https://research.adra.ac.id /index.php/ijen/
P - ISSN: 2988-1579
E - ISSN: 2988-0092

The Effect of Educational Institution Differences on the Metacognitive Awareness of Mathematics Education University Students in Indonesia

Zainal Abidin[1], Aiyub[2], Khairatul Ulya[3]
[1]Universitas Islam Negeri Ar-Raniry Banda Aceh, Indonesia
[2]Universitas Islam Negeri Ar-Raniry Banda Aceh, Indonesia
[3]Institut Agama Islam Negeri Langsa, Indonesia

ABSTRACT

Background. Metacognitive awareness concerns how students plan, monitor, and evaluate their thinking during mathematical problem solving. Evidence from Indonesian higher education remains limited, particularly across the two public university systems represented by State Islamic Religious Higher Education Institutions (PTKIN) and State Public Higher Education Institutions (PTUN).

Purpose. This study compared the metacognitive awareness of mathematics education students enrolled in PTKIN and PTUN institutions and used lecturer interviews to examine curricular and instructional explanations for the observed pattern. The longer-term aim is to inform curriculum review and metacognitive support across both systems.

Method. An explanatory sequential mixed-methods design was used. The quantitative phase involved 746 final-semester mathematics education students from 18 Indonesian institutions (402 from PTKIN and 344 from PTUN) who completed the 52-item Metacognitive Awareness Inventory (MAI). Group means were compared with an independent-samples t-test after assumption checks. Follow-up semi-structured interviews with lecturers and program leaders were organized around curriculum and learning-process themes.

Results. The PTKIN and PTUN groups had similar mean scores (5.2434 and 5.2552, respectively), and the independent-samples t-test showed no statistically significant difference, $t(744) = -0.061$, $p = .951$. Interview participants described substantial overlap in core mathematics and pedagogy courses and in practices used to support problem solving. Institutional affiliation was the only quantitative grouping variable tested; student-level predictors were not ranked.

Conclusion. Administrative affiliation alone did not distinguish students' metacognitive awareness in this sample. Programs in both systems should assess and teach metacognitive processes explicitly instead of treating institutional type as a proxy for students' learning needs.

KEYWORDS

Metacognitive Awareness, Metacognitive Knowledge, Metacognitive Regulation.

Citation: Abidin, Z., Aiyub, A., & Ulya, K. (2026). The Effect of Educational Institution Differences on the Metacognitive Awareness of Mathematics Education University Students in Indonesia. *International Journal of Educational Narrative*, *4*(4), 1669–1684. https://doi.org/10.70177/ijen.v4i4.4299

Correspondence:

Zainal Abidin,
zainalabidin@ar-raniry.ac.id

Received: February 10, 2026

Accepted: May 15, 2026

Published: September 05, 2026

INTRODUCTION

The current curriculum in Indonesia adopts the revised Bloom's Taxonomy updated by Lorin W. Anderson and Krathwohl (2001), which emphasizes two main dimensions:

the cognitive process dimension and
the knowledge dimension.

The cognitive process dimension includes the abilities to remember (C1), understand (C2), apply (C3), analyze (C4), evaluate (C5), and create (C6), whereas the knowledge dimension encompasses factual, conceptual, procedural, and metacognitive knowledge (Anderson & Krathwohl, 2001). In the context of mathematics education, the metacognitive dimension becomes crucial as it relates to students' ability to plan, monitor, and evaluate their own thinking processes during problem-solving.

Metacognition has long been recognized as a key factor in learning success, particularly in mathematical problem-solving. This concept was first introduced by Flavell (1979), who defined metacognition as "thinking about thinking" and distinguished it into two main components: knowledge of cognition and regulation of cognition. Further development of this concept was proposed by Schraw & Dennison (1994) as well as Schraw & Moshman (1995), who asserted that metacognition includes awareness and control over an individual's cognitive processes. Recent studies show that metacognition is closely related to problem-solving ability, conceptual understanding, and self-regulation in learning (Veenman, 2020; Dinsmore et al., 2020; Zohar & Barzilai, 2021).

A number of empirical studies demonstrate that metacognition plays a significant role in enhancing academic achievement and the quality of mathematics learning. Students with high metacognitive abilities tend to be more effective in planning problem-solving strategies, monitoring their thinking processes, and evaluating the outcomes obtained (Izzati & Mahmudi, 2018; Rambe & Surya, 2017). Furthermore, the application of metacognitive strategies in learning has been proven to yield a positive impact on improving learning outcomes and academic performance (Dignath & Veenman, 2021; Chytrý et al., 2020). Other research also indicates that metacognition can serve as an important predictor of learning success and problem-solving ability (Zhao et al., 2019; Teng, 2023).

However, research findings regarding the relationship between metacognition and academic achievement are not always consistent. Some studies show a strong relationship between metacognition and learning outcomes, while other studies report weak or non-significant relationships (Abdellah, 2015; Dinsmore et al., 2020). Recent meta-analytic findings also show that although there is a positive correlation between metacognition and academic achievement, the strength of this relationship is influenced by various factors such as the learning context, student characteristics, and the field of study (Veenman, 2020; Thi-Nga et al., 2024). This indicates that the relationship between metacognition and learning outcomes still warrants further investigation in more specific contexts.

