Mediating Role of Metacognitive Awareness Between Self-Efficacy and Mathematics Reasoning Among Education Undergraduate Students During Pandemic

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This research aimed to examine the contribution of metacognitive awareness as a moderator in the relationship between self-efficacy and mathematical reasoning among education undergraduates during the Covid-19 Pandemic. The analysis included 184 undergraduate students in one public university around Klang Valley, Malaysia. The researcher distributes mathematics reasoning assessment, metacognitive awareness, and self-efficacy questionnaires to collect research data. Statistical Package for the Social Sciences version 25 analyzes the mediating influence of metacognitive awareness in the correlation between self-efficacy and mathematics reasoning. The findings revealed that undergraduate mathematics and science education students had better mathematical reasoning abilities than undergraduates of non-mathematics and science education. However, the result indicated that mathematics and science education undergraduate students have high metacognitive awareness and utilize more strategies in mathematics reasoning assessment. This research suggested that further analysis can measure other populations, such as secondary school students' metacognitive awareness and self-efficacy in mathematics reasoning.

Keywords: moderator, metacognitive awareness, self-efficacy, mathematics reasoning, education undergraduate students

INTRODUCTION

The Covid-19 epidemic has caused various societal changes, especially in the educational system. According to Hindun et al. (2021), the worldwide pandemic epidemic has caused substantial disruptions in students' learning and education at every stage of education. Epidemic learning approaches are incompatible with a cognitive revolution that can impact students' efficacy in academics. Besides that, lecturers are responsible for assisting students in learning and completing their academics. They must also use practical teaching approaches to urge students to self-study as much as possible. Lecturers should leverage students' experiences to create an appealing mathematics context and activities (Hindun et al., 2021).

Developing students' metacognition and mathematical reasoning is extremely important. Because it will enable them to transform their learning environment more meaningfully, develop their thinking abilities and get them involved in problem-solving and generalization-making processes and the decision-making process for strategies to enhance cognitive performance in mathematics learning (Asy'ari et al., 2019; Risnawati et al., 2019). Chan et al. (2022) also mention that undergraduate students must strengthen their critical thinking, reasoning, and problem-solving abilities to improve education. These abilities will enable them to develop and evaluate understandings and provide justifications in mathematics (Chan et al., 2021).

Mathematics self-efficacy refers to an individual's perceived competence to perform mathematical tasks. Self-efficacy influences an individual's ideas, feelings, motivations, and behaviors (Bandura, 1993). In academic settings, varying degrees of self-efficacy, the foundation for self-regulatory learning, can lead to positive and negative outcomes. Students with stronger self-efficacy employ more practical knowledge and problem-solving skills (In'am & Sutrisno, 2020). Chan et al. (2022) discovered that the self-efficacy of undergraduates strongly indicated an interest in mathematics-related college courses or jobs. Furthermore, the positive association between self-efficacy and academic performance in previous research correlated to self-evaluation of capability as much as students' current mathematics ability.

Mathematics is a discipline of scientific knowledge that requires abstract reasoning. Mathematical reasoning is learning new things using mathematical symbols, concepts, or relationships. Mathematics reasoning includes inductive, deductive, comparative, and generalizing reasoning (Kartono & Shora, 2020). According to the National Council of Teachers of Mathematics (2021), reasoning is an essential component of mathematics and one of the fundamental standards. Reasoning is a mathematical principle that all students should cultivate. The core of cognitive activity is metacognition. Metacognition is the thinking process, implying that the individual is conscious of and controls his cognitive functions. The most often used terms to describe metacognition are cognition and self-control. Individuals with good self-discipline may control their thinking and learning processes using appropriate cognitive approaches (Ramli et al., 2019).

Metacognitive Awareness in Mathematics Reasoning

Reasoning capabilities include a metacognitive process based on self-awareness of one's cognitive abilities and the ability to monitor and manage one's reasoning process (Chan et al., 2021). Previous studies show that metacognitive knowledge is the basis of individual differences in mathematics (Misu et al., 2019; Salam et al., 2020). Metacognition involves two components: knowledge and regulation. Metacognitive knowledge comprises information about the learner's learning style, characteristics that will affect their performance, learning techniques, and when and how to employ them. A student with solid metacognitive knowledge understands their mathematical abilities, knowledge level, and the approaches and strategies they should use in the problem-solving activity. Planning, monitoring, and evaluating operations constitute metacognitive regulation. Schraw and Dennison (1994) described metacognitive awareness as the ability to reflect on, comprehend, and manage an individual's learning. Additionally, metacognitive awareness consists of two main components: knowledge of cognition and cognition regulation. It reflects learners' intelligence of their capacity evaluations.

