International Journal of Basic and Applied Sciences, 14 (7) (2025) 424-435

International Journal of Basic and Applied Sciences

Website: www.sciencepubco.com/index.php/IJBAS
https://doi.org/10.14419/arb93x39
Research paper

Mediation of Online Learning Performance on The Effect of Metacognition on Mathematics Achievement

Romer C. Castillo *

Batangas State University, Batangas City, Philippines
**Corresponding author E-mail: romer.castillo@g.batstate-u.edu.ph*

Received: July 20, 2025, Accepted: November 8, 2025, Published: November 16, 2025

Abstract

The purpose of the study is to establish the relationships among metacognition, online learning performance, and mathematics achievement. More particularly, it aims to determine the effects of metacognitive knowledge and metacognitive regulation on mathematics achievement and the mediating role of online learning performance on these effects. The study employs linear regression and the Sobel test for its mediation analysis using the data gathered from 311 students who answered the survey questionnaire. Results showed that most students have high levels of metacognitive knowledge and metacognitive regulation, with satisfactory online learning performance, and attain mathematical proficiency. Both metacognitive knowledge and metacognitive regulation have significant positive effects on mathematics achievement and on online learning performance. However, online learning performance does not significantly mediate the effect of each of the metacognitive knowledge and metacognitive regulation on mathematics achievement. Therefore, mathematics educators and institutions should exert efforts and develop strategies to enhance the students' metacognition for better mathematics achievement and online learning performance. They may also either enhance their online learning platforms or revert to traditional classroom learning settings for mathematics courses, but further studies on this matter are suggested before deciding.

Keywords: *Mathematics Achievement; Metacognition; Metacognitive Knowledge; Metacognitive Regulation; Online Learning Performance.*

1. Introduction

Students have different levels of knowledge about how they learn and skills on how to learn. Some students are active and self-directed learners who know how they learn and how to apply what they know to various learning tasks. Other students are passive learners who have little awareness of how they learn and how to regulate their learning. Some average students know how they learn, but cannot regulate their learning. In other words, students have various levels of metacognition. As such, universities should assess the level of their students' metacognition and help them enhance their metacognitive knowledge and regulation. They need to look into how this metacognition can be integrated into the curriculum and how the course instructors or professors can facilitate the acquisition and development of students' metacognitive knowledge and skills.

Metacognition is translated as "beyond cognition" and literally means "cognition about cognition" or "thinking about thinking". This term was formally defined as the knowledge and cognition about cognitive phenomena [1]. Metacognition also refers to the ability to reflect upon, understand, and control one's learning [2]. It is also defined as the ability to monitor and control one's cognition [3]. Generally, it has two aspects: knowledge about cognition and regulation of cognition [4]. The knowledge of cognition or metacognitive knowledge is what an individual knows about self, the strategies, and the conditions that make strategies most useful. The regulation of cognition, or metacognitive regulation, is the knowledge about the ways individuals plan, implement strategies, monitor, correct comprehension errors, and evaluate their learning [2].

Metacognitive knowledge is multidimensional, domain-general in nature, and teachable [4]. It has three different types of metacognitive awareness: declarative, procedural, and conditional knowledge. Declarative knowledge refers to knowing about things. It includes knowledge about an individual and about what factors affect an individual's performance [4], [5]. Procedural knowledge refers to knowing how to do things. It is the knowledge about the execution of procedural skills [5]. Much of this knowledge is represented as heuristics and strategies [4]. Conditional knowledge refers to knowing why and when to use declarative and procedural knowledge, and it enables individuals to adjust to the changing situational demands of each learning task [4]. It may be thought of as declarative knowledge about the relative utility of cognitive procedures [5].

Metacognitive regulation is also domain-general, which spans a wide variety of subject areas. It refers to a set of metacognitive activities that help individuals control their thinking or learning [5]. It has five components: planning, information management, monitoring, debugging, and evaluation [2]. Planning refers to the planning, goal setting, and allocation of resources before learning [2]. It involves the selection of appropriate strategies that affect performance [5]. Information management refers to the skills and strategy sequences used to process information more efficiently, such as organizing, elaborating, summarizing, and selective focusing [2]. Monitoring refers to the assessment of one's learning or strategy use [2]. It also refers to an individual's awareness of comprehension and task performance [5]. Debugging refers to the strategies to correct comprehension and performance errors [2]. Evaluation refers to the analysis of performance and strategy effectiveness after the learning task of an individual [2]. It also refers to appraising the products and regulatory processes of one's learning [5].

Although metacognition is domain-general, many scholars also believe that metacognition is initially domain-specific or task-specific. General metacognition is expected to improve as metacognition within a particular domain improves [4]. As learners acquire more meta-cognitive knowledge and regulation in a number of domains, they gain general metacognitive knowledge and regulatory skills that cut across all academic domains [5].

Metacognition is critical for successful learning as it enables individuals to better manage their cognitive skills. Metacognitive knowledge and regulation can be improved through classroom instructional practices, and students can use these newly acquired skills to improve performance [4].

Metacognition is a powerful predictor of learning performance [6]. Many studies have found that skilled learners possess metacognitive knowledge, which usually improves performance [4]. Researchers also agree that competence in metacognitive regulation improves per-formance in several ways, including better use of attentional resources and of existing strategies and greater awareness of comprehension failures [4], [5]. For instance, a study found that the use of metacognitive strategies enhanced the online learning performance of university students [7]. The study also affirmed that students who use metacognitive strategies in online learning are capable of evaluating their understanding of the course content, regulating their learning process.

Online education can reach a wider audience and level the playing field for students who do not have easy access to traditional education [8]. But with the increasing number of students taking online courses, there is a need to understand how students can apply metacognitive learning strategies for academic achievement within the online environment [9]. The unique needs and circumstances of online learners can affect their learning experiences, and universities should avoid aggravating the existing gaps [8].

Online learning emphasizes the openness of learning resources and communication among students [10]. It can be a powerful learning tool for nurturing motivation and skills of students for learning complex topics [11]. However, the online learning process involves many factors that may affect student performance [10]. Providing support and guidance to facilitate online learning can help students access and interact with the content functionality, allowing them to think about deeper concepts and structure disciplinary relations [11]. In online learning, it is necessary to understand the course material that is being taught and to involve metacognitive strategies in the learning process [12].

Online learning environments can provide opportunities and conditions to enable students to apply and use metacognitive strategies in their learning process [7]. These strategies play a vital role in motivating students and help them understand that they can control their own learning [12]. Moreover, the essence of online learning is the continuous development of students' cognitive level [10]. And metacognitive strategies can help students understand online course material and become more successful or achieve better results [12].

It is important to explore the current situations and issues with online learning to provide a better context for ways in which student performance may be improved [8]. To acquire effective learning, students need to participate actively in learning. They need to be fully engaged in the online learning, including both the quantity and the quality of engagement, both communication with others and learning consciously, and both guidance and help of others and self-management and self-control [10].

Academic achievement in online learning refers to achieving a particular result in an online assignment, exam, subject, or degree [9]. There are previous studies that examined the relationship between metacognition and academic achievement [3]. Evidence from the literature suggests that metacognition is a strong predictor of academic success [13], [14], and that learners with high levels of metacognitive aware-ness are more strategic and perform better than learners with low levels of metacognitive awareness [14], [15].

