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THE INFLUENCE OF METACOGNITIVE AWARENESS, MATHEMATICAL DISPOSITION, AND SELF-EFFICACY ON REFLECTIVE THINKING AND MATHEMATICS ACHIEVEMENT

Yoga Tegar Santosa*[1], Setya Antara[2], Ismiyati[3], Nining Setyaningsih[4]
[1,2,3,4] Universitas Muhammadiyah Surakarta

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ABSTRACT

Student learning achievement is one of the most crucial aspects of mathematics education. Various factors have been found to influence this achievement, such as metacognitive awareness, mathematical disposition, self-efficacy, and reflective thinking. However, previous studies have rarely investigated the simultaneous effect of these four factors, especially through the mediating role of reflective thinking. This study aims to: (1) examine the direct effects of metacognitive awareness, mathematical disposition, and self-efficacy on reflective thinking; (2) test the direct effects of these variables on mathematics achievement; and (3) analyze indirect effects on achievement through reflective thinking. This study uses quantitative-correlational. The study involved 200 students from grades X and XI at SMA 1 Boyolali. Data were collected using validated questionnaires and mathematics tests, then analyzed using path analysis. The results showed that metacognitive awareness, disposition, and self-efficacy significantly affected reflective thinking, with a contribution of 66.1%. Additionally, those three factors also had significant direct effects on mathematics achievement, contributing 67.4%. Furthermore, reflective thinking was found to mediate the indirect effect of metacognitive awareness, disposition, and self-efficacy on mathematics achievement. These findings contribute to the development of more comprehensive models of mathematics learning by highlighting the central role of reflective thinking as a mediator.

Corresponding Author:

Yoga Tegar Santosa,
Departement of Mathematics Education Master Program,
Universitas Muhammadiyah Surakarta, Indonesia
Email: a418240010@student.ums.ac.id
Phone Number : 081227605479

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1. INTRODUCTION

Mathematics is one of the subjects that must be studied in Indonesia, starting from elementary to higher education. This provision is contained in the Law of the Republic of Indonesia Number 20 of 2003 concerning the National Education System (Pemerintah Republik Indonesia, 2003). Teaching mathematics at all levels of education is an integral part of the curriculum because mathematical concepts such as numbers, space, measurements, and patterns have been used by humans for a long time in daily life (Diaz & Marlina, 2024). Given the importance of the role of mathematics, there is an expectation that every student has the potential to achieve exemplary learning achievements in this subject as a provision to face academic challenges and contextual problems in real life that require mathematical thinking skills.

However, the reality shows that the achievement of mathematics students in Indonesia is still alarming. The results of international assessments, such as the Programme for International Student Assessment (PISA) in 2022, show that the average mathematics score of Indonesian students only reaches 366, far below the OECD average of 472 (OECD, 2023). In addition, only about 18% of Indonesian students achieve Level 2 or higher in math literacy, the minimum level needed to participate effectively in modern life, compared to the OECD average of 69%. This fact reflects the low ability of students to understand, reason, and apply mathematical concepts in various real-life contexts. One of the cognitive abilities that needs to be developed to face these challenges is reflective thinking.

Reflective thinking is a deep thinking process that involves reviewing ideas, strategies, and results in solving a problem, allowing individuals to evaluate and improve their thinking (Dewey, 1933; Rodgers, 2010). Graham (2017) and Kholid et al. (2024) added that reflective thinking reflects an active and persistent thought process, based on the knowledge a person has to make better decisions. This ability plays an important role in helping students manage their thinking processes consciously and systematically, especially when facing mathematics challenges (Saputra & Zulmaulida, 2021; Syamsuddin et al., 2023). Through reflective thinking, students can minimize their inability to respond to difficulties and develop self-control during problem-solving (Kholid et al., 2022; Maksimović & Osmanović, 2019). Thus, reflective thinking is one of the crucial cognitive competencies to sustainably support the success of learning mathematics. To support the development of this ability, internal factors are needed that encourage awareness in regulating the thought process, namely, metacognitive awareness (Toraman et al., 2020).

