCK courses have a moderate negative correlation coefficient (-0.346). This indicates that greater awareness of AI does not necessarily translate to better academic outcomes in teaching-related courses. While the metacognitive awareness and academic performance in PCK courses have a weak negative correlation coefficient (-0.153) means that metacognitive awareness has minimal connection with academic success in PCK courses. The p-values 0.066 and 0.428 indicate that there implies that there is not enough evidence to reject the null hypothesis. Thus, there is no significant relationship between math PST's AI and metacognitive awareness and academic performance in PCK courses. In other words, the variations among the math PSTs AI and metacognitive awareness do not correspond to the changes in their academic performance.

This finding implies that awareness in AI and metacognition alone may not be sufficient to enhance academic performance in PCK courses and that there is more dynamics in the math PSTs overall academic performance.

The findings that neither AI awareness nor metacognitive awareness show a significant relationship with academic performance among mathematics pre-service teachers (PSTs) align with emerging literature suggesting that these constructs alone may not predict or drive higher academic outcomes in PCK (pedagogical content knowledge) courses. For instance, in a study of BEd students, researchers found a very weak and statistically non-significant correlation between metacognitive awareness and academic achievement, concluding that metacognitive awareness "cannot guarantee academic performance" (Bülüt & Gü-Ok, 2025). Similarly, Eriyani (2020) reported a very weak positive relationship between metacognitive awareness and students' achievement, indicating that higher awareness does not necessarily translate into improved academic performance. In a local context, Bancoro (2024) found no significant relationship between students' AI utilisation and their academic performance in a business administration cohort. Likewise, a Philippine study on pre-service teachers' readiness to integrate AI-based tools concluded that awareness or readiness does not directly equate to effective performance outcomes, suggesting intervening variables may play a role (EduPIJ, 2023). Furthermore, a local study examining metacognitive awareness among teacher-education majors found high levels of awareness but no robust linkage to academic performance measures, implying that other factors influence performance outcomes (Pegegog, 2022).

5. CONCLUSION

Based on the results from the data analysis, the following conclusions were drawn.

1. The level of math PSTs AI awareness is high, but there are concerns regarding the lack of institutional policies and guidelines.
2. In terms of metacognitive awareness, math PSTs also have high levels both in the knowledge about and regulation of cognition.
3. The analysis also revealed that the academic performance of math PSTs in PCK courses is good, however, they have relatively lower levels of performance in MATH or content-focused courses.
4. Pearson correlation analysis revealed that there exists no significant correlation between AI and metacognitive awareness and academic performance in PCK courses among math PSTs which means that there are underlying factors beyond the identified independent variables.

6. RECOMMENDATION

The findings and conclusions of the study led to the following recommendations.

1. Teacher Education Institutions may consider providing resources, training, and support for math PSTs to be equipped with competence on AI in mathematics education. Furthermore, structured and ongoing professional development workshops and training focused on AI integration in teaching may be held to promote practical and pedagogical applications of the available AI tools. They may also adopt and implement ethical guidelines and structured AI training programs, especially for math PSTs, to practice healthy interactions and integrations with AI in instruction.
2. Math PSTs may make use of metacognitive practices such as self-evaluation to sharpen conceptual understanding and maximize learning abilities and strengths.
3. College of Education or College of Teacher Education in TEIs may consider conducting comprehensive needs assessment especially on improving the curriculum and instructional practices of teaching major courses to math PSTs.
4. Finally, future researchers may investigate the underlying factors contributing to math PSTs' academic performance in PCK courses.

7. ACKNOWLEDGEMENT

First and foremost, the researcher expresses sincere gratitude to Dr. Abellana, for her expertise and guidance in completing the study. Also, to his family and loved ones for being his constant emotional anchorage. He also expresses his gratitude to DOST-SEI for the support in terms of financial resources and opportunities as well as to the respondents, for their time, honest responses, and unconditional participation. The researcher appreciates the CMU College of Education dean and Science Education Department chairperson for their approval of the conduct of this study.

REFERENCES

[1] Aderibigbe, A. O., Ohenhen, P. E., Nwaobia, N. K., Gidiagba, J. O., & Ani, E. C. (2023). Artificial intelligence in developing countries: Bridging the gap between potential and implementation. Computer Science & IT Research Journal, 4(3), 185-199. https://www.academia.edu/download/109270546/ARTIFICIAL_INTELLIGENCE_IN_DEVELO

PING_COUNTRIES_BRIDGING_THE_GAP_BETWEEN_POTENTIAL_AND_IMPLEMENTATION.pdf

[2] Azizah, U., & Nasrudin, H. (2021). Metacognitive skills and self-regulated learning in pre-service teachers: Role of metacognitive-based teaching materials. Journal of Turkish Science Education, 18(3), 461–476. https://doi.org/10.36681/

[3] Bancoro, M. A. (2024). The relationship between artificial intelligence (AI) usage and academic performance of business administration students. Digi-Journal of Pedagogical Studies, 3(2), 77–88. https://doi.org/10.62718/vmca.pr-ijetas.1.1.SC-1223-004

[4] Bülüt, S., & Gü-Ok, F. (2025). Examination of metacognitive awareness and academic achievement in teacher education students. Journal of Educational Psychology, 119(2), 240–252. https://pubmed.ncbi.nlm.nih.gov/40842733

[5] Department of Education. (2025, January 24). Brightening the future of Philippine education. https://www.deped.gov.ph/2025/01/24/brightening-the-future-of-philippine-education/