Moreover, the support of metacognitive strategy in an online learning environment is closely related to academic achievement in mathe-matics [11], [16]. Metacognitive skills also predict student engagement in mathematics [17]. Metacognitive self-regulation in online courses is correlated with students' engagement as an overall multidimensional construct of cognitive, emotional, and behavioral factors [18]. Achievement is also an important aspect of online students' learning experience in mathematics courses [16].

Metacognition is at the center of the integration and accumulation of knowledge and serves as an important predictor of engagement in learning [17]. Educational psychologists and researchers have spent time and effort exploring factors that enhance students' learning and performance in mathematics [19]. Teachers and students of mathematics are aware that there is much mental activity in learning mathe-matics, and metacognition may account for a significant part of that activity [20]. As mentioned earlier, there is a growing body of evidence that illustrates the effect of metacognition on mathematics learning [21], and the use of metacognition appears to be associated with aca-demic achievement and enhances learning outcomes [22].

Research on online learning in mathematics also abounds in the literature. One study focuses on large-scale exploration of students' activity in an online learning environment and shows that students' mathematics performance in lower-order thinking is higher than performance in higher-order thinking, which may point to metacognitive or motivational processes involved [23]. Studies reveal the positive correlation between mathematical self-efficacy and mathematics performance in online learning [24], as well as between frequent self-reflection and performance in an online mathematics course [25]. Findings from previous research suggest that students recognized the potential of online learning for a mathematics course, but they were uncomfortable and unsatisfied with the learning environment provided [26]. Moreover, an article emphasizes the importance of designing an adaptive online mathematics course based on an individualized approach to learning [27].

Previous studies have also shown the existence of mediators in the relationship between metacognition and academic achievement. Meta-cognition has direct and indirect effects on academic achievement, with academic self-control having a partial mediating role [28]. General self-efficacy also partially mediates the relationship between metacognition and academic success [29], but mathematics self-efficacy fully mediates the effect of metacognition on mathematics achievement [19]. Moreover, both learning strategy and learning behavior mediate the effect of metacognition on learning engagement [30].

How to lead the students into academic success is a simple question that has received research interest for decades [31]. Considering the difficulties encountered by students in learning mathematics and the promising potential of metacognition [19] and online learning [7], this study aims to provide insights into the effects of the students' metacognitive knowledge and regulation on their achievement in mathemat-ics, with online learning performance as a mediator. There is a need for the mathematics education community to adopt a metacognitive perspective on mathematical performance. The critical role of metacognition has to be made clearer so that educators will be able to incorporate metacognitive aspects into their mathematics teaching [20].

Several studies have assessed the effect of metacognition on both mathematics achievement and learning engagement. There are also previous studies that show the mediating roles of several variables on the effect of metacognition on academic achievement. However, no prior research has reported the effect of metacognition on mathematics achievement as mediated by online learning performance. To complement the existing research gaps and emerging issues, there is a need to conduct a study that will provide answers for the following research questions:

1) Does the metacognitive knowledge of students significantly affect their mathematics achievement?
2) Does the metacognitive regulation of students significantly affect their mathematics achievement?
3) Does the metacognitive knowledge of students significantly affect their online learning performance?
4) Does the metacognitive regulation of students significantly affect their online learning performance?
5) Does the online learning performance of students significantly mediate the effect of their metacognitive knowledge on their mathematics achievement?
6) Does the online learning performance of students significantly mediate the effect of their metacognitive regulation on their mathematics achievement?

2. Methods

This study employed a quantitative research survey approach using a self-administered questionnaire distributed through an online platform. The research design is non-experimental descriptive-causal research with mediation analysis. The sample consists of students enrolled in a mathematics online course who voluntarily submit themselves to participate.

2.1. Participants

The 311 participants in this study are students of the Bachelor of Science in Hospitality Management who took Mathematics in the Modern World at the same time under one faculty member in an online modality. They are 90% of the total number of students (347) taking the course under the program. They agreed to participate in the study after being well-informed. The sample consists of 74% female students (231) and 26% male students (80). They are all in their first year of tertiary study in the program.

2.2. Measurement

This study used the metacognitive awareness inventory [2] to measure the metacognition of hospitality management students. Metacognition has two components: the metacognitive knowledge and the metacognitive regulation. Metacognitive knowledge has three subcomponents: declarative knowledge, procedural knowledge, and conditional knowledge. Metacognitive regulation has five subcomponents: planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation. The metacognitive knowledge scale has a total of 17 items, while the metacognitive regulation scale has a total of 35 items. In this study, each item was measured using a five-point Likert scale as follows: 5 – almost always, 4 – often, 3 – sometimes, 2 – seldom, and 1 – rarely. The reliability of the instrument was measured through the internal consistency of the items per scale. The Cronbach coefficients for each scale or subscale, which were all above .70, are presented in Table 1.

To measure the online learning performance of hospitality management students in Mathematics in the Modern World, the study adapted a previously established learning performance tool [7]. Each of the 15 items in this tool was also measured using a Likert scale: 5 – almost always, 4 – often, 3 – sometimes, 2 – seldom, and 1 – rarely. The reliability of each scale was also measured through Cronbach's alpha, and the results are also shown in Table 1.

The final grades in Mathematics in the Modern World were used as the measurement for the mathematics achievement of hospitality management students.

Table 1: Cronbach Coefficients

Scale	Number of Items	Cronbach's Alpha
Declarative Knowledge	8	.788
Procedural Knowledge	4	.704
Conditional Knowledge	5	.742
Metacognitive Knowledge	17	.899
Planning	7	.808
Information Management Strategies	10	.833
Comprehension Monitoring	7	.775
Debugging Strategies	5	.753
Evaluation	6	.759
Metacognitive Regulation	35	.945
Attitude Towards Learning	6	.861
Student Engagement	4	.858
Student Satisfaction	5	.839
Online Learning Performance	15	.917

2.3. Research framework and hypotheses

The research framework is presented in Figure 1. The independent variables are metacognitive knowledge and metacognitive regulation, and the dependent variable is mathematics achievement. Online learning performance acts as the mediating variable.

This study has the following null hypotheses:

Ho1: Metacognitive knowledge does not significantly affect mathematics achievement.
Ho2: Metacognitive regulation does not significantly affect mathematics achievement.
Ho3: Metacognitive knowledge does not significantly affect online learning performance.
Ho4: Metacognitive regulation does not significantly affect online learning performance.
Ho5: Online learning performance does not significantly mediate the effect of metacognitive knowledge on mathematics achievement.
Ho6: Online learning performance does not significantly mediate the effect of metacognitive regulation on mathematics achievement.

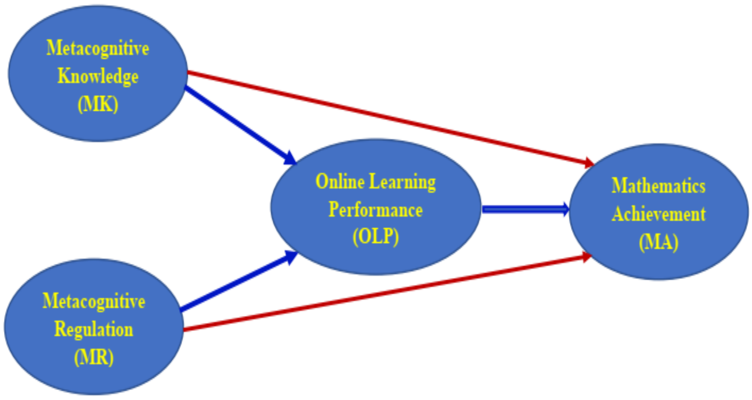

Fig. 1: Research Framework.