Students employ reasoning when engaging in mathematical argumentation, which is the action of formulating and supporting mathematical statements (Lestari et al., 2022). Deductive reasoning is the justification, or the portion of reasoning, that seeks to persuade oneself or another that the argument is correct (Nurjanah et al., 2020). Students are prone to noticing patterns, structures, or regularities in real-world and symbolic contexts. They speculate and verify whether those patterns are random or whether they have a purpose. As a result, a mathematics instructor must have an instrument to assess learners' reasoning skills (Calvin & Duane, 2002; Naufal et al., 2021).

According to Amir et al. (2021), metacognition is essential because it enhances learning acquisition, understanding, retention, and application. It also impacts learning efficiency, critical thinking, and problem-solving. Metacognitive awareness enables self-regulation of cognition and learning processes and consequences. The knowledge of cognition refers to what an individual knows about understanding in general or one's comprehension. Salam et al. (2020) defined metacognitive awareness as the process of increasing awareness about own personal, task, and strategy knowledge in a scenario through reflective thinking.

Metacognitive Awareness Mediator Role in Mathematics

When metacognitive awareness is a mediator in the mediation model, problem-solving abilities still showed a positive, significant influence on mathematics achievement. This reduction showed that metacognitive awareness moderated the association between problem-solving skills and mathematics success in secondary school students (Wajid & Jami, 2020). According to Wajid and Jami (2020), problem-solving and metacognition are complicated cognitive skills that have obtained little attention. Wajid and Jami (2020) mention that metacognitive awareness processes vary depending on the cognitive task. Metacognitive strategies are more substantial in learners with reasoning abilities and experienced weaker metacognitive approaches.

Metacognitive knowledge was a significant mediator between internal locus of control and mathematics achievement. The study also discovered that an external locus of control is directly and strongly associated with mathematics success without the intervention of metacognitive knowledge (Roick & Ringeisen, 2018). However, another possible explanation for this finding is that an internal locus of control, defined as the ability to manage and impact events, entails the acquisition of metacognitive knowledge and that this information allows students to attain greater levels of mathematics performance (Roick & Ringeisen, 2018).

Wafubwa and Csíkos (2022) research on understanding the link between collaborative and metacognitive conversation and investigating the possibility that they may mutually mediate in mathematics learning is focused. The finding discovered that metacognitive discussion was more likely than any other sort of discourse to satisfy the requirements for cooperation by using a small-scale case study. Furthermore, whether the prior knowledge was transitive or non-transitive had the most significant impact on the chances of following metacognitive conversation in mathematics learning (Wafubwa & Csíkos, 2022).

Self-Efficacy Differences in Mathematics Reasoning

Bandura (1993) defined self-efficacy as confidence in one's ability to plan and execute courses of action necessary to accomplish specified results. In this context, self-efficacy refers to "cognitive structures that offer reference mechanisms" and "a collection of mechanisms for experience, assessment, and control of the action." Recent research consistently finds that adult learners with a higher level of self-efficacy and self-concept are more satisfied with their secondary school experience, more persistent when faced with educational barriers, and more likely to participate in future courses (Muhtadi et al., 2022; Sides & Cuevas, 2020; Zulkarnain et al., 2020). Self-efficacy beliefs affect individual performance through four basic processes: cognitive, motivational, emotional, and selection. In the ongoing control of personal functioning, these several mechanisms often engage in combination rather than standalone. There are several types of effectiveness belief effects regarding cognitive processes. Self-evaluation of capacities influences personal goal setting. The higher individual's perceived self-efficacy, the higher the goals they set for themselves and the more committed they are to them (In'am & Sutrisno, 2020).

Reasoning is a fundamental basis for a productive and meaningful knowledge of mathematics. Chan et al. (2021) explored the effect of academic self-efficacy as a moderator in the link between personality traits and mathematical performance. They confirmed that academic self-efficacy has a mediating function between the five-component model and mathematics performance. According to Kotova et al. (2021), individuals' belief in their academic self-efficacy and capacity to begin and sustain their mathematics performance is exceptionally vital in academics.