On the other hand, most research on metacognition remains dominated by the context of developed nations, while studies within the higher education context in Indonesia are still relatively limited. Yet, the higher education system in Indonesia possesses unique characteristics, notably the dual management of higher education institutions under the Ministry of Education, Culture, Research, and Technology (PTUN) as well as the Ministry of Religious Affairs (PTKIN). Differences in the institutional systems and academic cultures of these two types of institutions have the potential to influence the development of students' metacognitive abilities. Nevertheless, to date, there is still limited research examining the metacognitive awareness of mathematics education students based on their institutional backgrounds.

To measure metacognitive awareness empirically, a valid and reliable instrument is required. One widely used instrument in international research is the Metacognitive Awareness Inventory (MAI) developed by Schraw & Dennison (1994). This instrument measures two primary dimensions of metacognition—knowledge of cognition and regulation of cognition and has been extensively utilized across various studies to obtain a comprehensive overview of students' metacognitive awareness (Schraw & Dennison, 1994; Abdullah & Soemantri, 2018).

Based on this background, this study examines the level of metacognitive awareness among mathematics education students in Indonesia using the MAI and tests whether it differs between PTKIN and PTUN institutions. Follow-up interviews are used to interpret the quantitative pattern through the curriculum and learning practices reported by lecturers and program leaders. Beyond the immediate comparison, the study is intended to provide a baseline for curriculum review, lecturer development, and cross-institution monitoring of metacognitive learning outcomes. If administrative affiliation does not differentiate students' scores, improvement efforts can be directed toward the learning experiences and student-level conditions that operate within both systems.

LITERATURE REVIEW

The Nature of Metacognition in Mathematics Education

The concept of metacognition was first introduced by Flavell (1979) as an individual's awareness of their own thinking processes, which includes the ability to plan, monitor, and evaluate cognitive activities. In its subsequent development, metacognition was understood as a multidimensional construct consisting of two main components: knowledge of cognition and regulation of cognition (Schraw & Dennison, 1994; Schraw & Moshman, 1995). Knowledge of cognition encompasses declarative, procedural, and conditional knowledge, whereas regulation of cognition includes planning, monitoring, and evaluation.

In the context of mathematics education, metacognition plays a strategic role because mathematical activities demand the engagement of higher-order thinking processes. Students are required not only to understand concepts, but also to control their thinking processes in solving complex problems. Consequently, metacognition is often linked to self-reflection abilities and decision-making in problem-solving (Veenman, 2020; Zohar & Barzilai, 2021). Furthermore, Dinsmore et al. (2020) emphasize that metacognition is an integral part of self-regulated learning, enabling individuals to manage their learning strategies independently and adaptively.

Metacognition and Mathematical Problem-Solving Ability

The relationship between metacognition and mathematical problem-solving ability has been a primary focus in various studies. Metacognition enables students to understand problems deeply, select appropriate strategies, and evaluate the solutions obtained. Research findings indicate that students with high levels of metacognition tend to be more systematic in solving mathematical problems compared to those with low metacognition (Izzati & Mahmudi, 2018; Rambe & Surya, 2017).

Furthermore, research by Shilo & Kramarski (2019) shows that the use of metacognitive discourse in mathematics learning can enhance students' abilities to plan, monitor, and reflect on the problem-solving process. This aligns with the findings of Dignath & Veenman (2021), who state that metacognitive-based learning strategies significantly impact the improvement of problem-solving skills through the reinforcement of self-regulation.

However, the relationship between metacognition and problem-solving is neither simple nor linear. Veenman (2020) emphasizes that the effectiveness of metacognition depends heavily on the task context, problem difficulty, and individual learning experiences. Consequently, the development of metacognition needs to account for the complex and contextual characteristics of mathematics learning.

Metacognition and Academic Achievement: Empirical Findings and Inconsistencies

A number of empirical studies show that metacognition has a positive relationship with academic achievement. Metacognition serves as an important predictor of learning success because it enables students to manage their learning strategies effectively (Zhao et al., 2019; Teng, 2023). Furthermore, a study by Chytrý et al. (2020) demonstrates that students with high metacognitive abilities tend to have better academic performance compared to those with low metacognitive abilities.

However, research findings are not always consistent. Several studies have found that the relationship between metacognition and academic achievement is non-significant or influenced by other variables, such as motivation, learning environment, and educational background (Abdellah, 2015; Dinsmore et al., 2020). Recent meta-analytic findings also show that although there is a positive correlation between metacognition and academic achievement, the strength of this relationship varies depending on the context and student characteristics (Thi-Nga et al., 2024).

This inconsistency indicates that metacognition is not the sole factor determining academic success; rather, it interacts with various other factors within the learning system. Therefore, more contextual research is required to understand this relationship more comprehensively, particularly within the higher education context.

Metacognition Measurement and Research Gaps in the Indonesian Context

Empirical measurement of metacognition requires valid and reliable instruments. One of the most widely used instruments is the Metacognitive Awareness Inventory (MAI), developed by Schraw & Dennison (1994). This instrument measures two primary dimensions of metacognition known as Knowledge of Cognition and Regulation of Cognition that has been used extensively across various educational studies (Abdullah & Soemantri, 2018).

Nevertheless, most of the research using the MAI has been conducted in developed countries that leave the generalizability of these findings including in Indonesia, still limited. In the Indonesian context, the higher education system possesses unique characteristics, notably the dual management of institutions between PTKIN and PTUN. Differences in institutional systems, curricula, and academic cultures across these two types of institutions have the potential to influence the development of students' metacognition.