2.4. Data analysis and interpretation

Mean and standard deviation were used to assess the metacognition in terms of metacognitive knowledge and metacognitive regulation, and the online learning performance of hospitality management students. The indicators to measure metacognition and online learning performance, and the levels of metacognitive knowledge, metacognitive regulation, and online learning performance were interpreted as follows:

Table 2: Range of Mean and Corresponding Interpretation

Mean	Frequency of Indicators	Level of Metacognitive Knowledge and Regulation	Online Learning Performance
4.50 – 5.00	Almost Always	Very High	Outstanding
3.50 – 4.49	Often	High	Very Satisfactory
2.50 – 3.49	Sometimes	Moderate	Satisfactory
1.50 – 2.49	Seldom	Low	Poor
1.00 – 1.49	Rarely	Very Low	Very Poor

Frequencies and means were used to describe the mathematics achievement of hospitality management students. The mathematics achievement was measured in terms of final grade in Mathematics in the Modern World and interpreted as follows:

Table 3: Range of Mathematics Grade and Corresponding Interpretation

Grade	Level of Mathematics Achievement
98 – 100	Advanced
94 – 97	Very Proficient
88 – 93	Proficient
85 – 87	Approaching Proficiency
80 – 84	Developing
75 – 79	Beginning
Below 75	Not Proficient

Simple linear regression analysis was used to determine the significant effect of each of metacognitive knowledge and metacognitive regulation on each of mathematics achievement and online learning performance. Regression analysis and the Sobel test were used to determine the significant mediation of online learning performance on the effect of each of the metacognitive knowledge and metacognitive regulation on mathematics achievement. The effects and mediations were interpreted as either significant or not significant using the p-values at the .05 level of significance.

3. Results and discussion

3.1. Assessment of metacognition

Table 4 presents the assessment of hospitality management students on their metacognition per the indicator of metacognitive knowledge.

Table 4: Components and Indicators of Metacognitive Knowledge

Components and Indicators	Mean	Standard Deviation	Interpretation
Declarative Knowledge			
1. I understand my intellectual strengths and weaknesses.	4.05	.887	Often
2. I know what kind of information is most important to learn.	3.99	.859	Often
3. I am good at organizing information.	3.49	.811	Sometimes
4. I know what the teacher expects me to learn.	3.77	.861	Often
5. I am good at remembering information.	3.34	.791	Sometimes
6. I have control over how well I learn.	3.60	.828	Often
7. I am a good judge of how well I understand something.	3.49	.811	Sometimes
8. I learn more when I am interested in the topic.	4.33	.852	Often
Procedural Knowledge			
1. I try to use strategies that have worked in the past.	3.81	.880	Often
2. I have a specific purpose for each strategy I use.	3.68	.863	Often
3. I am aware of what strategies I use when I study.	3.77	.873	Often
4. I find myself using helpful learning strategies automatically.	3.56	.788	Often
Conditional Knowledge			

1. I learn best when I know something about the topic.	4.10	.918	Often
2. I use different learning strategies depending on the situation.	3.71	.846	Often
3. I can motivate myself to learn when I need to.	4.05	.918	Often
4. I use my intellectual strengths to compensate for my weaknesses.	3.68	.857	Often
5. I know when each strategy I use will be most effective.	3.56	.805	Often

Most of the indicators of metacognitive knowledge were assessed as often. The highest mean for declarative knowledge is in learning more when interested in the topic, while the lowest mean is in being good at remembering information. In procedural knowledge, the highest is in trying to use strategies that have worked in the past, and the lowest is in automatically using helpful learning strategies. For conditional knowledge, the mean is highest in learning best when knowing something about the topic and lowest in knowing when each strategy will be most effective.

Results of this study is similar to a previous study that also showed students have highest mean assessment for learning more in interested topic in terms of declarative knowledge and for learning best when with previous knowledge about the topic for conditional knowledge but differs in the results of procedural knowledge with the highest mean assessment of the previous study in the use of helpful learning strategies [32].

Table 5 presents the level of metacognition of hospitality management students in terms of their metacognitive knowledge.

Table 5: Level of Metacognitive Knowledge

Variable	Mean	Standard Deviation	Interpretation
Declarative Knowledge	3.76	.532	High Level
Procedural Knowledge	3.71	.620	High Level
Conditional Knowledge	3.82	.611	High Level
Metacognitive Knowledge	3.76	.527	High Level

As shown in the table, hospitality management students have a high level of metacognitive knowledge, with the highest mean assessment in conditional knowledge and the lowest in procedural knowledge. A previous study among business administration students also revealed a high level of metacognitive knowledge, with the highest in conditional and the lowest in procedural [33]. First-year college students in another university also have a high level of metacognitive knowledge, and also highest in conditional and the lowest in procedural knowledge [34]. Results of another study showed that customs administration students have a generally high level of declarative and procedural knowledge, but they have a very high level of conditional knowledge [32].

Table 6 presents the assessment of hospitality management students on their metacognition per the indicator of metacognitive regulation.

Table 6: Components and Indicators of Metacognitive Regulation

Components and Indicators	Mean	Standard Deviation	Interpretation
Planning			
1. I pace myself while learning to have enough time.	3.71	.857	Often
2. I think about what I really need to learn before I begin a task.	4.05	.868	Often
3. I set specific goals before I begin a task.	3.95	.928	Often
4. I ask myself questions about the material before I begin.	3.63	.898	Often
5. I think of several ways to solve a problem and choose the best one.	3.87	.907	Often
6. I read instructions carefully before I begin a task.	4.22	.892	Often
7. I organize my time to best accomplish my goals.	3.98	.935	Often
Information Management Strategies			
1. I slow down when I encounter important information.	3.93	.890	Often
2. I consciously focus my attention on important information.	3.92	.831	Often
3. I focus on the meaning and significance of new information.	3.80	.896	Often
4. I create my own examples to make information more meaningful.	3.52	.912	Often
5. I draw pictures or diagrams to help me understand while learning.	3.11	1.010	Sometimes
6. I try to translate new information into my own words.	3.71	.940	Often
7. I use the organizational structure of the text to help me learn.	3.41	.904	Sometimes
8. I ask myself if what I'm reading is related to what I already know.	3.78	.824	Often
9. I try to break studying down into smaller steps.	3.48	.830	Sometimes
10. I focus on overall meaning rather than specifics.	3.53	.798	Often
Comprehension Monitoring			
1. I ask myself periodically if I am meeting my goals.	3.77	.955	Often
2. I consider several alternatives to a problem before I answer.	3.60	.844	Often
3. I ask myself if I have considered all options when solving a problem.	3.75	.888	Often
4. I periodically review to help me understand important relationships.	3.72	.878	Often
5. I find myself analyzing the usefulness of strategies while I study.	3.67	.889	Often
6. I find myself pausing regularly to check my comprehension.	3.49	.795	Sometimes
7. I ask myself questions about how well I am doing while learning something new.	3.71	.873	Often
Debugging Strategies			
1. I ask others for help when I don't understand something.	4.06	.933	Often
2. I change strategies when I fail to understand.	3.69	.902	Often
3. I re-evaluate my assumptions when I get confused.	3.77	.867	Often
4. I stop and go back over the new information that is not clear.	3.85	.937	Often
5. I stop and reread when I get confused.	4.07	.926	Often
Evaluation			
1. I know how well I did once I finish a test.	3.82	.862	Often
2. I ask myself if there was an easier way to do things after I finish a task.	3.83	.954	Often
3. I summarize what I've learned after I finish.	3.49	.915	Sometimes
4. I ask myself how well I accomplish my goals once I'm finished.	3.92	.949	Often
5. I ask myself if I have considered all options after I solve a problem.	3.51	.815	Often
6. I ask myself if I learned as much as I could have once I finish a task.	3.75	.866	Often