According to the National Council of Supervisors of Mathematics (2020), reasoning abilities are mathematical skills that the learner must acquire. Aside from metacognition, individuals' self-efficacy in mathematics affects their performance. Bandura (1993) social cognition theory states that students' self-efficacy beliefs in the judgment of confidence in doing academic studies or succeeding in educational activities will impact their eventual capacity to achieve such tasks or engage in scholarly activities. Mathematics self-efficacy is a scenario or problem-specific assessment of an individual's belief in their ability to execute or complete a particular task or difficulty. Individuals with high self-efficacy will be more effective in achieving the tasks assigned based on this understanding of how individual beliefs may impact their performance (Sides & Cuevas, 2020). Chan et al. (2022) discovered a relatively substantial link between mathematics self-efficacy and mathematics performance among undergraduate students. In correlational research, Chan et al. (2022) found a positive correlation between self-efficacy and cognitive engagement. In conclusion, research into mathematics self-efficacy and metacognition are essential for determining how these qualities contribute to mathematics academic accomplishment.

In university academic settings, self-efficacy research generally concentrates on two major areas. First, investigate the correlations between self-efficacy beliefs, associated psychological categories, motivation, and accomplishment. Second, examine the relationship between self-efficacy beliefs, college majors, and career choices (In'am & Sutrisno, 2020; Kotova et al., 2021; Muhtadi et al., 2022). Individuals with greater levels of mathematics self-efficacy also have better mathematics performance and are therefore more likely to pursue mathematics or science-related professional sector (Kotova et al., 2021).

METHODOLOGY

Research Design

This research uses the correlational research design approach. A correlational study investigates the correlations between two or more variables without intervention. The correlation coefficients discovered give evidence to identify specific outcomes (Creswell & Creswell, 2018). This research analyzed the predicted correlations between self-efficacy and mathematical reasoning, where metacognitive awareness is a mediator between variables.

Sampling and Participants

The research included 184 undergraduate education students selected using a simple sampling method. Mathematics and Science education undergraduate participants represented 51% (n = 94) of the pupils, while Non-Mathematics and Science education undergraduate participants represented 49% (n = 90). The participants from a university in Klang Valley are selected randomly from various socioeconomic backgrounds. Before data collection, the research ethics committee consented to the study, and all participants provided informed permission.

Measurement Instrument

The researcher adapted the mathematics reasoning questions from Calvin and Duane (2002). On the mathematics reasoning measurement, there are eight open-ended questions. The assessment takes approximately 60 minutes to complete. The answer to the mathematics reasoning questions is scored on a scale of 0 to 4 using a rubric. Two mathematics instructors conducted the scoring. The scorers had nearly perfect agreement (kappa = 0.86). A consensus was attained by evaluating the outcomes where there was no agreement amongst the scorers. The assessment yields the lowest score of 0 and the maximum score of 4 for each question. High scores indicate more excellent mathematical reasoning abilities. The Cronbach's alpha coefficient calculated in this research for the mathematics reasoning assessment was 0.71.

TABLE 1
THE MATHEMATICS REASONING SCORING RUBRIC

Score	Description
0	Some answers wrongly solve the problem or are left unsolved.
1	Some solutions demonstrate their lack of understanding of the procedure and explanation for resolving the problem.
2	Whereas the technique of solving the issue and its explanation demonstrate that the problem is understood slightly, specific answers indicate that he lacks knowledge in some elements of the solution explanations.
3	Some solutions are correct except for a few minor errors or misunderstandings in how they solved and explained the issue, expressing their views using suitable mathematical notation and symbols, articulating how they reasoned, and claiming that they fully comprehended.
4	Some solutions accurately explain the approach to solving the issue and its justification, express their views using precise mathematical notation and symbols, correctly explain their reasoning, and demonstrate a comprehensive understanding.

The researcher used the Metacognitive Awareness Inventory developed by Schraw and Dennison (1994) and Rahman et al. (2014). The instrument has 6-dimensional, and used the scale is a 5-point Likert type (1=Totally does not Agree, 5=Absolutely Agree). This research used the metacognitive awareness sub-dimension of the inventory consisting of 30 items. Higher scores imply that metacognitive approaches are utilized more frequently in mathematical reasoning. In the present research, Cronbach's alpha value for the metacognitive awareness inventory was 0.85. Ultimately, the researcher used the Self-efficacy Inventory developed by May (2009) to determine university students' self-efficacy level in mathematical reasoning. The measurement inventory has 3-dimensional structures. The scale is a 5-point Likert type (1=Totally does not Agree, 5=Absolutely Agree). In this research, the self-efficacy three sub-dimension of the inventory consisting of 17 items. Higher scores imply self-efficacy and more confidence or belief in mathematical reasoning learning. In the present research, Cronbach's alpha value for the Self-efficacy inventory was 0.85.