However, to date, there remains a scarcity of research comparatively examining the metacognitive awareness of mathematics education students based on their institutional backgrounds. Therefore, this study seeks to address this gap by analyzing the metacognitive awareness of mathematics education students in Indonesia using the MAI instrument, as well as comparing it across different types of higher education institutions.

RESEARCH METHODOLOGY

This study used an explanatory sequential mixed-methods design. The first phase compared metacognitive-awareness scores from two naturally occurring institutional groups, PTKIN and PTUN. The second phase used interviews to interpret why similar or different quantitative patterns might occur. This design was selected because the independent-samples comparison directly addresses the group-difference question, while the qualitative follow-up provides curriculum and teaching context that a survey alone cannot supply. An experimental design was not appropriate because institutional affiliation was a pre-existing characteristic and was not manipulated.

The quantitative sample comprised 746 final-semester mathematics education students from 18 Indonesian higher education institutions. Ten institutions were PTUN and eight were PTKIN, with accreditation ranks represented across the participating programs. The final group sizes were 344 students from PTUN and 402 students from PTKIN. Restricting the sample to final-semester students provided respondents with sustained exposure to their program curricula and learning practices.

Metacognitive awareness was measured with the 52-item Metacognitive Awareness Inventory developed by Schraw and Dennison (1994). The instrument covers knowledge of cognition (declarative, procedural, and conditional knowledge) and regulation of cognition (planning, information-management strategies, comprehension monitoring, debugging strategies, and evaluation). Responses were recorded as yes or no and coded 1 or 0. The MAI was selected because its dimensions correspond directly to the planning, monitoring, and evaluation processes examined in this study and it permits a common measure across the two institutional groups.

Questionnaire data were collected online through Google Forms. After the quantitative analysis, semi-structured interviews were conducted through WhatsApp with lecturers and heads of mathematics education programs representing PTKIN and PTUN institutions and different accreditation categories. The interview questions addressed curriculum structure, the place of metacognitive competencies in the program, modes of instruction, digital tools, and lecturers' perceptions of student learning. The responses were organized into two recurring themes: curriculum and learning process.

Quantitative analysis was conducted in SPSS 24 for Windows. The Kolmogorov-Smirnov test was used as a preliminary normality check, and Levene's test assessed homogeneity of variance. Because institutional affiliation formed two independent groups, an independent-samples t-test was used to compare their mean scores at an alpha level of .05. The mean difference and its 95% confidence interval were used to interpret the size and precision of the observed group difference. The interview findings were used as contextual explanations and were not treated as statistically tested predictors.

RESULT AND DISCUSSION

Complete MAI responses were obtained from 746 mathematics education students. Each of the 52 items was coded 1 for yes and 0 for no. The items represented the two MAI domains and their eight component dimensions: declarative, procedural, and conditional knowledge; planning; information management; comprehension monitoring; debugging strategies; and evaluation.

Before comparing the group means, the distribution and variance assumptions were examined. The Kolmogorov-Smirnov procedure was used as a preliminary normality check, and Levene's test indicated homogeneous variances ($p = .963$). The two independent groups were therefore compared with an independent-samples t-test.

Table 1 summarizes metacognitive-awareness scores for 402 PTKIN students and 344 PTUN students. The mean scores were 5.2434 for PTKIN and 5.2552 for PTUN, with standard deviations of 1.15166 and 1.15565, respectively. The descriptive difference between the groups was small.

Table 1. Analysis of the average value and standard deviation of students' metacognitive awareness data from PTKIN and PTUN

Group Statistics

	Lembaga	N	Mean	Std. Deviation	Std. Error Mean
Pilihan	PTKIN	402	5.2434	1.15166	.14396
	PTUN	344	5.2552	1.15565	.12921

The independent-samples t-test evaluated the null hypothesis that PTKIN and PTUN students had equal mean metacognitive-awareness scores. The alternative hypothesis stated that the group means differed. Statistical significance was evaluated at alpha = .05, and the analysis was conducted in SPSS 24 for Windows (Table 2).

Table 2. Independent-samples t-test comparing the metacognitive awareness of PTKIN and PTUN mathematics education students

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pilihan	Equal variances assumed	.002	.963	-.061	744	.951	-.01181	.19351	-.39435	.37072
	Equal variances not assumed			-.061	135.343	.951	-.01181	.19344	-.39436	.37074

The independent-samples t-test did not show a statistically significant difference between PTKIN and PTUN students, t(744) = -0.061, p = .951. The reported mean difference was -0.01181, with a 95% confidence interval from -0.39435 to 0.37072. The interval includes zero and the observed group means were nearly identical. Institutional affiliation was the only quantitative explanatory variable tested, and it was not statistically significant. The present analysis therefore provides no basis for identifying a variable with the 'most significant impact.' Student-level factors such as academic achievement, motivation, mathematics anxiety, and learning strategies were outside the quantitative model.

Table 3. Analysis results of Case Processing Summary Data between Higher Education and Metacognition Ability

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Higher Education * Metacognition Ability	746	100.0%	0	0.0%	746	100.0%

Table 3 shows that all 746 cases were included in the cross-tabulation, with no missing cases. Data completeness avoids loss of observations in this analysis, although it does not by itself establish measurement validity.

Association between the Metacognitive Abilities of Mathematics Education Students and Their Higher Education Background

A chi-square test was also used to examine the association between institutional background and the metacognitive-ability classification used in the data set. Statistical significance was evaluated at alpha = .05.