The majority of the indicators of metacognitive regulation were also assessed as often. The highest mean assessment for each component is as follows: reading instructions carefully before beginning a task (planning); consciously focusing attention on important information (information management); periodically asking oneself if meeting goals (comprehension monitoring); stopping and rereading when confused (debugging); and asking oneself how goals were accomplished (evaluation). The lowest mean for each component is as follows: asking oneself about the material before beginning (planning); drawing pictures or diagrams to understand (information management); regularly pausing to check comprehension (comprehension monitoring); changing strategies if one cannot understand (debugging); and summarizing the learning (evaluation).
Table 7 presents the level of metacognition of hospitality management students in terms of their metacognitive regulation.

Table 7: Level of Metacognitive Regulation

Variable	Mean	Standard Deviation	Interpretation
Planning	3.92	.612	High Level
Information Management Strategies	3.62	.560	High Level
Comprehension Monitoring	3.67	.571	High Level
Debugging Strategies	3.89	.648	High Level
Evaluation	3.72	.602	High Level
Metacognitive Regulation	3.74	.528	High Level

As shown in the table, hospitality management students have a high level of metacognitive regulation, with the highest mean assessments in planning and debugging strategies and the lowest in information management strategies. In a previous study, business administration students also high level of metacognitive regulation, with the highest mean assessment in debugging strategies and the lowest in comprehension monitoring [33]. In another university, first-year college students also have a high level of metacognitive regulation and also highest in debugging strategies, and the lowest in comprehension monitoring [34].

3.2. Level of mathematics achievement

Table 8 presents the frequencies and means of the final grades of hospitality management students and the corresponding description or level of mathematics achievement.

Table 8: Mathematics Achievement

Grade	Description	Frequency
98 – 100	Advanced	0
94 – 97	Very Proficient	27
88 – 93	Proficient	154
85 – 87	Approaching Proficiency	72
80 – 84	Developing	34
75 – 79	Beginning	17
Below 75	Not Proficient	7
Mean = 87.58	Proficient	N = 311

Results showed that almost half (154 out of 311) of the hospitality management students achieved proficiency in mathematics. However, no one has achieved the advanced level, and there are a few students who have not attained proficiency. Generally, the mean grade (87.58) implied that the hospitality management students are proficient in Mathematics in the Modern World. In a similar study, first-year college students of Mathematics in the Modern World have their mean grade of 88.65 [35].

3.3. Assessment of online learning performance

Table 9 presents the online learning performance of hospitality management students per indicator.

Table 9: Components and Indicators of Online Learning Performance

Components and Indicators	Mean	Standard Deviation	Interpretation
Attitude Towards Learning			
1. I can apply the content learned in the online learning course.	3.59	.830	Often
2. I can give my own opinion or intelligently critique the content in the online learning course.	3.48	.872	Sometimes
3. I am more independent after an online learning course.	3.52	.919	Often
4. I am a better thinker after an online learning course.	3.41	.860	Sometimes
5. I can use my skills learned in an online learning course outside of class.	3.57	.884	Often
6. I can demonstrate to others my skills learned in an online learning course.	3.39	.894	Sometimes
Student Engagement			
1. I acquire useful knowledge by interacting with other students during the online learning course.	3.57	.858	Often
2. I acquire useful knowledge by interacting with my lecturer during the online learning course.	3.46	.837	Sometimes
3. I acquire skills in using web applications by engaging with online learning tools.	3.51	.876	Often
4. I fully engage in online learning tasks to learn more than what is required of me.	3.54	.860	Often
Student Satisfaction			
1. I am interested in doing online tasks as I enjoy learning.	3.46	.936	Sometimes
2. I am satisfied with the online learning course.	3.29	1.072	Sometimes
3. Completing an online task was not difficult.	3.37	.958	Sometimes
4. The online tasks help me understand the course better.	3.01	1.136	Sometimes
5. The knowledge I gained from online learning was as good as from face-to-face learning.	3.03	1.198	Sometimes

The majority of the indicators of online learning performance were assessed as sometimes. The highest mean assessment for attitude towards learning is in applying the content learned, and the lowest is in demonstrating the skills learned to others. In student engagement, the highest mean is in acquiring useful knowledge by interacting with other students, while the lowest is in acquiring useful knowledge by

interacting with the lecturer. For student satisfaction, being interested in doing online tasks due to joy in learning has the highest mean, and understanding the course better due to online tasks has the lowest mean.
Table 10 presents the online learning performance of hospitality management students.

Table 10: Online Learning Performance

Variable	Mean	Standard Deviation	Interpretation
Attitude towards Learning	3.49	.673	Satisfactory
Student Engagement	3.52	.718	Very Satisfactory
Student Satisfaction	3.23	.830	Satisfactory
Online Learning Performance	3.41	.639	Satisfactory

As shown in the table, hospitality management students have satisfactory online learning performance. The highest mean is in their engagement in online learning, while the lowest mean is in their satisfaction with online learning.

3.4. Effects of metacognitive knowledge and metacognitive regulation on mathematics achievement

Table 11 shows the results of simple linear regression analysis on the effect of metacognitive knowledge on the mathematics achievement of hospitality management students.

Table 11: Effect of Metacognitive Knowledge on Mathematics Achievement

Variable	B	Std. Error	t-value	p-value	Decision on Ho	Interpretation
(Constant)	81.053	2.088	38.820	< .001	-	-
Metacognitive Knowledge	1.735	.549	3.158	.002	Reject	Significant

Model Summary: $R = .177$, $R^2 = .031$
Regression Model: $F = 9.970$, $p = .002$

As shown in the table, metacognitive knowledge and mathematics achievement are correlated with R = .177. However, only 3.1% of the total variation in mathematics achievement can be explained by metacognitive knowledge. Further, the regression model significantly predicts mathematics achievement with F = 9.970 and p = .002, or that the model is a good fit for the data. Moreover, metacognitive knowledge has a significant effect on mathematics achievement as indicated by p = .002. The following equation can be used to predict mathematics achievement (MA) from metacognitive knowledge (MK):

$$MA = 81.053 + 1.735 (MK) \quad (1)$$

This means that for every one unit increase in metacognitive knowledge, there is a corresponding 1.735 unit increase in mathematics achievement. The positive unstandardized beta coefficient (B = 1.735) implies that the effect is positive, or that when the level of metacognitive knowledge gets higher, the mathematics achievement gets better.
Results of previous studies also revealed that metacognition is positively correlated with academic achievement [28], [36], with academic success [29], and with mathematics performance [37]. Substantial awareness of metacognition was significantly and positively correlated with academic performance [33]. Previous findings also suggest that metacognition significantly influences success in learning mathematics [34]. In addition, there is also a significant positive association between metacognitive awareness and mathematics achievement [34], and metacognitive knowledge is a predictor of mathematics performance [31]. A significant relationship also exists between metacognitive awareness and mathematics grades [15]. More findings revealed that metacognition significantly and positively affects both mathematics self-efficacy and mathematics achievement [19]. Metacognitive awareness, problem-solving skills, and mathematics achievement are also significantly correlated with each other [38].
However, metacognition is only weakly correlated with academic performance as it predicts academic performance when controlling for intelligence [14]. Another study also showed that there was no significant correlation between metacognition and overall academic achievement [39]. The correlation between metacognition and academic achievement is driven only by metacognitive regulation and not by metacognitive knowledge [13].
Table 12 shows the results of simple linear regression analysis on the effect of metacognitive regulation on the mathematics achievement of hospitality management students.