Data Analysis

The analysis used the Skewness and Kurtosis Coefficients to examine the distribution of mathematical reasoning, metacognitive awareness, and self-efficacy scores. The Skewness and Kurtosis Coefficients in the ±1 range indicate that the scores follow a normal distribution (Denis, 2021). The Skewness and Kurtosis Coefficients were within the acceptable limits shown in Table 2. The scores have univariate normal distributions based on the data analysis. The following analysis used Pearson Correlation coefficients to explore the relationships between mathematical reasoning, metacognitive awareness, and self-efficacy scores. The correlation coefficient has a range of values between ±1. The coefficients between 0 and ±0.30 indicate low-level coefficients. Besides that, coefficients range of ±0.30 and ±0.70 indicate moderate-level correlations, and coefficients range between ±0.70 and ±1 show high-level correlations (Tabachnick & Fidell, 2019).

TABLE 2
THE SKEWNESS AND KURTOSIS COEFFICIENTS

Variables	Skewness		Kurtosis	
	z	SE	z	SE
Mathematics Reasoning	-.072	.165	-.588	.337
Metacognitive Awareness	.070	.179	.036	.356
Self-efficacy	-.403	.174	.016	.346

From table 2, the skewness of the mathematics reasoning and self-efficacy was found to be -.07 and -.40, indicating that the distribution was left-skewed. Besides that, the skewness of the metacognitive awareness .07 was found, showing that the distribution was right-skewed. The kurtosis of the mathematics reasoning, metacognitive awareness, and self-efficacy show that -.59, .04, and .02, indicating that the distribution was a less extreme outlier than a normal distribution. Moreover, the correlation coefficient of mathematics reasoning, metacognitive awareness, and self-efficacy show moderate-level correlations.

RESULTS

The Level of Self-Efficacy, Metacognitive Awareness, and Mathematical Reasoning

The self-efficacy, metacognitive awareness, and mathematical reasoning mean scores of education undergraduate students show in Table 3. Mathematics and Science education undergraduate students' mathematics reasoning (M=28.46, SD=5.30) score was significantly higher than the mean (M=27.20, SD=4.82) score of non-Mathematics and Science education undergraduate students ($t(76.53)=0.36$, $p<0.001$). Mathematics and Science education undergraduate students’ metacognitive awareness mean (M=115.67, SD=13.86) score was significantly higher than non- Mathematics and Science education undergraduate students’ mean (M=114.54, SD=13.54) score ($t(112.12)=1.02$, $p<0.001$). Mathematics and Science education undergraduate students’ self-efficacy (M=51.63, SD=8.65) score was significantly higher than the mean (M=48.56, SD=7.58) score of non-Mathematics and Science education undergraduate students ($t(82.52)=0.61$, $p<0.001$).

TABLE 3
STANDARD DEVIATIONS AND MEAN OF THE VARIABLE

Variables	Mathematics and Science students (n=94)		Non-Mathematics and Science students (n=90)		All (n=184)			
	M	SD	M	SD	M	SD	Min.	Max
Mathematics Reasoning	28.46	5.03	25.89	4.24	27.20	4.82	13	37
Metacognitive Awareness	115.67	13.86	113.36	14.16	114.54	13.54	80	150
Self-efficacy	51.63	8.65	48.56	7.58	65	50.13	26	65

The Relationships Between Self-Efficacy, Metacognitive Awareness, and Mathematical Reasoning

The researcher examined the relationships between self-efficacy, metacognitive awareness, and mathematical reasoning scores by calculating Pearson Correlation coefficients. The finding of the correlation coefficient analyzes as given in Table 4.

TABLE 4
PEARSON CORRELATION WITH SELF-EFFICACY, METACOGNITIVE AWARENESS, AND MATHEMATICS REASONING

No.	Variables	1.	2.	3.
1.	Self-efficacy	1		
2.	Metacognitive Awareness	.17	1	
3.	Mathematics Reasoning	.17	.63	1

**p<0.01, N=184

Table 4 shows that self-efficacy with metacognitive awareness ($r= 0.17$, $p<0.01$) and mathematics reasoning ($r=0.17$, $p<0.01$) were positively correlated. Mathematics reasoning with metacognitive awareness ($r=0.63$, $p<0.01$) were positively correlated.