Table 4. Analysis results of the correlations between higher education and the metacognitive ability

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.000[a]	744	1.000
Likelihood Ratio	.000	744	1.000
Linear-by-Linear Association	.000	1	1.000
N of Valid Cases	746		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.00.

The Pearson chi-square test reported an Asymptotic Significance (two-sided) value of 1.000, which was above .05. The analysis therefore did not detect an association between institutional background and the metacognitive-ability classification used in this study. This result describes the present sample and operationalization; it should not be interpreted as proof that institutional conditions can never be related to metacognitive development.

Interview Results

Follow-up interviews were used to interpret the absence of a quantitative difference between PTKIN and PTUN students. Lecturers and program leaders were asked about curriculum structure, metacognitive competencies, and the learning processes used in mathematics education programs. Their responses were organized under two themes: curriculum and learning process.

a. Curriculum

The curriculum theme showed considerable overlap between PTKIN and PTUN mathematics education programs, particularly in their core mathematics and pedagogy courses. Program-level differences were reported mainly in elective offerings, credit allocations, and local emphases such as Indonesian Realistic Mathematics Education. A senior lecturer from an Excellent-accredited program in Surabaya, for example, described realistic mathematics as a defining focus within mathematics education courses.

Although metacognition was not always named explicitly in course titles or content descriptions, participants viewed planning, monitoring, and evaluation as embedded in mathematical problem solving. MSR explained that metacognitive components are present in the characteristics of mathematics even when instruction is not formally labeled as metacognitive (Gama, 2004).

The following is an interview excerpt with FS from a PTKIN-affiliated university holding a "Very Good" accreditation status.

Researcher : In preparing the curriculum currently applied, is prepared based on guidelines provided by association?

FS : Yes, that's right, guided by the IndoMS and I-MES associations and several PTKI Mathematics education study program curricula

Researcher : Does the curriculum that has been prepared have similarities with those in other universities' study programs, in which group of curricula they are similar? and what are the differences?

FS : Some courses are similar, but some courses are different from what offered by other campuses. The difference lies in the optional courses offered and the different credits given to several core courses.

Researcher : Is metacognitive knowledge also considered as a graduate competency?

FS : It is very much considered, in every course that is taught the student must be aware of what they have learned.

Researcher : What metacognitive abilities are emphasized in the curriculum?

FS : Ability to plan, monitor and evaluate in the problem-solving stages

Below is an excerpt from an interview with ZK, representing a university under PTUN with a "Good" accreditation status.

Researcher : In preparing the curriculum currently applied, is prepared based on guidelines provided by association?

ZK : Yes. At the latest curriculum of 2021 MBKM, it adopts I-MES curriculum guidelines.

Researcher : Does the curriculum that has been prepared have similarities with those in other universities' study programs, in which group of curricula they are similar? and what are the differences?

ZK : It is mostly similar, there are only few different courses offered. The courses description are also different for example in our Ethnomatics course, the material descriptions are developed based on local culture.

Researcher : Is metacognitive knowledge also considered as a graduate competency?

ZK : Yes

Researcher : What metacognitive abilities are emphasized in the curriculum?

ZK : There is no specific course on metacognition. But there are several courses that can be related to metacognition, for example problem solving related courses and other courses related to thinking processes.

b. Learning Process

Below is an excerpt from an interview with MSR, a senior lecturer in a Mathematics Education Study Program with an "Excellent" accreditation rank.

Researcher : How was the learning process implemented in the last two or three years ago?

MSR : Learning process for the last two years was carried out online.

Researcher : What e-learning application was used?

MSR : We use several applications, such as Zoom, Google Classroom, Google Meet etc.

Researcher : If you use an application, is there any requirement to do it synchronously?

MSR : Yes, we are required by UNESA rules to do it synchronously at least 6 times, but every time I teach it is always synchronous. I always use zoom or google meet.

Researcher : Are there any obstacles in teaching mathematics material?

MSR : For me, not so much, at the beginning of using zoom there was a bit of problems.

Researcher : According to you, which is better to teach directly face to face or by using an application, let's say Zoom.

MSR : It's the same, everything has its advantages and disadvantages.

Researcher : If you use an online application, in terms of student achievement, is there a real difference in student achievement?

MSR : For my students, it seems there is no significance differences.

Researcher : Why?

MSR : Because in teaching I also write down explanations that are needed, such as when I write on a blackboard in the classroom. I use media that can be seen by students what I write.

Researcher : Do you pay attention to certain student abilities in your teaching? For example, students' metacognitive abilities.

MSR : It depends on the course; in mathematics courses I only explain the materials related to the concepts of that material. But if you teach mathematics education component courses such as mathematics learning evaluation, yes, students metacognition abilities are also observed as they are related to students' evaluation.

The interview accounts did not support a simple contrast between online and face-to-face instruction. Participants described efforts to preserve explanation, interaction, and problem-solving support across both modes. Their statements suggest that course design and the teaching of mathematical thinking may be more informative than delivery mode alone, but the interviews were contextual evidence and did not test causal effects.

ASD, a senior lecturer at an Excellent-accredited university, offered a similar account of the learning process:

Researcher : How was the learning process implemented in the last two or three years ago?

ASD : Learning for the last two years has been carried out online.

Researcher : What application do you use?

ASD : In lectures we use our own Learning Management system (LMS) designed by the campus.

Researcher : If you use an application, is there an obligation to do it synchronously?

ASD : Yes, we are required several times synchronously, but almost every time we teach it is always synchronous.

Researcher : Are there any obstacles in teaching mathematics material?