Metacognitive awareness is a person's ability to be aware, regulate, and control their cognitive processes, which includes planning, managing, and evaluating the learning process that is being undertaken (Flavell, 1979; Karaoglan-Yilmaz et al., 2023). According to Gregory & Sperling (1994), there are two aspects to metacognitive awareness: knowledge of cognition and regulation of cognition. Knowledge of cognition refers to an individual's knowledge of learning strategies, strengths, and cognitive limitations. Meanwhile, regulation of cognition refers to the ability to plan, monitor, and evaluate the thought process consciously and in a directed manner. In mathematics learning, metacognitive awareness helps students focus not only on the final answer but also on the thought process taken to achieve the solution (Arum et al., 2019). In addition, students with a high level of metacognition tend to be more reflective in solving problems, because they are used to monitoring and evaluating their thought processes (Lestari et al., 2018). Metacognitive awareness can synergize with positive mathematical dispositions to encourage meaningful reflection in solving mathematical problems.

Mathematical disposition refers to students' tendencies towards mathematics, including the belief that mathematics is meaningful, confidence in solving problems, perseverance in facing challenges, and interest in learning and exploring mathematical ideas (Almerino et al., 2019). National Council of Teachers of Mathematics conveys indicators of mathematical disposition (NCTM, 2000), including thinking flexibility, persistence, curiosity, the ability to reflect on thought processes, and appreciation for the value of mathematics in life. A strong mathematical disposition is important in determining how students respond to learning difficulties, encouraging them to give up easily and be more reflective in solving problems. In addition, self-efficacy or belief in one's ability to understand and complete math tasks also supports the emergence of more active reflection during the learning process.

Self-efficacy is an individual's belief in their ability to plan, organize, and carry out the actions necessary to achieve specific goals, including completing mathematical tasks (Bandura, 1997). In mathematics learning, self-efficacy influences how students respond to challenges, face mistakes, and maintain efforts when experiencing difficulties (Zakariya, 2022). Students with high self-efficacy tend to set challenging learning goals, persistently complete tasks, manage academic stress and negative emotions, and are more active and directed in evaluating their thought processes (Izzatunnisa et al., 2023; Putri & Hariyanti, 2022). Thus, self-efficacy impacts motivation and learning performance and is also expected to strengthen the ability to think reflectively, which is the key to achieving better mathematics learning achievement.

Several studies relevant to this research have been conducted previously, including those by 1) Asakereh & Yousofi (2018) regarding the relationship between self-efficacy and reflective thinking skills, 2) Toraman et al. (2020) related to the relationship between metacognitive awareness and mathematical reflective thinking skills, 3) Rorimpandey & Midun (2021) examining the influence of self-efficacy on learning outcomes, 4) Kamid et al. (2021) regarding the disposition of mathematics to mathematics learning outcomes, 5) Chamdani et al. (2022) discussing the relationship between reflective thinking and achievement student learning, 6) Thalib et al. (2022) related to the role of mathematical disposition and metacognition on mathematics learning outcomes, and 7) Setiyani et al. (2022) examined the role of mathematical disposition on reflective thinking skills. However, previous studies have several limitations. First, most studies tend to examine these psychological constructs in isolation or in pairs, without exploring their simultaneous and integrated influence on reflective thinking. Second, the analytical methods commonly used are limited to simple or multiple regression models, which may not capture indirect and complex causal relationships among variables.

In contrast, this study uses path analysis to describe the direct and indirect relationships between variables in more depth. Therefore, further studies are needed to examine the relationship between metacognitive awareness, mathematical disposition, and self-efficacy in reflective thinking skills and their implications on students' mathematics learning achievement. This research is important because it can provide a more comprehensive understanding of the psychological and cognitive factors that affect reflective thinking skills and how these abilities impact students' mathematics learning achievement. Practically, understanding the interaction between metacognitive awareness, mathematical disposition, and self-efficacy is crucial for teachers and policymakers, as it enables them to design learning strategies that not only develop students' reflective thinking but also support a more effective and motivating mathematics learning environment.

Based on the description above, this research has three objectives. First, to examine the direct influence of metacognitive awareness, disposition, and self-efficacy on reflective thinking. Second, to examine the direct influence of metacognitive awareness, disposition, self-efficacy, and reflective thinking on mathematics learning achievement. Third, to examine the indirect influence of metacognitive awareness, disposition, and self-efficacy on mathematics learning achievement through reflective thinking. Accordingly, this study proposes three hypotheses. First, metacognitive awareness, disposition, and self-efficacy have a direct influence on reflective thinking. Second, metacognitive awareness, disposition, self-efficacy, and reflective thinking have a direct influence on mathematics learning achievement. Third, metacognitive awareness, disposition, and self-efficacy have an indirect influence on mathematics learning achievement through reflective thinking.