The Mediating Role of Metacognitive Awareness in The Effect of Self-Efficacy on Mathematics Reasoning

The researcher used SPSS Amos version 25 to test the mediating role of metacognitive awareness in the effect of self-efficacy on mathematics reasoning. Figure 1 indicates the typical mediation model; the path coefficient (0.23) is the term for the direct effect of self-efficacy on mathematics reasoning, also known as the effect of the metacognitive awareness of self-efficacy on mathematics reasoning or residual effect. Path coefficient (0.60) is the effect of self-efficacy on metacognitive awareness, also known as the first stage effect. Path coefficient (0.34) is the effect of metacognitive awareness on mathematics reasoning, also known as the second stage effect. If the direct effect of self-efficacy on mathematics reasoning after the addition of metacognitive awareness is insignificant, it is known as full mediation.

FIGURE 1
DIRECT EFFECT OF SELF-EFFICACY ON MATHEMATICS REASONING

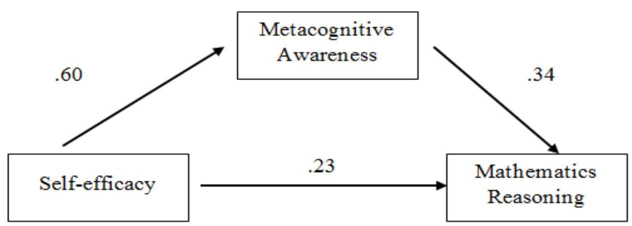
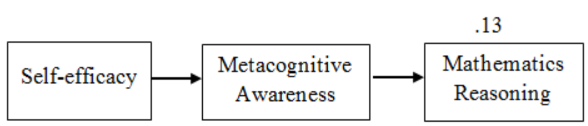


Figure 2 indicates the impact path of self-efficacy on mathematics reasoning, and the path coefficient (0.13) is also known as the total effect of self-efficacy on mathematics reasoning. This research explores whether self-efficacy impacts mathematics reasoning from another factor, termed mediator variable, represented by metacognitive awareness. Hence, mediation analysis has at least three variables in this research: self-efficacy, metacognitive awareness, and mathematics reasoning.

FIGURE 2
INDIRECT EFFECT OF SELF-EFFICACY ON MATHEMATICS REASONING



Path coefficients for direct and indirect effects in Table 5, Model 1 examines the impact of self-efficacy on metacognitive awareness ($F(118.46)=61.61$, $R=0.63$, $p<0.01$). The fact that the confidence interval (95% CI= 0.865, 1.247) did not contain a zero-value showed that the observed effect was significant (Denis, 2021). Self-efficacy positively and significantly affected metacognitive awareness ($\beta=0.628$, $p<0.001$). The results show a positive coefficient of self-efficacy's direct effect on metacognitive awareness. The finding indicated that the standard deviation of metacognitive awareness among undergraduate students is 13.857; the standard deviation of self-efficacy among education undergraduate students is 8.240.

TABLE 5
DIRECT AND INDIRECT EFFECT OF SELF-EFFICACY ON MATHEMATICS REASONING

Model	B	SE	β	t	Sig	*LLCI*	*ULCI*
SE →MA (Direct Effect) **Model 1**	1.056	.097	.628	10.884	0.00***	.865	1.247
SE→MR (Direct Effect) **Model 2**	.097	.043	.166	2.274	.024	.013	.187
MA→MR (Direct Effect) **Model 3**	.058	.025	.167	2.287	.023	.008	.108
SE →MA→MR (Indirect Effect) **Model 4**	20.106	2.960		6.793	0.00***	14.265	25.946

*** p<0.005, SE= Self-efficacy, MA= Metacognitive Awareness, MR= Mathematics Reasoning, LLCI= Lower Limit of the Confidence Interval, ULCI = Upper Limit of the Confidence Interval

In Model 2, the effects of self-efficacy with mathematics reasoning ($F(5.172)=22.33$, $R=0.17$, $p<0.01$) were analyzed. Confidence intervals calculated for self-efficacy and mathematics reasoning (95% CI= 0.01, 0.19) did not contain zero values, indicating that the observed effects were statistically significant (Denis, 2021). Self-efficacy (β =-0.17, $p<0.001$) significantly affected mathematical reasoning.

In Model 3, the effect of metacognitive awareness on mathematics reasoning ($F(5.23)=20.54$, $R=0.17$, $p<0.01$) was examined. The fact that the confidence interval (95% CI= 0.01, 0.11) did not contain a zero-value showed that the observed effect was significant (Denis, 2021). Metacognitive awareness positively and significantly affected mathematics reasoning (β=-0.17, $p<0.001$). Additionally, the finding indicated the standard deviation of metacognitive awareness, 114.538; the standard deviation of mathematics reasoning, with a standard deviation, 27.20.