ASD : For me not too much, in the beginning there was a little.

Researcher : In your opinion, which is better to teach directly face to face using an application, let's say Zoom?

ASD : It is better directly, but each method has its own advantages and disadvantages.

Researcher : If you use an online application, in terms of student achievement, is there a real difference in student achievement?

ASD : For my students it seems there not much different.

Researcher : Why?

ASD : Because when teaching I also use a pen tablet, so it makes it easier to explain things.

Researcher : Do you pay attention to certain student abilities in your teaching? For example, students' metacognitive abilities.

ASD : Yes, if I teach the courses related learning and problem solving, but if I teach pure mathematics material, I don't pay too much attention to that, the priority is on how student understand the concepts of the material that are taught.

The quantitative finding indicates that PTKIN or PTUN affiliation did not separate the mean metacognitive-awareness scores in this sample. The result is comparable to Dessie, Gebeyehu, and Eshetu (2023) only in the limited sense that a broad learning condition was not, by itself, associated with a statistically detectable metacognitive difference. Direct comparison must remain cautious because the present study examined institutional affiliation, whereas Dessie et al. examined instructional models in a different disciplinary and national context.

The present result differs in emphasis from studies that examine metacognition as a predictor of achievement. Young and Fry (2008), Hassan and Rahman (2017), and Toraman et al. (2020) reported relationships between metacognition and academic or mathematical performance. This study asked whether metacognitive awareness differed across administrative systems; it did not test whether metacognition predicted achievement. Similar PTKIN and PTUN means can therefore coexist with strong student-level relationships between metacognition and performance.

The interview findings offer a plausible contextual explanation for the similar group means. Participants from both systems described overlapping core mathematics and pedagogy courses, shared curriculum guidance, and the inclusion of planning, monitoring, and evaluation in problem-solving activities even when no stand-alone metacognition course was offered. These similarities may reduce between-system differences, although the interview evidence cannot establish mediation or causation.

Previous studies also identify student-level conditions that were not measured in the present quantitative model. Mathematical ability, self-efficacy, motivation, confidence, and mathematics anxiety have been associated with metacognitive knowledge or awareness (Tian et al., 2018; Udil et al., 2017; Yorulmaz et al., 2021; Hoorfar & Taleb, 2015). Variation in these conditions within PTKIN and PTUN may be larger than any average difference between the two institutional categories.

No variable can be identified as having the strongest impact from the present results. Institutional type was the only quantitative grouping variable and was not statistically significant. The curriculum and learning-process themes emerged from interviews and should be treated as explanations to be tested in later studies, not as ranked predictors. A future multivariable design could compare the contribution of achievement, motivation, learning strategies, mathematics anxiety, and program-level curriculum features.

The practical implication is not that metacognitive support is unnecessary. The result indicates that administrative affiliation is too broad a basis for deciding which students need such support. PTKIN and PTUN programs can use the same evidence-informed instructional options while adapting them to program-level and student-level needs. The strategies below illustrate how planning, monitoring, and evaluation can be made visible in mathematics learning.

Below are several learning strategies that can be implemented to enhance students' metacognitive awareness:

a. Problem-Based Learning (PBL)

Problem-Based Learning (PBL) is an instructional approach oriented toward active student engagement in solving contextual problems that mirror real-life situations (Hmelo-Silver, 2004). In the context of higher education mathematics, the implementation of PBL enables students to meaningfully construct conceptual understanding through exploration, discussion, and the application of mathematical principles in resolving open-ended problems (Barrows & Tamblyn, 1980). This approach significantly contributes to enhancing critical thinking skills and problem-solving abilities, while also encouraging the development of students' metacognitive awareness in monitoring and evaluating the cognitive strategies utilized during the learning process (Savery, 2006; Loyens et al., 2008).

b. Reflective Journals

The implementation of reflective journal writing after each learning session is an effective pedagogical strategy to encourage students to reflect deeply on their thinking processes. Through this activity, students can evaluate their conceptual understanding, identify effective learning strategies, and formulate improvement plans for subsequent learning. Reflective journals also play an important role in the development of metacognitive awareness, as they enable students to consciously monitor and regulate the cognitive processes they use during learning (Zohar & Barzilai, 2022; Boud, Keogh, & Walker, 2013). Furthermore, written reflection has been proven to support the growth of learning autonomy and critical thinking skills within the context of competency-based learning in higher education (Ryan & Ryan, 2015; Chiu & Cheng, 2023).

c. Instructional Scaffolding

Instructional scaffolding refers to the provision of temporary support tailored to students' needs to facilitate their cognitive and metacognitive development during the learning process. This support can be realized through explicit prompts, constructive feedback, and the provision of space for collaborative discussion and reflection. As students' abilities and independence increase, this support is gradually reduced (fading), thereby encouraging them to become self-directed learners capable of effectively regulating their own learning processes (van de Pol, Volman, & Beishuizen, 2010; Belland, 2017). Scaffolding has been proven effective in enhancing metacognitive skills, especially when combined with self-monitoring and self-reflection strategies (Cho & Shen, 2023).

d. Discovery Learning

Discovery-based learning (Discovery Learning) is a constructivist approach that positions students as active subjects in the learning process through exploratory, investigative, and experimental activities. In the context of mathematics education, this approach encourages students to independently discover mathematical concepts, principles, and patterns through direct involvement in problem-solving. This discovery process not only reinforces conceptual understanding but also facilitates the development of students' metacognitive awareness through reflection on strategies, errors, and findings generated during learning (Alfieri et al., 2011; Prince & Felder, 2020). Consequently, Discovery Learning contributes to shaping self-directed, reflective learners who are capable of effectively regulating their own thinking processes.