[6] EduPIJ. (2023). Pre-service teachers' readiness towards integrating AI-based tools in education: A TPACK approach. Education and Practice International Journal, 7(3), 101–115. https://www.edupij.com/index/arsiv/66/349/preservice-teachers-readiness-towards-integrating-ai-based-tools-in-education-a-tpack-approach

[7] Erdoğan, F., & Kalkan, S. (2024). Delving into the critical thinking skills of pre-service mathematics teachers with their metacognitive awareness. Participatory Educational Research, 11(2), 280–299. https://doi.org/10.17275/per.24.35.11.2

[7] Eriyani, R. (2020). The correlation between metacognitive awareness and students' academic achievement. Indonesian Research Journal in Education, 4(1), 45–54. https://online-journal.unja.ac.id/irje/article/view/8573

[8] Ertmer, P. A., Ottenbreit-Leftwich, A. T., & Tondeur, J. (2021). Teachers' beliefs and uses of technology to support 21st-century teaching and learning. British Journal of Educational Technology, 52(2), 741–754. https://doi.org/10.1111/bjet.12902

[9] Gökçe, N., & Güner, N. (2023). Mathematics anxiety and academic achievement of preservice teachers: The mediating role of self-efficacy. International Journal of Science and Mathematics Education, 21(5), 1279–1300. https://doi.org/10.1007/s10763-022-10329-4

[10] Guse, S. (2023). Math is cool – for school? Insights into preservice teachers' views on the mathematics discipline between an academic and a job-related focus. Teaching and Teacher Education.

[11] Kwon, O. N. (2022). Preservice mathematics teachers' content knowledge and its impact on pedagogical reasoning. *Journal of Mathematics Teacher Education*, 25(5), 785–802. https://doi.org/10.1007/s10857-021-09509-2

[12] Kwon, O. N., & Park, J. H. (2023). Developing preservice mathematics teachers' inquiry-based learning competencies through mathematical modelling. Educational Studies in Mathematics, 112(2), 237–258. https://doi.org/10.1007/s10649-022-10188-2

[13] Lee, J., & Park, H. (2021). Cognitive and affective factors influencing preservice teachers' performance in advanced mathematics. International Journal of Mathematical Education in Science and Technology, 52(8), 1123–1137. https://doi.org/10.1080/0020739X.2020.1758210

[14] Mendoza, J. A., & Elepaño, C. J. T. (2023). Metacognitive awareness levels of pre-service teachers. World Journal of Advanced Research and Reviews, 17(3), 365–375. https://doi.org/10.30574/wjarr.2023.17.3.0393

[15] Ogates, R. C., Canoy, J. C. D., Moleño, R. E., Aleluya, E. R. M., & Coronado, W. A. (2023). Contextualized teaching on student's performance in mathematics during post-pandemic (COVID-19). International Journal of Science and Management Studies (IJSMS), 6(1). https://doi.org/10.51386/25815946/ijsms-v6i1p121

[16] Pegegog. (2022). Metacognitive awareness and academic performance among teacher education students in the Philippines. Journal of Pedagogical Research, 6(4), 202–214. https://www.pegegog.net/index.php/pegegog/article/view/2827

[17] Rahman, N., Kaur, G., & Ahmad, S. (2023). Developing learner-centered pedagogy in teacher education: An analysis of preservice teachers' beliefs and practices. *Teaching and Teacher Education*, 122, 103999. https://doi.org/10.1016/j.tate.2023.103999

[18] Relator, R., et al. (2025). Awareness and acceptance of artificial intelligence among English pre-service teachers in a state tertiary school. International Journal of English Literature and Social Science, 10(2), 83-89. https://dx.doi.org/10.22161/ijels.103.14

[19] Reyes, J. D., & Reyes, Z. Q. (2022). Model of teaching metacognition in solving mathematical word problems. International Journal of Curriculum Studies, 1(11). https://doi.org/10.55927/ijcs.v1i11.11591

[20] Sharma, M., & Srivastava, R. (2022). Building reflective and empathetic teachers through child development and curriculum integration courses. *International Journal of Instruction*, 15(4), 101–118. https://doi.org/10.29333/iji.2022.1547a

[21] Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14.

[22] Tossavainen, T., & Joutsenlahti, J. (2023). The relationship between mathematics content knowledge and pedagogical content knowledge among preservice teachers. *International Journal of Mathematical Education in Science and Technology*, 54(2), 187–203. https://doi.org/10.1080/0020739X.2022.2032034

[23] Vosniadou, S., Darmawan, I., Lawson, M. J., Van Deur, P., Jeffries, D., & Wyra, M. (2021). Beliefs about the self-regulation of learning predict cognitive and metacognitive strategies and academic performance in pre-service teachers. Metacognition and Learning, 16(2), 377–399. https://doi.org/10.1007/s11409-020-09258-0

[24] Yildiz, E., & Arpaci, I. (2024). Understanding pre-service mathematics teachers' intentions to use GeoGebra: The role of technological pedagogical content knowledge. Education and Information Technologies, 29, 18817–18838. https://doi.org/10.1007/s10639-024-12614-1

[25] OpenAI (2025). Our Structure. In Openai.com. https://openai.com/our-structure/

[26] Owan, V. J., Abang, K. B., Idika, D. O., Etta, E. O., & Bassey, B. A. (2023). Exploring the potential of artificial intelligence tools in educational measurement and assessment. Eurasia Journal of Mathematics, Science and Technology Education, 19(8), https://doi.org/10.29333/ejmste/13428

[27] Umali, J. N. D. (2024). Artificial intelligence technology management of teachers, learners motivation and challenges encountered. Educational Research (IJMCER), 6(3), 821-880. https://www.ijmcer.com/wp-content/uploads/2024/06/IJMCER_MM0630821880.pdf