In Model 4, the following analysis has investigated the indirect effect of self-efficacy on mathematical reasoning skills. The indirect impact ($B=20.11$, $p<0.001$) was statistically significant as the confidence interval (95% CI= 14.27, 25.95). The significant indirect effect showed that metacognitive awareness mediates the relationship between self-efficacy and mathematical reasoning. Only a part of the total effects through the mediating variable indicates that metacognitive awareness was a mediator.

DISCUSSIONS

This research investigates the relationships between self-efficacy, metacognitive awareness, and mathematical reasoning. Furthermore, it examined whether self-efficacy mediated metacognitive awareness differences in mathematical reasoning. The findings revealed that Mathematics and Science education undergraduate students performed better on mathematical reasoning than non- Mathematics and Science education undergraduate students. Course content is essential in mathematics learning and can lead to efficacy differences in mathematics performance. However, some researchers claim no difference in the self-efficacy mathematics course taken (In'am & Sutrisno, 2020; Kotova et al., 2021). The finding consistent with previous studies has attributed the cause of mathematics learning may difference to environmental or other learning factors (Kotova et al., 2021; Muhtadi et al., 2022; Sides & Cuevas, 2020; Zulkarnain et al., 2020).

Previous research has revealed that the student's mathematical reasoning differs. Unlike the literature studies, the present research argues that this difference may be in mathematics understanding. Some students' explanations of the patterns are less profound, and they tend to misunderstand the practices and draw incorrect conclusions (Lestari et al., 2022; Nurjanah et al., 2020). Some students use standard algorithmic reasoning methods (Kartono & Shora, 2020). Besides that, some students had a higher rate of making correct assumptions about mathematical patterns, understanding mathematical problems, and checking the accuracy of results (Risnawati et al., 2019). The researcher found that the answers given by the Mathematics and Science education undergraduate students at the stage of understanding the issue were more detailed than those of the non-Mathematics and Science education undergraduate students.

Mathematics is a cognitively demanding discipline. One of the findings obtained in this study is that sciences and mathematics education undergraduate students use metacognitive strategies more than non-sciences and mathematics education undergraduate students. These results are consistent with the researchers who indicated that students had better metacognitive strategy knowledge (Asy'ari et al., 2019; Naufal et al., 2021; Robillos & Bustos, 2022). Previous research has revealed that the cognitive approaches of students to mathematics differ, which is consistent with this research's finding (Ramli et al., 2019; Risnawati et al., 2019).

The present research has provided quantitative evidence that education undergraduate metacognitive awareness differences in mathematical skills. The finding noted that undergraduate science and mathematics students are highly aware of metacognitive mathematical reasoning skills. In this respect, sciences and mathematics education undergraduate students who use metacognitive strategies effectively are more likely to solve mathematical problems. The finding observed that sciences and mathematics education undergraduate students who used mathematical approaches more effectively had higher mathematical reasoning performance.

Another significant result of the present research is that metacognitive awareness partially mediates the self-efficacy difference in mathematical reasoning. Students with inadequate metacognitive skills cannot correctly operate cognitive processes such as planning, evaluation, and monitoring learning processes. In this regard, even if these students have high intelligence and motivation, they are less likely to achieve high academic achievement. Researchers found that students with a high level of mathematical metacognition can evaluate, control, and regulate cognitive processes in mathematics reasoning, consistent with previous research (Misu et al., 2019; Salam et al., 2020).

This research investigates the correlation between self-efficacy and mathematical reasoning with the effect of metacognitive awareness as a mediator. On the other hand, the research finding indicates that metacognitive awareness can impact mathematical reasoning performance. Besides that, high metacognitive awareness affects their mathematical reasoning skills based on the present research findings. The researcher proposed that educators integrate critical reasoning elements in mathematics learning to establish self-efficacy and improve students' mathematical reasoning abilities. This research also recommends further analysis of model studies with more extensive and diverse student populations. The researcher also suggested that several interesting learning strategies for mathematical reasoning be diversified to improve students' self-efficacy and metacognitive awareness.