2. METHODS

This research applies quantitative approach with a correlational design. The correlational research design is intended to examine associations among two or more variables without direct intervention (Sutama et al., 2022). This study has three variables: exogenous variables (,metacognitive awareness, mathematical disposition, and self-efficacy), intervening variables (reflective thinking), and endogenous variables (mathematics learning achievement).

The population of this research consisted of tenth and eleventh-grade students from a selected senior high school located in Boyolali Regency, with a total population of 400 students. The selected school was chosen using purposive sampling based on its status as a public school categorized as a favorite school in Boyolali Regency. The sample size was determined using Slovin's opinion with a formula (Sutama et al., 2022)

$$n = \frac{N}{1 + Ne^2}$$

where n = sample size, N = population size, and e = error rate (in this case, 5% is chosen). Based on the calculation of the formula, a sample size of 200 students was obtained. The sample was selected using proportional random sampling, ensuring that both tenth and eleventh grade students were represented according to their proportion in the population.

Data was collected using two types of instruments, questionnaires and question tests. Questionnaires were used to measure metacognitive awareness, mathematical disposition, and self-efficacy, while question tests were used to measure reflective thinking skills and math learning achievement. The metacognitive awareness questionnaire was compiled based on the Metacognitive Awareness Inventory (MAI) by Gregory & Sperling (1994), the mathematical disposition questionnaire was compiled based on indicators from NCTM (2000), and the self-efficacy questionnaire was compiled with reference to the Mathematics Self-Efficacy Scale (MSES) by Betz & Hackett (1983). The three questionnaires were prepared using a Likert scale of 1-5. Furthermore, the test of questions for reflective thinking is in the form of description questions developed based on aspects of reflective thinking according to Zehavi & Mann (2005), while the mathematics learning achievement test uses non-routine questions that measure the understanding of concepts and their application. All instruments have undergone validity and reliability tests before being used in data collection.

Data analysis uses inferential statistical analysis, namely, path analysis. Figure 1 presents the path diagram that illustrates the estimated causal relationship between metacognitive awareness, mathematical disposition, self-efficacy, reflective thinking, and mathematics learning achievement.

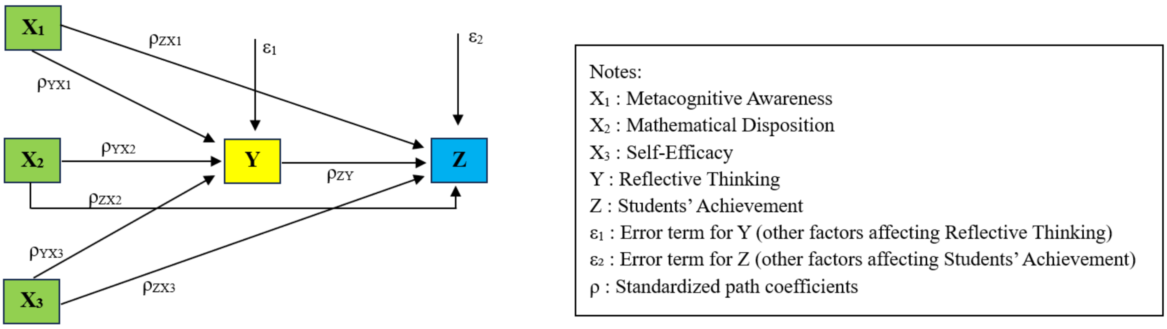

Figure 1. Path Diagram

Based on Figure 1, two structural equation models are obtained as follows.

a. Model I

$$Y = \rho_{YX1}X_1 + \rho_{YX2}X_2 + \rho_{YX3}X_3 + \varepsilon_1$$

b. Model II

$$Z = \rho_{ZX1}X_1 + \rho_{ZX2}X_2 + \rho_{ZX3}X_3 + \rho_{ZY}Y + \varepsilon_2$$

Before inferential statistical analysis with path-analysis, the assumption tests was first carried out, which included normality, linearity, multicollinearity, and heteroscedasticity tests (Creswell, 2014). All analyses, both assumption tests and path-analysis, were carried out using SPSS software version 16.