Table 12: Effect of Metacognitive Regulation on Mathematics Achievement

Variable	B	Std. Error	t-value	p-value	Decision on Ho	Interpretation
(Constant)	82.083	2.083	39.415	< .001	-	-
Metacognitive Regulation	1.468	.551	2.666	.008	Reject	Significant

Model Summary: $R = .150$, $R^2 = .022$
Regression Model: $F = 7.109$, $p = .008$

As shown in the table, metacognitive knowledge and mathematics achievement are correlated with R = .150. However, only 2.2% of the total variation in mathematics achievement can be explained by metacognitive regulation. Further, the regression model significantly predicts mathematics achievement with F = 7.109 and p = .008, or that the model is a good fit for the data. Moreover, metacognitive regulation has a significant effect on mathematics achievement as indicated by p = .008. The following equation can be used to predict mathematics achievement (MA) from metacognitive regulation (MR):

$$MA = 82.083 + 1.468 (MR) \quad (2)$$

This means that for every one unit increase in metacognitive regulation, there is a corresponding 1.468 unit increase in mathematics achievement. The positive unstandardized beta coefficient (B = 1.468) implies that the effect is positive or that when the level of metacognitive regulation gets higher, the mathematics achievement gets better.
These results are similar to the findings of previous studies. Metacognitive regulation of students is related to their task performances and scores [3]. Those who demonstrate a higher level of metacognitive skills tend to perform better academically [36]. Previous results also

indicate that metacognitive monitoring and control are predictors of college academic achievement [13]. Students with proficient metacognitive abilities excel academically in mathematics [34], and those who have higher metacognitive abilities achieve better in mathematics than those who are less metacognitive [19].

3.5. Mediation of online learning performance on the effects of metacognitive knowledge and metacognitive regulation on mathematics achievement

As shown earlier, metacognitive knowledge has a significant effect on mathematics achievement. Part of the conduct of mediation analysis as to whether or not online learning performance mediates this effect is to determine the significant effect of metacognitive knowledge on online learning performance. Table 13 shows the results of simple regression analysis on the effect of metacognitive knowledge on the online learning performance of hospitality management students.

Table 13: Effect of Metacognitive Knowledge on Online Learning Performance

Variable	B	Std. Error	t-value	p-value	Decision on Ho	Interpretation
(Constant)	.374	.196	1.913	.057	-	-
Metacognitive Knowledge	.808	.051	15.690	< .001	Reject	Significant

Model Summary: $R = .666$, $R^2 = .443$
Regression Model: $F = 246.177$, $p < .001$

As shown in the table, metacognitive knowledge and online learning performance are correlated with R = .666. Moreover, 44.3% of the total variation in online learning performance can be explained by metacognitive knowledge. Further, the regression model significantly predicts online learning performance with $F = 246.177$ and $p < .001$, or that the model is a good fit for the data. In addition, metacognitive knowledge has a significant effect on online learning performance as indicated by $p < .001$. The following equation can be used to predict online learning performance (OLP) from metacognitive knowledge (MK):

$$OLP = .374 + .808\,(MK) \tag{3}$$

This means that for every one unit increase in metacognitive knowledge, there is a corresponding .808 unit increase in online learning performance. The positive unstandardized beta coefficient (B = .808) implies that the effect is positive or that when the level of metacognitive knowledge gets higher, the online learning performance gets better.

These results support the findings of previous studies. Previous results indicate that there is a positive correlation between metacognition and learning engagement of college students [30]. A significant relationship also exists between metacognition and blended learning engagement, and the presence of metacognition has a positive influence on student engagement in both offline and online learning [40]. Previous findings further emphasize the critical role of metacognition for students to overcome open and distance education difficulties toward superior learning outcomes [41].

Since metacognitive knowledge has a significant effect on both online learning performance and mathematics achievement, the next step is to conduct a multiple regression analysis on the effect of metacognitive knowledge and online learning performance on the mathematics achievement of hospitality management students. Table 14 shows the results of this analysis.

Table 14: Effect of Metacognitive Knowledge and Online Learning Performance on Mathematics Achievement

Variable	B	Std. Error	t-value	p-value	Decision on Ho	Interpretation
(Constant)	81.405	2.095	38.848	< .001	-	-
Online Learning Performance	-.941	.606	-1.553	.122	Fail to Reject	Not Significant
Metacognitive Knowledge	2.494	.735	3.395	.001	Reject	Significant

Model Summary: $R = .197$, $R^2 = .039$
Regression Model: $F = 6.213$, $p = .002$

As shown in the table, online learning performance and metacognitive knowledge are correlated to mathematics achievement with R = .197. However, only 3.9% of the total variation in mathematics achievement can be explained by online learning performance and metacognitive knowledge. Further, the regression model significantly predicts mathematics achievement with $F = 6.213$ and $p = .002$, or that the model is a good fit for the data. In addition, metacognitive knowledge has a significant effect on mathematics achievement, but online learning performance has no significant effect. These results imply that online learning performance does not significantly mediate the effect of metacognitive knowledge on mathematics achievement.

Table 15 shows the results of the analysis on the effect of metacognitive knowledge on the mathematics achievement of hospitality management students as mediated by their online learning performance.

Table 15: Mediation of Online Learning Performance (OLP) on the Effect of Metacognitive Knowledge (MK) on Mathematics Achievement (MA)

Path	B	Std. Error	t-value	p-value	Decision on Ho	Interpretation
Total Effect						
MK → MA	1.735	.549	3.158	.002	Reject	Significant
Direct Effect						
MK → OLP	.808	.051	15.690	< .001	Reject	Significant
OLP → MA	-.941	.606	-1.553	.122	Fail to Reject	Not Significant
MK → MA	2.494	.735	3.395	.001	Reject	Significant
Path	Sobel Test	Std. Error	t-value	p-value	Decision on Ho	Interpretation
Indirect Effect						
MK → OLP → MA	-1.545	.492	-	.122	Fail to Reject	Not Significant

As shown in the table, the total effect of metacognitive knowledge on mathematics achievement is significant with $p = .002$. In addition, the direct effect of metacognitive knowledge on online learning performance is also significant with $p < .001$. With the inclusion of online learning performance in the regression model, the direct effect of metacognitive knowledge on mathematics achievement is still significant with $p = .001$. Although there is a change in the beta coefficients from 1.735 in the total effect to 2.494 in the direct effect of metacognitive knowledge on mathematics achievement, this change is insignificant as implied by the non-significant effect of online learning performance

on mathematics achievement with p = .122. The non-mediating role of online learning performance is further confirmed by the Sobel test, which shows that the indirect effect of metacognitive knowledge on mathematics achievement with the intervention of online learning performance is not significant, with p = .122.
These results are summarized in Figure 2.