CONCLUSION

In conclusion, the present research showed that metacognitive awareness mediated self-efficacy differences in mathematical reasoning. Including educational content that supports mathematical reasoning has shown differences between self-efficacy and metacognitive awareness among undergraduate students. Conducting this research involves only undergraduate education students limits the results' generalizability. These studies may help clarify and generalize the relationships between mathematics reasoning, metacognition awareness, and self-efficacy among undergraduate education students. In addition, this study also found that self-efficacy mediates metacognitive awareness observed in mathematical reasoning among undergraduate education students was finding positively significant.

REFERENCES

Asy'ari, M., Ikhsan, M., & Muhali. (2019). The effectiveness of inquiry learning model in improving prospective teachers' metacognition knowledge and metacognition awareness. *International Journal of Instruction*, *12*(2), 455–470. https://doi.org/10.29333/iji.2019.12229a

Bandura, A. (1993). Perceived Self-Efficacy in Cognitive Development and Functioning. *Educational Psychologist*, *28*(2), 117–148. Retrieved from https://www.itma.vt.edu/courses/tel/resources/bandura(1993)_self-efficacy.pdf

Calvin, T.L., & Duane, W.D. (2002). *Mathematical Reasoning for Elementary Teachers* (3rd edition). Addison Wesley.

Chan, C.T., Hutkemri, Z., & Leong, K.E. (2021). Analysis Validity and Reliability of Self-Efficacy and Metacognitive Awareness Instrument Toward Mathematical Reasoning. *Turkish Journal of Computer and Mathematics Education*, *12*(9), 3332–3344. Retrieved from https://www.turcomat.org/index.php/turkbilmat/article/view/5739/4789

Chan, C.T., Hutkemri, Z., & Leong, K.E. (2022). Measurement model testing: Adaption of self-efficacy and metacognitive awareness among university students. *EURASIA Journal of Mathematics, Science and Technology Education*, *18*(9), 1–11. https://doi.org/https://doi.org/10.29333/ejmste/12366

Creswell, J.W., & Creswell, J.D. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. In *Journal of Chemical Information and Modeling* (5th Ed., Vol. 53, Iss. 9). SAGE Publications. https://doi.org/10.1017/CBO9781107415324.004

Denis. (2021). *Applied Univariate, Bivariate, and Multivariate Statistics Using Python: A Beginner's Guide to Advanced Data Analysis* (1st Ed.). Wiley.

Hindun, I., Husamah, H., Nurwidodo, N., Fatmawati, D., & Fauzi, A. (2021). E-learning in COVID-19 Pandemic: Does it challenge teachers' work cognition and metacognitive awareness? *International Journal of Instruction*, *14*(3), 547–566. https://doi.org/10.29333/iji.2021.14332a

In'am, A., & Sutrisno, E.S. (2020). Strengthening Students' Self-efficacy and Motivation in Learning Mathematics through the Cooperative Learning Model. *International Journal of Instruction*, *14*(1), 395–410. https://doi.org/10.29333/IJI.2021.14123A

Kartono, & Shora, R.Y. (2020). Effectiveness of process-oriented guided inquiry learning with peer feedback on achieving students' mathematical reasoning capabilities. *International Journal of Instruction*, *13*(3), 555–570. https://doi.org/10.29333/iji.2020.13338a

Kotova, S., Hasanova, I., Sadovnikova, N., Komarov, E., & Wenbin, L. (2021). Self-efficacy as a personality predictor of the career orientations of college students. *International Journal of Instruction*, *14*(4), 1047–1064. https://doi.org/10.29333/iji.2021.14460a

Lestari, K.E., Utami, M.R., & Yudhanegara, M.R. (2022). Exploratory Analysis on Adaptive Reasoning of Undergraduate Student in Statistical Inference. *International Journal of Instruction*, *15*(4), 535–554. https://doi.org/10.29333/iji.2022.15429a

May, D.K. (2009). *Mathematics Self-Efficacy And Anxiety Questionnaire*. The University of Georgia.

Misu, L., Budayasa, I.K., Lukito, A., Hasnawati, & Rahim, U. (2019). Profile of metacognition of mathematics education students in understanding the concept of integral in category classifying and summarizing. *International Journal of Instruction*, *12*(3), 481–496. https://doi.org/10.29333/iji.2019.12329a

Muhtadi, A., Assagaf, G., & Hukom, J. (2022). Self-Efficacy and Students' Mathematics Learning Ability in Indonesia: A Meta-Analysis Study. *International Journal of Instruction*, *15*(3), 1131–1146. https://doi.org/10.29333/iji.2022.15360a