3. RESULTS AND DISCUSSION

3.1. Results

Assumption Tests

Table 1. Normality Test for Model I and Model II

		Unstandardized Residual
Model I	Asymptotic Significance (2-tailed)	0.896
Model II	Asymptotic Significance (2-tailed)	0.874

Table 1 shows the results of normality tests on Models I and II using the Kolmogorov–Smirnov One-Sample test. For Model I, a significance value (Sig.) of 0.896 was obtained, greater than α = 0.05. Meanwhile, Model II obtained a significance value (Sig.) 0.874, greater than α = 0.05. Thus, it can be concluded that the data is normally distributed.

Table 2. Linearity Test for Model I and Model II

		Dependent–Independent Variable Pairs	**Significance**
Model I	Deviation for Linearity	Reflective Thinking*Metacognitive Awareness	0.262
		Reflective Thinking*Mathematical Disposition	0.525
		Reflective Thinking*Self-Efficacy	0.972
Model II	Deviation for Linearity	Students' Achievements*Metacognitive Awareness	0.263
		Students' Achievements *Mathematical Disposition	0.538
		Students' Achievements *Self-Efficacy	0.631
		Students' Achievements*Reflective Thinking	0.976

The outcomes of the linearity analysis for both Model I and Model II are shown in Table 2. The findings indicated that in Model I, where reflective thinking served as the dependent variable, each pair of independent variables produced a significance value (Sig.) in the Deviation from Linearity test exceeding $\alpha = 0.05$. Likewise, in Model II, with students' achievement as the dependent variable, the significance values (Sig.) also surpassed $\alpha = 0.05$. These results suggest that the relationship between the independent and dependent variables in both models can be considered linear.

Table 3. Multicollinearity Test for Model I and Model II

	Variable	Tolerance	VIF
Model I	Metacognitive Awareness	0.973	1.028
	Mathematical Disposition	0.990	1.010
	Self-Efficacy	0.981	1.019
Model II	Metacognitive Awareness	0.689	1.451
	Mathematical Disposition	0.891	1.122
	Self-Efficacy	0.371	2.693
	Reflective Thinking	0.334	2.991

Table 3 shows the results of the multicollinearity test on Model I and Model II. In both models, it can be seen that all independent variables have a Tolerance value of > 0.1 and a VIF of < 10. Thus, it can be concluded that there are no symptoms of multicollinearity or there is no high correlation between independent variables in the two models.

Table 4. Heteroscedasticity Test for Model I and Model II

	Variable	Significance
Model I	Metacognitive Awareness	0.651
	Mathematical Disposition	0.724
	Self-Efficacy	0.828
Model II	Metacognitive Awareness	0.680
	Mathematical Disposition	0.127
	Self-Efficacy	0.053
	Reflective Thinking	0.806

Table 4 shows the results of the heteroscedasticity test in Model I and Model II. In both models, it was obtained that all independent variables had a significance value (Sig.) greater than $\alpha = 0.05$. This means that there are no symptoms of heteroscedasticity, or that the residual variant of the model is homogeneous (consistent) in both models.

Hypothesis Testing

Before conducting hypothesis testing, it is necessary to first determine the magnitude of the path coefficients in each structural model. To achieve this, linear regression analyses were performed on Model I and Model II. The results of the linear regression analysis for Model I are presented in Table 5.

Table 5. Linear Regression Test for Model I

Exogenous Variables	Standardized Coefficients Beta	R^2	Significance
Metacognitive Awareness	0.376		0.000
Mathematical Disposition	0.194	0.661	0.000
Self-Efficacy	0.748		0.000

Based on Table 5, the path coefficient values of each variable were obtained, namely $\rho_{YX1} = 0.376$, $\rho_{YX2} = 0.194$, and $\rho_{YX3} = 0.748$. The residual error value (ε_1) was calculated using the formula $\sqrt{1 - R^2}$ and was obtained as 0.5822. In addition, each path coefficient had a significance value (Sig.) that was smaller than $\alpha = 0.05$, so it can be concluded that all paths in Model I are significant. Thus, a path diagram can be compiled for Model I as shown in Figure 2. In addition, the structural equation of Model I is formulated as $Y = 0.376X_1 + 0.194X_2 + 0.748X_3 + 0.339$.