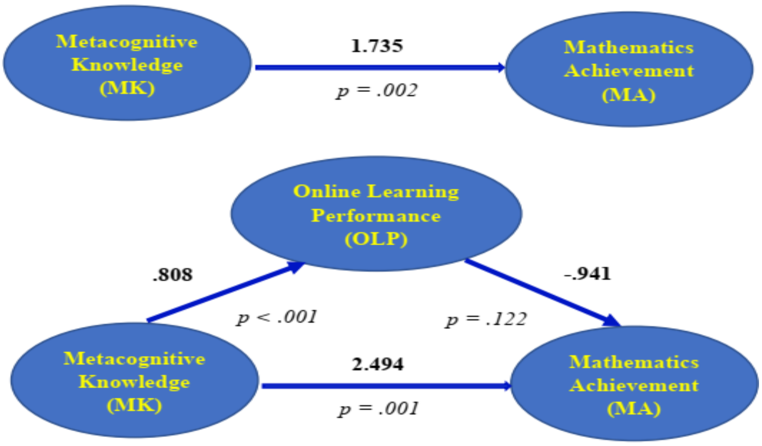

Fig. 2: Mediation of Online Learning Performance on the Effect of Metacognitive Knowledge on Mathematics Achievement.

It was also shown earlier that metacognitive regulation has a significant effect on mathematics achievement. Part of the conduct of mediation analysis as to whether or not online learning performance mediates this effect is to determine the significant effect of metacognitive regulation on online learning performance. Table 16 shows the results of simple regression analysis on the effect of metacognitive regulation on the online learning performance of hospitality management students.

Table 16: Effect of Metacognitive Regulation on Online Learning Performance

Variable	B	Std. Error	t-value	p-value	Decision on Ho	Interpretation
(Constant)	.340	.191	1.775	.077	-	-
Metacognitive Regulation	.821	.051	16.230	< .001	Reject	Significant

Model Summary: R = .678, R^2 = .460
Regression Model: F = 263.412, p < .001

As shown in the table, metacognitive regulation and online learning performance are correlated with R = .678. Moreover, 46% of the total variation in online learning performance can be explained by metacognitive regulation. Further, the regression model significantly predicts online learning performance with F = 263.412 and p < .001, or that the model is a good fit for the data. In addition, metacognitive regulation has a significant effect on online learning performance as indicated by p < .001. The following equation can be used to predict online learning performance (OLP) from metacognitive regulation (MR):

$$OLP = .340 + .821 (MR) \quad (3)$$

This means that for every one unit increase in metacognitive regulation, there is a corresponding .821 unit increase in online learning performance. The positive unstandardized beta coefficient (B = .821) implies that the effect is positive or that when the level of metacognitive regulation gets higher, the online learning performance gets better.
Previous studies have related results. Metacognition enables students' self-regulated learning, enhances their engagement, and improves achievement [40]. These imply that teachers should have flexibility in adapting learning activities for online learning [42]. Metacognitive strategies have also been identified as vital by previous studies to ensure better learning outcomes in open and distance education settings, and findings showed that through metacognition, students can plan, monitor, and evaluate learning strategies more effectively for the difficulties associated with distance education [41]. Previous results also showed that metacognitive strategies of college students in online collaborative learning environments significantly and positively affect their academic achievement [43].
Since metacognitive regulation has a significant effect on both online learning performance and mathematics achievement, the next step is to conduct a multiple regression analysis on the effect of metacognitive regulation and online learning performance on the mathematics achievement of hospitality management students. Table 17 shows the results of this analysis.

Table 17: Effect of Metacognitive Regulation and Online Learning Performance on Mathematics Achievement

Variable	B	Std. Error	t-value	p-value	Decision on Ho	Interpretation
(Constant)	82.331	2.092	39.358	< .001	-	-
Online Learning Performance	-.730	.619	-1.180	.122	Fail to Reject	Not Significant
Metacognitive Regulation	2.068	.749	2.760	.006	Reject	Significant

Model Summary: R = .164, R^2 = .027
Regression Model: F = 4.255, p = .015

As shown in the table, online learning performance and metacognitive regulation are correlated to mathematics achievement with R = .164. However, only 2.7% of the total variation in mathematics achievement can be explained by online learning performance and metacognitive regulation. Further, the regression model significantly predicts mathematics achievement with F = 4.255 and p = .015, or that the model is a good fit for the data. In addition, metacognitive regulation has a significant effect on mathematics achievement, but online learning performance has no significant effect. These results imply that online learning performance does not significantly mediate the effect of metacognitive regulation on mathematics achievement.

Table 18 shows the results of the analysis on the effect of metacognitive regulation on the mathematics achievement of hospitality management students as mediated by their online learning performance.

Table 18: Mediation of Online Learning Performance (OLP) on the Effect of Metacognitive Regulation (MR) on Mathematics Achievement (MA)

Path	B	Std. Error	t-value	p-value	Decision on Ho	Interpretation
Total Effect						
MR → MA	1.468	.551	2.666	.008	Reject	Significant
Direct Effect						
MR → OLP	.821	.051	16.230	< .001	Reject	Significant
OLP → MA	-.730	.619	-1.180	.239	Fail to Reject	Not Significant
MR → MA	2.068	.749	2.760	.006	Reject	Significant
Path	Sobel Test	Std. Error	t-value	p-value	Decision on Ho	Interpretation
Indirect Effect						
MR → OLP → MA	-1.176	.510	-	.240	Fail to Reject	Not Significant

As shown in the table, the total effect of metacognitive regulation on mathematics achievement is significant with p = .008. In addition, the direct effect of metacognitive regulation on online learning performance is also significant with p < .001. With the inclusion of online learning performance in the regression model, the direct effect of metacognitive regulation on mathematics achievement is still significant with p = .006. Although there is a change in the beta coefficients from 1.468 in the total effect to 2.068 in the direct effect of metacognitive regulation on mathematics achievement, this change is insignificant, as implied by the non-significant effect of online learning performance on mathematics achievement with p = .239. The non-mediating role of online learning performance is further confirmed by the Sobel test, which shows that the indirect effect of metacognitive regulation on mathematics achievement with the intervention of online learning performance is not significant, with p = .240.
These results are summarized in Figure 3.