e. The Use of Technology in Developing Metacognitive Awareness

The integration of technology in the learning process holds significant potential for enhancing students' metacognitive awareness. The utilization of digital tools such as problem-solving software, interactive simulations, and adaptive learning platforms enables students to plan, monitor, and evaluate problem-solving strategies independently and reflectively. The use of such technology not only enriches the learning experience but also facilitates active student engagement in developing higher-order thinking skills, including planning, self-monitoring, and the evaluation of thinking processes (Azevedo et al., 2022; Lai & Hwang, 2021). Consequently, technology serves as an effective mediator in supporting self-regulation and metacognition-based learning in higher education environments.

The findings support five actions that can be applied in both institutional systems. Each action is tied to what the study can establish: institutional labels did not differentiate average scores, so support should be embedded in courses and directed by evidence from programs and students.

1. Embed Metacognitive Prompts in Core Courses
   Lecturers can add short planning questions before problem solving, monitoring prompts during solution development, and evaluation questions after a solution is completed. Problem-based learning, reflective journals, and adaptive tools can provide a structure for these routines (Zohar & Barzilai, 2022; Dignath & Veenman, 2021).
2. Map Metacognition Across the Curriculum
   Program teams can identify where declarative, procedural, and conditional knowledge and the five regulation components are introduced, practiced, and assessed. This mapping can reveal gaps that are hidden when metacognition is assumed to be implicit in mathematics courses (Wilson et al., 2023).
3. Monitor Student-Level Variation
   Programs should examine MAI results by relevant student characteristics instead of relying on PTKIN or PTUN affiliation. Academic achievement, motivation, learning strategy use, and mathematics anxiety are suitable variables for targeted support and for later multivariable analysis.
4. Prepare Lecturers to Model Metacognitive Thinking
   Lecturer development can focus on think-aloud demonstrations, feedback on strategy choice, reflective questioning, and the gradual removal of scaffolding. Common training across PTKIN and PTUN programs would also allow institutions to compare implementation using shared indicators (Peeters et al., 2022).
5. Use Assessments that Make Metacognition Visible
   Self-assessment, peer assessment, reflective solution notes, and project-based tasks can document how students plan and revise their work, not only whether an answer is correct. These records provide instructors with evidence for feedback and give future studies outcomes beyond self-report scores (Panadero et al., 2018).

CONCLUSION

The analysis found no statistically significant difference in metacognitive awareness between mathematics education students from PTKIN and PTUN institutions. The group means were almost identical, and the interview findings described substantial overlap in curriculum content and learning practices. The study therefore indicates that administrative affiliation alone did not distinguish metacognitive awareness in this sample.

For practice, both institutional systems can use a common framework for metacognitive development while making support responsive to program and student evidence. Mathematics education programs can map the MAI dimensions across courses, train lecturers to model planning and monitoring, and use reflective assessment tasks to identify students who need additional support. The longer-term value of the study lies in shifting curriculum review from assumptions about institutional labels to observable learning processes.

Several limitations qualify the conclusions. The cross-sectional design does not permit causal inference, the MAI relies on self-reported awareness, and institutional type was the only quantitative explanatory variable. The interview evidence was used for contextual interpretation and was not designed for statistical generalization. The sample was also limited to final-semester students from the participating institutions. Future research should include academic achievement, motivation, learning strategies, mathematics anxiety, and direct measures of problem solving. Longitudinal or multilevel designs could then estimate how student characteristics, classroom practices, and program-level conditions jointly relate to metacognitive development.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the authors used ChatGPT to improve grammar, language quality, and readability. The authors reviewed and edited the resulting text and take full responsibility for the content of the publication.

ACKNOWLEDGEMENT

Acknowledgments are conveyed to the Rector of UIN Ar-Raniry for the financial assistance via LP2M of UIN Ar-Raniry and also many thanks to the reviewers who have provided the suggestions and valuable inputs on this research. We also appreciate the support from all parties and institutions that help in research data collection process.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Methodology; Data curation; Investigation; Project administration.
Author 2: Conceptualization; Methodology; Data collection.
Author 3: Formal analysis; Methodology; Validation.

DECLARATION OF COMPETING INTEREST

The author(s) declare that there are no financial, professional, or personal relationships that could be perceived as influencing the results or interpretation of this study.

REFERENCES

Abdullah, M., & Soemantri, S. (2018). Metacognitive skills and mathematics learning achievement. *Journal of Physics: Conference Series, 1088*(1),012056. https://doi.org/10.1088/1742-6596/1088/1/012056

Abdellah, R. (2015). Metacognitive awareness and its relation to academic achievement and teaching performance of pre-service female teachers. *Procedia - Social and Behavioral Sciences, 191*, 2503–2509. https://doi.org/10.1016/j.sbspro.2015.04.708

Abidin, Z., & Jarmita, N. (2020). Students' Intuition of Field Independent and Field Dependent in Solving Divergence Mathematical Problem. *Kreano, Jurnal Matematika Kreatif-Inovatif*, *11*(2), 223–235. https://doi.org/10.15294/kreano.v11i2.26804