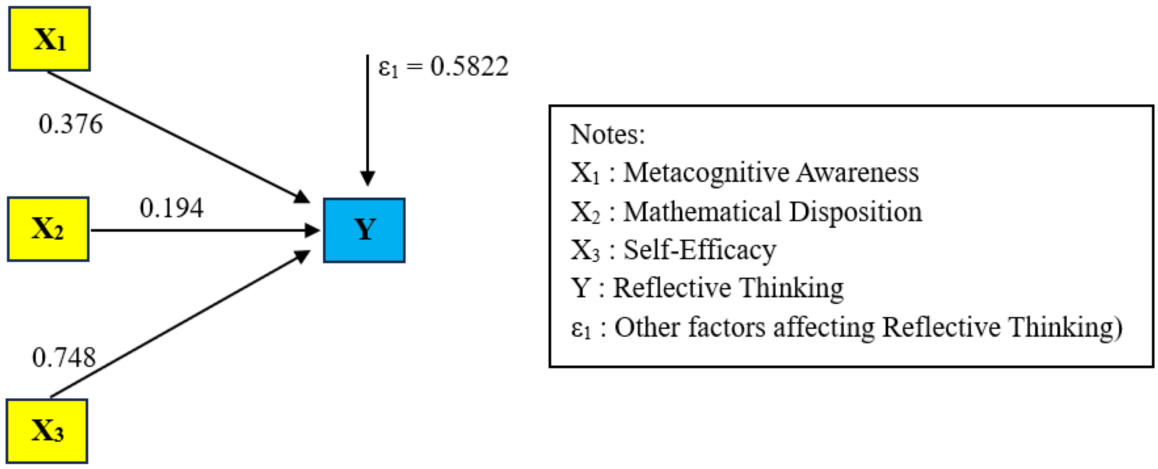

Figure 2. Diagram of Model I

Meanwhile, Table 6 presents the results of the linear regression test for Model II. Based on Table 6, the path coefficient values for each variable are as follows: $\rho_{ZX1} = 0.153$, $\rho_{ZX2} = 0.085$, $\rho_{ZX3} = 0.243$, $\rho_{ZY} = 0.578$. The residual error (ε_2) was calculated using the formula $\sqrt{1 - R^2}$, resulting in a value of 0.571. In addition, each path coefficient has a significance value (Sig.) less than or equal to $\alpha = 0.05$. In this case, the mathematical disposition variable has a Sig. value equal to the significance threshold, which is 0.050, indicating marginal significance and representing the weakest influence among the variables.

Table 6. Linear Regression Test for Model II

Exogenous Variables	Standardized Coefficients Beta	R^2	Significance
Metacognitive Awareness	0.153	0.674	0.002
Mathematical Disposition	0.085		0.05
Self-Efficacy	0.243		0.000
Reflective Thinking	0.578		0.000

Therefore, it can be concluded that all the paths in Model II are statistically significant. Thus, a path diagram can be compiled for Model II as shown in Figure 3. In addition, the structural equations of Model II are formulated as $Z = 0.153X_1 + 0.085X_2 + 0.243X_3 + 0.578Y + 0.326$.

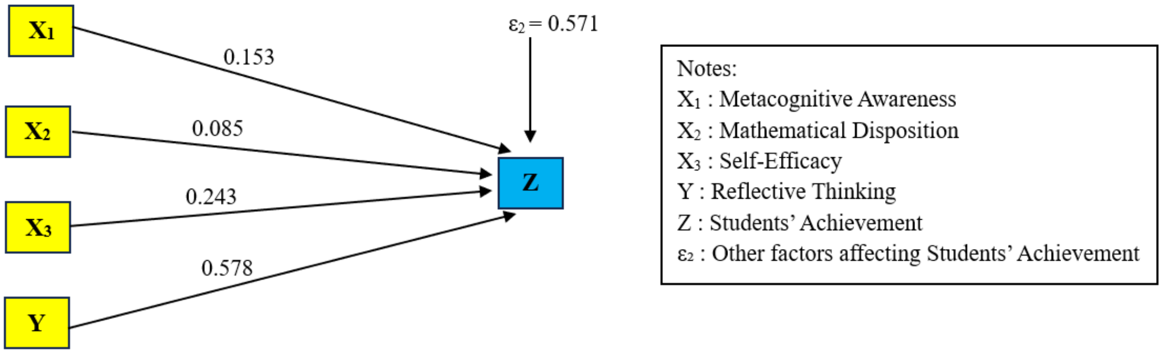

Figure 3. Diagram of Model II

After that, the three hypotheses that have been assumed previously will be tested.