Mz, Z.A., Risnawati, R., Nurdin, E., Azmi, M.P., & Andrian, D. (2021). The Increasing of Math Adversity Quotient in Mathematics Cooperative Learning Through Metacognitive. *International Journal of Instruction*, *14*(4), 841–856. https://doi.org/10.29333/iji.2021.14448a

National Council of Supervisors of Mathematics. (2020). The Common Core State Standards for Mathematics. *National Council of Supervisors of Mathematics*, pp. 1–6. https://doi.org/10.21890/ijres.61754
National Council of Teachers of Mathematics. (2021). Moving Forward: Mathematics Learning in the Era of COVID-19. *Moving Forward, June 2020*, pp. 1–18.
Naufal, M.A., Abdullah, A.H., Osman, S., Abu, M.S., & Ihsan, H. (2021). The effectiveness of infusion of metacognition in van Hiele model on secondary school students' geometry thinking level. *International Journal of Instruction*, *14*(3), 535–546. https://doi.org/10.29333/iji.2021.14331a
Nurjanah, Dahlan, J.A., & Wibisono, Y. (2020). The Effect of Hands-On and Computer-Based Learning Activities on Conceptual Understanding and Mathematical Reasoning. *International Journal of Instruction*, *14*(1), 143–160. https://doi.org/10.29333/IJI.2021.1419A
Rahman, S., Yasin, R.M., Salamuddin, N., & Surat, S. (2014). The use of metacognitive strategies to develop research skills among postgraduate students. *Canadian Center of Science and Education*, *10*(19), 271–275. https://doi.org/10.5539/ass.v10n19p271
Ramli, Mukminatien, N., Saukah, A., & Prayogo, J.A. (2019). Word recognition from speech, syntactic knowledge, metacognitive awareness, self-efficacy as determination for l2 listening comprehension. *International Journal of Instruction*, *12*(3), 89–104. https://doi.org/10.29333/iji.2019.1236a
Risnawati, Andrian, D., Azmi, M.P., Amir, Z., & Nurdin, E. (2019). Development of a definition maps-based plane geometry module to improve the student teachers' mathematical reasoning ability. *International Journal of Instruction*, *12*(3), 541–560. https://doi.org/10.29333/iji.2019.12333a
Robillos, R.J., & Bustos, I.G. (2022). Learners' Listening Skill and Metacognitive Awareness through Metacognitive Strategy Instruction with Pedagogical Cycle. *International Journal of Instruction*, *15*(3), 393–412. https://doi.org/10.29333/iji.2022.15322a
Roick, J., & Ringeisen, T. (2018). Students' math performance in higher education: Examining the role of self-regulated learning and self-efficacy. *Learning and Individual Differences*, *65*, 148–158. https://doi.org/10.1016/j.lindif.2018.05.018
Salam, M., Misu, L., Rahim, U., Hindaryatiningsih, N., & Ghani, A.R.A. (2020). Strategies of metacognition based on behavioural learning to improve metacognition awareness and mathematics ability of students. *International Journal of Instruction*, *13*(2), 61–72. https://doi.org/10.29333/iji.2020.1325a
Schraw, G., & Dennison, R.S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, *19*(4), 460–475. https://doi.org/10.1006/ceps.1994.1033
Sides, J.D., & Cuevas, J.A. (2020). Effect of Goal Setting for Motivation, Self-Efficacy, and Performance in Elementary Mathematics. *International Journal of Instruction*, *13*(4), 1–16. https://doi.org/10.29333/iji.2020.1341a
Tabachnick, B.G., & Fidell, L.S. (2019). Using Multivariate Statistics. In *Pearson Education* (Vol. 5, Issue 7th). Pearson. Retrieved from https://lccn.loc.gov/2017040173
Wafubwa, R.N., & Csíkos, C. (2022). Impact of Formative Assessment Instructional Approach on Students' Mathematics Achievement and their Metacognitive Awareness. *International Journal of Instruction*, *15*(2), 119–138. https://doi.org/10.29333/iji.2022.1527a
Wajid, U., & Jami, H. (2020). Research self-efficacy among students: Role of metacognitive awareness of reading strategies, research anxiety, and attitude towards research. *Pakistan Journal of Psychological Research*, *35*(35), 271–293. https://doi.org/10.33824/PJPR.2020.35.2.15
Zulkarnain, Zulnaidi, H., Heleni, S., & Syafri, M. (2020). Effects of SSCS Teaching Model on Students' Mathematical Problem solving Ability and Self-efficacy. *International Journal of Instruction*, *14*(1), 475–488. https://doi.org/10.29333/IJI.2021.14128A