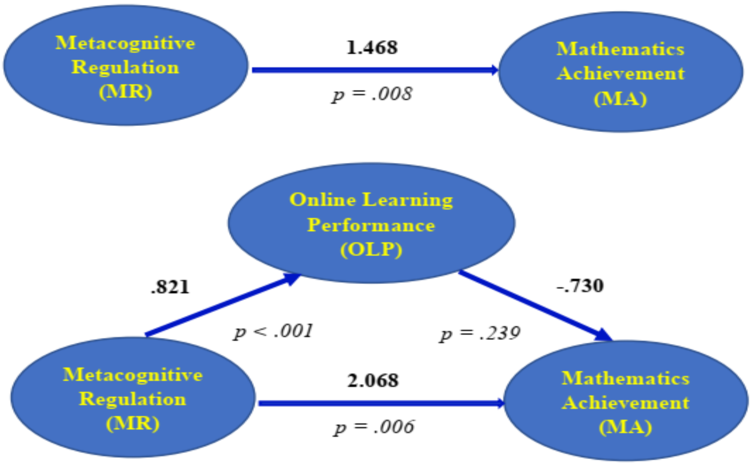

Fig. 3: Mediation of Online Learning Performance on the Effect of Metacognitive Regulation on Mathematics Achievement.

This study found that online learning performance does not significantly mediate the effect of both metacognitive knowledge and metacognitive regulation on mathematics achievement. The non-significant mediation may be attributed to the design of the online platform used, which lacks interactive features critical for mathematics learning. An online platform, most of the time, cannot really replicate the spontaneous and rich interaction of a physical classroom that enhances the students' interest to learn. It has to be noted that learning interest is correlated with the learners' intent to use an open online course [44]. Results from a previous study show that mathematics students were uncomfortable and unsatisfied with an online learning environment that practiced low interactions with the features of the interface created and low interactions with teachers and fellow students [26]. This may also be attributed to some student-related factors, such as a lack of motivation. A previous study demonstrated that motivational and emotional support are necessary to enhance students' success rate in online mathematics courses [16].

4. Conclusions

The participants of this study are first-year students of Mathematics in the Modern World under the program Bachelor of Science in Hospitality Management, and the majority of them are female. Most of these hospitality management students have high levels of metacognitive knowledge and metacognitive regulation, are proficient in mathematics, and have satisfactory online learning performance.
Both metacognitive knowledge and metacognitive regulation have a significant positive effect on mathematics achievement. These imply that students with higher levels of metacognition are more proficient in mathematics. Both metacognitive knowledge and metacognitive regulation also have a significant positive effect on online learning performance, which was measured in terms of the students' attitude, engagement, and satisfaction with online learning. These imply that more metacognitive students have better online learning performance. Therefore, mathematics educators and the colleges or universities they belong to should exert efforts and strategies to help students enhance their metacognition that will lead to better online learning performance and higher mathematics achievement.
However, the online learning performances of the students do not significantly mediate the effect of their metacognitive knowledge on their mathematics achievement. Similarly, their online learning performances do not significantly mediate the effect of their metacognitive regulation on their mathematics achievement. These imply that, in this case, mathematics achievement is not reliant on students' attitude, engagement, and satisfaction with online learning.
As this study focuses only on first-year Hospitality Management students from one university, the findings of this study cannot be applied or generalized to other students with different year levels, academic programs, or institutions. Similar studies focusing on more advanced students, particularly those in their senior levels, or under mathematics-related academic programs, or from institutions with more

interactive online learning platforms, will most probably have different results. Future studies may aim to include a more diverse and balanced sample to have generalizable findings.

Moreover, as this study fails to establish a significant mediation of online learning performance on the effect of metacognition on mathematics achievement due to a variety of possible factors, one of which is the online learning platform's limitations, future research may also explore whether platforms with adaptive feedback or virtual manipulatives enhance the mediating role of online learning performance. Other topics that future researchers may consider are the role of specific online tools (e.g., interactive simulations) or the role of student characteristics (e.g., prior knowledge or mathematical ability) on the effect of metacognition on mathematics achievement, and practical applications such as designing metacognitive training modules for online platforms.

In addition, mathematics educators may adapt online platforms to better leverage metacognition. This may be done by explicitly integrating in their online content the tools and activities that may guide students in the planning, monitoring, and evaluation of their own learning. This will foster among the students self-awareness and self-directed learning. Further, mathematics educators and their institutions may have either of these two options: the first is to enhance their online learning platforms, and the second is to revert to traditional classroom learning settings for mathematics courses. However, further studies on this matter are suggested for better decision-making.

References

[1] Flavell JH (1979), Metacognition and cognitive monitoring: a new era of cognitive-developmental inquiry. *American Psychologist* 34(10), 906-911. https://doi.org/10.1037/0003-066X.34.10.906.

[2] Schraw G & Dennison RS (1994), Assessing metacognitive awareness. *Contemporary Educational Psychology* 19(4), 460-475. https://doi.org/10.1006/ceps.1994.1033.

[3] Young A & Fry JD (2008), Metacognitive awareness and academic achievement in college students. Journal of the Scholarship of Teaching and Learning 8(2), 1-10. https://scholarworks.iu.edu/journals/index.php/josotl/article/view/1696.

[4] Schraw G (1998), Promoting general metacognitive awareness. Instructional Science 26, 113-125. https://doi.org/10.1023/A:1003044231033.

[5] Schraw G & Moshman D (1995), Metacognitive theories. Educational Psychological Review 7, 351-371. https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1040&context=edpsychpapers. https://doi.org/10.1007/BF02212307.

[6] Zhao N, Teng X, Li W, Li Y, Wang S, Wen H, & Yi M (2019), A path model for metacognition and its relation to problem solving strategies and achievement for different tasks. ZDM Mathematics Education 51, 641-653. https://doi.org/10.1007/s11858-019-01067-3.

[7] Anthonysamy L (2021), The use of metacognitive strategies for undisrupted online learning: preparing university students in the age of pandemic. Education and Information Technologies 26, 6881-6899. https://doi.org/10.1007/s10639-021-10518-y.

[8] Dumford AD & Miller AL (2018), Online learning in higher education: exploring advantages and disadvantages for engagement. Journal of Computing in Higher Education 30, 452-465. https://doi.org/10.1007/s12528-018-9179-z

[9] Broadbent J & Poon WL (2015), Self-regulated learning strategies & academic achievement in online higher education learning environments: a systematic review. Internet and Higher Education 27, 1-13. https://doi.org/10.1016/j.iheduc.2015.04.007.

[10] Hu M & Li H (2017), Student engagement in online learning: a review. International Symposium on Educational Technology 2017, 39-43. https://doi.org/10.1109/ISET.2017.17.

[11] Kramarski B & Gutman M (2006), How can self-regulated learning be supported in mathematical e-learning environments. Journal of Computer Assisted Learning 22(1), 24-33. https://doi.org/10.1111/j.1365-2729.2006.00157.x

[12] Puska A, Puska E, Dragic L, Maksimovic A & Osmanovic N (2021), Students' satisfaction with e-learning platforms in Bosnia and Herzegovina. Technology, Knowledge and Learning 26, 173-191. https://doi.org/10.1007/s10758-020-09446-6.

[13] Amzil A & Stine-Morrow EAL (2013), Metacognition: components and relation to academic achievement in college. Arab World English Journal 4(4), 371-385. https://www.awej.org/images/AllIssues/Volume4/Volume4Number4Dec2013/22.pdf.

[14] Ohtani K & Hisasaka T (2018), Beyond intelligence: a meta-analytic review of the relationship among metacognition, intelligence, and academic performance. Metacognition Learning 13, 179-212. https://doi.org/10.1007/s11409-018-9183-8.