First Hypothesis

H_0 : There is no direct influence of metacognitive awareness, disposition, and self-efficacy on reflective thinking

H_a : There is a direct influence of metacognitive awareness, disposition, and self-efficacy on reflective thinking

Based on Table 5, the significance value for the metacognitive awareness variable was 0.000 < α = 0.05, mathematical disposition 0.000 < α = 0.05, and self-efficacy 0.000 < α = 0.05. Since the total significance value is smaller than the significance level (α), H_0 is rejected for each variable. Thus, it can be concluded that metacognitive awareness, mathematical disposition, and self-efficacy significantly influence reflective thinking ability.

Second Hypothesis

H_0 : There is no direct influence of metacognitive awareness, disposition, self-efficacy, reflective thinking on mathematics learning achievement

H_a : There is a direct influence of metacognitive awareness, disposition, self-efficacy, reflective thinking on mathematics learning achievement

Based on Table 6, the significance value for metacognitive awareness is 0.002 < α = 0.05, mathematical disposition is 0.05 = α, self-efficacy is 0.000 < α = 0.05, and reflective thinking is 0.000 < α = 0.05. Since the significance value of all variables is less than or equal to α, H0 is rejected for each variable. Therefore, it can be concluded that metacognitive awareness, mathematical disposition, self-efficacy, and reflective thinking ability directly influence mathematics learning achievement. Especially for mathematical dispositions, the influence is significant but at the critical limit of significance values.

Third Hypothesis

H_0 : There is no indirect influence of metacognitive awareness, disposition, and self-efficacy on mathematics learning achievement through reflective thinking

H_a : There is an indirect influence of metacognitive awareness, disposition, and self-efficacy on mathematics learning achievement through reflective thinking

The direct influence of metacognitive awareness on learning achievement is $\rho_{ZX1} = 0.153$. Meanwhile, the indirect influence of metacognitive awareness on learning achievement is $\rho_{YX1} \times \rho_{ZY} = 0.376 \times 0.578 = 0.217328$. These results show that the indirect influence is greater than the direct influence. Thus, H_0 for the metacognitive awareness variable is rejected. This means that there is a significant indirect influence of metacognitive awareness on mathematics learning achievement through reflective thinking.

Then, the direct influence of mathematical disposition on learning achievement is $\rho_{ZX2} = 0.085$. The indirect influence of mathematical disposition on learning achievement is $\rho_{YX2} \times \rho_{ZY} = 0.194 \times 0.578 = 0.112132$. The value of this indirect influence is greater than its direct influence. Therefore, H_0 for the mathematical disposition variable is rejected, so it can be concluded that mathematical disposition significantly indirectly influences mathematics learning achievement through reflective thinking.

Furthermore, the direct effect of self-efficacy on learning achievement is $\rho_{ZX3} = 0.243$. Meanwhile, the indirect influence of self-efficacy on learning achievement is $\rho_{YX3} \times \rho_{ZY} = 0.748 \times 0.578 = 0.432344$. The value of this indirect influence is also greater than that of direct influence. Thus, H_0 for the self-efficacy variable is rejected. This shows a significant indirect influence of self-efficacy on mathematics learning achievement through reflective thinking.