Ajisuksmo, C. R. P., & Saputri, G. R. (2017). The Influence of Attitudes towards Mathematics, and Metacognitive Awareness on Mathematics Achievements. *Creative Education*, *08*(03), 486–497. https://doi.org/10.4236/ce.2017.83037

Alindra, D., Fauzan, A., & Asmar, A. (2018). *Metacognitive Awareness and Its Effect on Students' Problem Solving Ability in Implementing RME Approach*. *178*(ICoIE 2018), 318–322. https://doi.org/10.2991/icoie-18.2019.70

Alzahrani, K. S. (2017). Metacognition and Its Role in Mathematics Learning: an Exploration of the Perceptions of a Teacher and Students in a Secondary School. *International Electronic Journal of Mathematics Education*, *12*(3), 521–537. https://doi.org/10.29333/iejme/629

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? A meta-analytic review. Review of Educational Research, 81(4), 1–36. https://doi.org/10.3102/0034654311422391

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). *Read and Download Ebook PDF Download A Taxonomy For Learning, Teaching, And Assessing: A Revision Of Bloom's Taxonomy Of Educational Objectives, Complete Edition PDF PDF File: PDF Download A Taxonomy For Learning, Teaching, And Assessing: A Revision Of Bl*. 1–4.

Azevedo, R., Taub, M., & Mudrick, N. V. (2022). Using advanced learning technologies to foster self-regulated learning and metacognition. In M. C. Nelson & M. C. Dinsmore (Eds.), The Cambridge Handbook of Cognition and Education (pp. 631–654). Cambridge University Press. https://doi.org/10.1017/9781108635466.027

Bell, F. H. (1978). *Teaching and Learning Mathematics (In Secondary Schools)*. Lowa: Wm. C. Brown Company Publisher.

Barrows, H. S., & Tamblyn, R. M. (1980). Problem-based learning: An approach to medical education. Springer Publishing Company.

Belland, B. R. (2017). Instructional scaffolding in STEM education: Strategies and efficacy evidence. Springer.

Boud, D., Keogh, R., & Walker, D. (2013). Reflection: Turning experience into learning. Routledge.

Chiu, T. K. F., & Cheng, K. H. (2023). Reflective writing and learning outcomes in higher education: A systematic review of empirical studies (2011–2021). Educational Research Review, 38, 100507. https://doi.org/10.1016/j.edurev.2022.100507

Cho, M.-H., & Shen, D. (2023). Effects of metacognitive scaffolding on students' self-regulated learning and academic performance in an online learning environment. The Internet and Higher Education, 58, 100867. https://doi.org/10.1016/j.iheduc.2023.100867

Chytrỳ, V., Říčan, J., & Medová, J. (2020). The influence of metacognitive strategies on students' academic performance. *Education Sciences, 10*(11), 1–15. https://doi.org/10.3390/educsci10110312

Dessie, E., Gebeyehu, D., & Eshetu, F. (2023). Enhancing critical thinking, metacognition, and conceptual understanding in introductory physics: The impact of direct and experiential instructional models. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(7). https://doi.org/10.29333/ejmste/13273

Dignath, C., & Veenman, M. V. J. (2021). The role of direct strategy instruction and indirect activation of self-regulated learning Evidence from classroom intervention studies. *Educational Psychology Review, 33*, 489–533. https://doi.org/10.1007/s10648-020-09534-0

Dinsmore, D. L., Alexander, P. A., & Loughlin, S. M. (2020). Focusing the conceptual lens on metacognition, self-regulation, and self-regulated learning. *Educational Psychology Review, 32*, 451–469. https://doi.org/10.1007/s10648-020-09535-z

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist*, *34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906

Gama, C. A. (2004). *Integrating Metacognition Instruction in Interactive Learning Environments (D. Phil Dissertation, University of Sussex)*. Diperoleh dari http://homes. dcc. ufba. br/~ claudiag/thesis/Thesis_Gama. pdf.

Hassan, N., & Rahman, S. (2017). Problem Solving Skills, Metacognitive Awareness, and Mathematics Achievement: A Mediation Model. *The New Educational Review*, *49*(3), 201–212. https://doi.org/10.15804/tner.2017.49.3.16

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? Educational Psychology Review, 16(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Izzati, N., & Mahmudi, A. (2018). The influence of metacognition on mathematics problem solving. *Journal of Physics: Conference Series, 1097*, 012107. https://doi.org/10.1088/1742-6596/1097/1/012107

Kesici, S., Erdogan, A., & Özteke, H. I. (2011). Are the dimensions of metacognitive awareness differing in prediction of mathematics and geometry achievement? *Procedia - Social and Behavioral Sciences*, *15*, 2658–2662. https://doi.org/10.1016/j.sbspro.2011.04.165

Lai, C.-L., & Hwang, G.-J. (2021). A review of game-based learning in computer science education: Research trends, challenges, and future directions. Computers & Education, 166, 104121. https://doi.org/10.1016/j.compedu.2021.104121

Loyens, S. M. M., Magda, J., & Rikers, R. M. J. P. (2008). Self-directed learning in problem-based learning and its relationships with self-regulated learning. Educational Psychology Review, 20(4), 411–427. https://doi.org/10.1007/s10648-008-9082-7

Ozturk, M. (2021). Cognitive and metacognitive skills performed by math teachers in the proving process of number theory. *Athens Journal of Education*, *8*(1), 53–72. https://doi.org/10.30958/aje.8-1-4

Prince, M. J., & Felder, R. M. (2020). Inductive teaching and learning methods: Definitions, comparisons, and research bases. Journal of Engineering Education, 95(2), 123–138. https://doi.org/10.1002/j.2168-9830.2006.tb00884.x