[15] Baltaci S, Yildiz A & Ozcakir B (2016), The relationship between metacognitive awareness levels, learning styles, genders and mathematics grades of fifth graders. Journal of Education and Learning 5(4), 78-89. https://doi.org/10.5539/jel.v5n4p78

[16] Cho MH & Heron ML (2015), Self-regulated learning: the role of motivation, emotion, and use of learning strategies in students' learning experiences in a self-paced online mathematics course. Distance Education 36(1), 80-99. https://doi.org/10.1080/01587919.2015.1019963

[17] Wang M, Binning KR, Del Toro J, Qin X & Zepeda CD (2021), Skill, thrill, and will: the role of metacognition, interest, and self-control in predicting student engagement in mathematics learning over time. Child Development 92(4), 1369-1387. https://doi.org/10.1111/cdev.13531.

[18] Pellas N (2014), The influence of computer self-efficacy, metacognitive self-regulation and self-esteem on student engagement in online learning programs: evidence from the virtual world of second life. Computers in Human Behavior 35, 157-170. https://doi.org/10.1016/j.chb.2014.02.048.

[19] Arcenal A., Balila J, Mergal, V, Saban G, De Leon J & Marticio FV (2016), Moderated mediation effects of self-efficacy on metacognition and mathematics achievement of college students. AUP Research Journal 19(2), 40-47. https://www.academia.edu/102175115/Moderated_Mediation_Effects_of_Self_Efficacy_on_Metacognition_and_Mathematics_Achievement_of_College_Students.

[20] Garofalo J & Lester FK (1985), Metacognition, cognitive monitoring, and mathematical performance. Journal for Research in Mathematics Education 16(3), 163–176. https://doi.org/10.2307/748391.

[21] Dolinting PP & Pang V (2022), The classroom climate, students' mathematics achievement, students' knowledge of cognition and regulation cognition: a mediation analysis. Malaysian Journal of Sciences and Humanities 7(6), 1-19. https://doi.org/10.47405/mjssh.v7i6.1533

[22] Bae H & Kwon K (2019), Developing metacognitive skills through class activities: what makes students use metacognitive skills? Educational Studies 47(4), 456-471. https://doi.org/10.1080/03055698.2019.1707068.

[23] Haleva L, Hershkovitz A & Tabach M (2020), Students' activity in an online learning environment for mathematics: the role of thinking levels. Journal of Educational Computing Research 59(4), 686-712. https://doi.org/10.1177/0735633120972057.

[24] Negara HRP, Nurlaelah E, Wahyudin, Herman T & Tamur M (2021), Mathematics self-efficacy and mathematics performance in online learning. Journal of Physics: Conference Series 1882, 1-5. https://doi.org/10.1088/1742-6596/1882/1/012050

[25] Choi J, Walters A & Hoge P (2017), Self-reflection and math performance in an online learning environment. Online Learning 21(4), 79-102. https://doi.org/10.24059/olj.v21i4.1249.

[26] Alomari AM (2009), Investigating online learning environments in a web-based math course in Jordan. International Journal of Education and Development using Information and Communication Technology 5(3), 19-36. http://ijedict.dec.uwi.edu//viewarticle.php?id=700.

[27] Konnova L, Lipagina L, Postovalova G, Rylov A & Stepanyan I (2019), Designing adaptive online mathematics course based on individualization learning. Education Sciences 9(3), 1-27. https://doi.org/10.3390/educsci9030182.

[28] Simsir Gokalp Z, Demirci A & Turgut I (2025), The relationship between metacognition and academic achievement in adolescents: the mediating role of academic control. Kastamonu Education Journal 33(1), 158-167. https://doi.org/10.24106/kefdergi.1628437.

[29] Koyuncuoglu D (2023), The mediating role of general self-efficacy in the relationship between metacognition and academic success of university students. International Journal of Modern Education Studies 7(1), 184-201. https://doi.org/10.51383/ijonmes.2023.302

[30] An D, Ye C & Liu S (2024), The influence of metacognition on learning engagement the mediating effect of learning strategy and learning behavior. Current Psychology 43, 31241-31253. https://doi.org/10.1007/s12144-024-06400-y.

[31] 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, 1-11. https://doi.org/10.3389/fpsyg.2018.02518
[32] Castillo RC, Cabatay MFD, Ronquillo RF & Seva MSB (2019), Customs administration students' usage of metacognitive knowledge in their internships. International Journal of Education and Practice 7(4), 347-362. https://doi.org/10.18488/journal.61.2019.74.347.362
[33] Al Awdah D, Jasmeen S & Alexander A (2017), A quantitative evaluation of metacognitive awareness among business administration students. Archives of Business Research 5(1), 16-25. https://doi.org/10.14738/abr.51.2565.
[34] Baguin RA & Janiola FR (2024), Students' level of metacognitive awareness as correlates of their mathematics achievement. Psychology and Education: A Multidisciplinary Journal 16 (6), 639-645.
[35] Embodo EJB & Baraquia LG (2019), Metacognitive and computational skills: predicting students' performance in mathematics. International Journal of Scientific Engineering and Science 3(5), 30-35.
[36] Mwangi EW, Mwaniki EW & Mutua JN (2024), Metacognition as a correlate of academic achievement among high school students in Nairobi Country, Kenya. Interdisciplinary Education and Psychology 4(1), 1-7.
[37] Muncer G, Higham PA, Gosling CJ, Cortese S, Wood-Downie H & Hadwin JA (2022), A meta-analysis investigating the association between metacognition and math performance in adolescence. Educational Psychology Review 34, 301-334. https://doi.org/10.1007/s10648-021-09620-x.
[38] Hassan N & Rahman S (2017), Problem solving skills, metacognitive awareness, and mathematics achievement: a mediation model. The New Educational Review 49, 201-212. https://doi.org/10.15804/tner.2017.49.3.16
[39] Poh BLG, Muthoosamy K, Lai CC & Gee OC (2016), Assessing the metacognitive awareness among foundation in engineering students. IAFOR Journal of Education 4(2), 48-61. https://doi.org/10.22492/ije.4.2.03
[40] Booc NBB, Cortez N, Enriquez D, Espino R, Loteria JL & Sabanal J (2024), The mediating effect of technostress on the relationship between metacognition and blended learning engagement of students in mathematics in the modern world. European Journal of Contemporary Education and E-Learning 2(1), 44-52. https://doi.org/10.59324/ejceel.2024.2(1).04.
[41] Karagianni GK (2024), Metacognition as a catalyst for improved learning outcomes in open & distance education. European Journal of Open Education and E-Learning Studies 9(1), 126-142. https://doi.org/10.46827/ejoe.v9i1.5567
[42] Leite WL, Kuang H, Jing Z, Xing W, Cavanaugh C & Huggins-Manley AC (2022), The relationship between self-regulated student use of a virtual learning environment for algebra and student achievement: an examination of the role of teacher orchestration. Computers & Education 191, 1-15. https://doi.org/10.1016/j.compedu.2022.104615.
[43] Liang Y, Ren L, Wei C & Shi Y (2023), The influence of internet-specific epistemic beliefs on academic achievement in an online collaborative learning context for college students. Sustainability 15, 1-22. https://doi.org/10.3390/su15118938
[44] Tsai Y, Lin C, Hong J & Tai K (2018), The effects of metacognition on online learning interest and continuance to learn with MOOCs. Computers & Education 121, 18-29. https://doi.org/10.1016/j.compedu.2018.02.011.