3.2. Discussion

The results of the data analysis showed that cognitive awareness, mathematical disposition, and self-efficacy had a significant direct effect on reflective thinking. The R-Square value was obtained as 0.661, meaning that cognitive awareness, mathematical disposition, and self-efficacy contributed 66.1% to reflective thinking. In comparison, 33.9% contributed to other variables beyond the study. Self-efficacy is the variable that has the most significant influence on reflective thinking, which is shown by the coefficient value of the path $\rho_{YX3} = 0.748$. This is in line with research by Ariany et al. (2023), which shows that self-efficacy plays a role as one of the main internal factors that affect the reflective thinking ability of prospective mathematics teachers, especially in dealing with non-routine problems. In addition, cognitive awareness also has a significant direct effect and this is in line with the opinion of Adadan & Oner (2018) that individuals with a high level of metacognitive awareness can plan, monitor, and evaluate their thought processes more effectively, which is the essence of reflective thinking (Kholid et al., 2020). Moreover, although mathematical disposition is the variable with the weakest influence on reflective thinking (coefficient value $\rho_{YX2} = 0.194$), the role of disposition is important in supporting the formation of reflective thinking habits, namely through a positive attitude towards mathematics that encourages perseverance, curiosity, and openness to various problem-solving strategies (Marisa et al., 2023).

In addition, the results of the data analysis also show that metacognitive awareness, mathematical disposition, self-efficacy, and reflective thinking have a significant direct effect on students' mathematics learning achievement. The R Square value was obtained as 0.674, meaning that the variables of metacognitive awareness, mathematical disposition, self-efficacy, and reflective thinking contributed 67.4% to student learning achievement. In comparison, 32.6% were the contributions of other variables beyond the study. In this case, reflective thinking is the variable that has the most significant influence on learning achievement, which is indicated by the value of the path coefficient of $\rho_{ZY} = 0.578$. This is in accordance with the opinion of Titus & Muttungal (2024), who stated that reflective thinking is an important part of the process of meaningful learning, as it helps students review, evaluate, and revise their understanding to increase learning outcomes. Meanwhile, mathematical disposition was the variable with the weakest influence on learning achievement, with a coefficient value $\rho_{ZX2} = 0.085$. This is supported by the opinion of Hutajulu et al. (2019) that mathematical disposition affects students' affective and motivational aspects more in the long term than academic achievement.

Furthermore, the results of the data analysis showed that metacognitive awareness, mathematical disposition, and self-efficacy significantly indirectly affected students' learning achievement through reflective thinking. These findings indicate that reflective thinking is a mediator that strengthens the influence of these three variables on mathematics learning outcomes. This aligns with the opinion of Putri et al. (2020), who stated that reflective thinking is an important element that acts as a mediator in connecting students' cognitive and affective abilities with mathematics learning outcomes. In addition, Widyastuti & Nuriadin (2021) found that self-efficacy positively correlates with students' mathematical reflective thinking skills in online learning, contributing to increased learning achievement. In the context of mathematical disposition, positive dispositions such as perseverance and curiosity encourage student involvement in mathematical problem-solving through reflective thinking, which has implications for improved learning outcomes (Hoon et al., 2021).

This study used purposive sampling by selecting leading public senior high schools in Boyolali Regency. Although this approach ensures that participants come from established educational environments, it may limit the generalizability of the findings to other schools with different characteristics, such as rural schools or schools with different academic profiles. Furthermore, the sample was limited to tenth and eleventh-grade students, which may not represent reflective thinking skills and related factors across grade levels. Future research can expand the sample to include more schools and grade levels to improve the applicability of the results.

4. CONCLUSION

Metacognitive awareness, mathematical disposition, self-efficacy, reflective thinking, and learning achievement have a causal relationship in mathematics learning. The results showed that metacognitive awareness, mathematical disposition, and self-efficacy significantly and directly affected reflective thinking, with a contribution of 66.1%. Among these three variables, self-efficacy has the most significant influence on reflective thinking. Furthermore, metacognitive awareness, mathematical disposition, self-efficacy, and reflective thinking significantly and directly affected students' mathematics learning achievement, with a contribution of 67.4%. In this case, reflective thinking is the variable that contributes the most to student learning achievement. Furthermore, reflective thinking is a significant mediator in the relationship between psychological variables (metacognitive awareness, mathematical disposition, and self-efficacy) on learning achievement. These three variables significantly indirectly influence student learning achievement through reflective thinking, with an indirect influence greater than the direct influence. These findings serve as a basis for educators and curriculum developers to design learning strategies that focus on academic material and strengthen students' internal aspects, such as metacognitive awareness, positive disposition toward mathematics, and self-efficacy. In addition, developing students' reflective thinking skills needs to be the primary focus in learning because of its strategic role in improving academic achievement.

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