Panadero, E., Andrade, H., & Brookhart, S. (2018). Fusing self-regulated learning and formative assessment: A roadmap of where we are, what we know and where we want to go. Assessment in Education: Principles, Policy & Practice, 25(4), 431–456. https://doi.org/10.1080/0969594X.2018.1449890

Peeters, J., De Backer, F., Buffel, T., & Lombaerts, K. (2022). Teacher professional development for fostering metacognition in higher education: A review of the literature. Teaching in Higher Education, 27(1), 1–17. https://doi.org/10.1080/13562517.2020.1822312

Rambe, A. Y. F., & Surya, E. (2017). The effect of metacognitive strategy on students' mathematical problem solving ability. *International Journal of Sciences: Basic and Applied Research, 33*(3), 146–156.

Ryan, M., & Ryan, M. (2015). A model for reflection in the pedagogic field of higher education. Teaching in Higher Education, 20(4), 339–351. https://doi.org/10.1080/13562517.2015.1005867

Shilo, A., & Kramarski, B. (2019). Mathematical-metacognitive discourse and problem solving. , 339–357. https://doi.org/10.1007/s10649-019-09890-0

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. Interdisciplinary Journal of Problem-Based Learning, 1(1), 9–20. https://doi.org/10.7771/1541-5015.1002

Schraw, G., & Dennison, R. S. (1994). Assessing Metacognitive Awareness. *Contemporary Educational Psychology*, *19*(4), 460–475. https://doi.org/10.1006/ceps.1994.1033

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review*, *7*(4), 351–371. https://doi.org/10.1007/BF02212307

Soedjadi, R. (2000). *Kiat Pendidikan Matematika di Indonesia: Konstatasi keadaan masa kini menuju harapan masa depan*. Direktorat Jenderal Pendidikan Tinggi, Departeme Pendidikan Nasional.

Temur, Ö. D., Özsoy, G., & Turgut, S. (2019). Metacognitive instructional behaviours of preschool teachers in mathematical activities. *ZDM*, *51*(4), 655–666. https://doi.org/10.1007/s11858-019-01069-1

Teng, M. F. (2023). The role of metacognitive strategies in improving students' academic writing performance. *System, 114*, 102999. https://doi.org/10.1016/j.system.2023.102999

Thi-Nga, N., Nguyen, T., & Pham, H. (2024). A bibliometric analysis of metacognition research in mathematics education. *International Journal of Instruction, 17*(1), 345–362.

Tian, Y., Fang, Y., & Li, J. (2018). The Effect of Metacognitive Knowledge on Mathematics Performance in Self-Regulated Learning Framework—Multiple Mediation of Self-Efficacy and Motivation. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.02518

Toraman, Ç., Orakcı, Ş., & Aktan, O. (2020). Analysis of the Relationships between Mathematics Achievement, Reflective Thinking of Problem Solving and Metacognitive Awareness. *International Journal of Progressive Education*, *16*(2), 72–90. https://doi.org/10.29329/ijpe.2020.241.6

Udil, P. A., Kusmayadi, T. A., & Riyadi, R. (2017). Metacognition Process of Students with High Mathematics Anxiety in Mathematics Problem-Solving. *International Journal of Science and Applied Science: Conference Series*, *2*(1), 261. https://doi.org/10.20961/ijsascs.v2i1.16724

Van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in teacher–student interaction: A decade of research. Educational Psychology Review, 22(3), 271–296. https://doi.org/10.1007/s10648-010-9127-6

Veenman, M. V. J. (2020). Metacognition: Definitions, components, and their intricate relations. *Metacognition and Learning, 15*, 1–19. https://doi.org/10.1007/s11409-019-09199-8

Wilson, C. D., Arce-Trigatti, A., & Yamaguchi, R. (2023). Curriculum design for metacognitive development: Evidence from higher education initiatives. Journal of Curriculum Studies, 55(2), 147–167. https://doi.org/10.1080/00220272.2022.2076365

Yorulmaz, A., Uysal, H., & Çokçaliskan, H. (2021). Pre-service primary school teachers' metacognitive awareness and beliefs about mathematical problem solving. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, *6*(3), 239–259. https://doi.org/10.23917/jramathedu.v6i3.14349

Young, A., & Fry, J. D. (2008). Metacognitive awareness and academic achievement in college students. *Journal of the Scolarship of Teaching and Learning*, *8*(2), 441–442. https://doi.org/10.3109/0142159X.2010.487711

Zohar, A., & Barzilai, S. (2022). Metacognition and science education: Advancing the field through research-based strategies. Educational Psychologist, 57(1), 1–15. https://doi.org/10.1080/00461520.2021.2007469

Zhao, N., Wardeska, J. G., McGuire, S. Y., & Cook, E. (2019). Metacognition: An effective tool to promote success in college science learning. *Journal of Chemical Education, 96*(11), 2549–2555. https://doi.org/10.1021/acs.jchemed.9b00295

Zohar, A., & Barzilai, S. (2021). A review of research on metacognition in science education. *Studies in Science Education, 57*(2), 1–42. https://doi.org/10.1080/03057267.2021.1873390

Zohar, A., & Barzilai, S. (2022). Metacognition in STEM education: Research-based strategies for advancing the field. Educational Psychologist, 57(1), 1–15. https://doi.org/10.1080/00461520.2021.2007469