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Measurement model testing: Adaption of self-efficacy and metacognitive awareness among university students

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Abstract
Individuals' perceptions or beliefs about their mathematical aptitude are commonly classified as mathematics self-efficacy. Conversely, metacognitive awareness is characterized as a phenomenon that presents itself in a variety of ways as people engage with objects and circumstances in their everyday lives. The objective of this quantitative research was to evaluate the reliability of a self-efficacy and metacognitive awareness test administered to 184 undergraduate university students. In completing tasks in mathematical reasoning, students clearly discriminated between their self-efficacy and metacognitive awareness. Self-efficacy demonstrated discriminant and convergent validity in these quantitative investigations, which conforms to the Bandura (1993) theory and contains three dimensions: course self-efficacy, test self-efficacy, and future self-efficacy. Metacognitive awareness shows discriminant and convergent validity, which relates to Flavell (1979) theory and contains six factors: procedural knowledge, declarative knowledge, conditional knowledge, monitoring, planning, and evaluation. The casual correlation approach was used in the research design to explore the influence of metacognitive awareness and self-efficacy on mathematical thinking. The Cronbach's alpha internal consistency reliability research demonstrated that the self-efficacy and metacognitive awareness instrument that was developed was exceptionally reliable and may be used by researchers to assess self-efficacy and metacognitive awareness among university students.

Keywords: measurement model, exploratory factor analysis, metacognitive awareness, university students, self-efficacy

INTRODUCTION

The National Council of Teachers of Mathematics (2021) emphasizes on mathematical knowledge that assists students in developing mathematical abilities and knowledge, with a focus on problem solving and mathematical reasoning. Generalization is a type of reasoning in which numerous contexts are involved. However, the focus is not primarily on the context, but also on patterns, processes, structures, and links between the forms. Mathematical activity involves two kinds of reasoning: logical reasoning, which is formed by hypothesis, and deductive reasoning, which is derived by mathematical knowledge that has been established. In mathematics, there are four phases of reasoning: identifying patterns, generating conjectures, seeking evidence, and providing unproven arguments (National Council of Supervisors of Mathematics, 2020).

Mathematical reasoning is a part of the disciplines in which students struggle the most, and it has been shown that students struggled with mathematics difficulties since the start of the basic education in the early years (Saleh et al., 2018). According to Gurefe and Bakalim (2018), individuals use mathematics in their real learning experiences: they use familiar formulas or methods to solve ordinary problems, or they confront challenging circumstances using traditional mathematical techniques (example: finding for patterns; generalizing and simplifying; trying to identify special circumstances; reasoning by analogy; converting to a different context). A low-efficiency belief and metacognitive awareness implies poor performance in mathematical reasoning,

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Contribution to the literature

- The study produced the latest instrument to measure self-efficacy and metacognitive awareness among university students.
- The use of EFA proves the construct validity of the self-efficacy and metacognitive awareness instruments for university students
- This study becomes a new literature for studies involving self-efficacy and metacognitive awareness and can be developed at various levels of study.

which complicates their involvement and putting in additional effort to learning (Drysdale & McBeath, 2018). According to Zayyadi and Kurniati (2018), approximately 63% of Malaysia's young generation still struggles with problem solving and mathematical reasoning, and almost half of them are already suffering anxiety in their learning.

The novelty of this research is that it draws a new conclusion on undergraduate students' metacognitive awareness and self-efficacy in mathematical reasoning which lead to greater knowledge discovery in mathematics education. The measurement of assessment of metacognitive awareness and self-efficacy in mathematical reasoning must be identified by the researcher since it describes the type of statistical analysis that can be accomplished and, as a result, the pattern of findings obtained from the research.

LITERATURE REVIEW

Self-Efficacy

Mathematical reasoning skills are necessary for a person to describe and compare mathematical patterns in a clear and concise manner (Aprisal & Abadi, 2018). According to Widya et al. (2019), students must be able to explain their reasoning for each interpretation in order to solving mathematics problems. Assertions are a useful tool for implementing mathematical principles in practice. It is a fundamental goal for learning activities to enhance the ability for coherent reasoning while inferring numerical values. Self-efficacy is described as an assumption in one's ability to cope or develop in order to achieve one's aims and outcomes as it makes it possible to evaluate conceptual statements on the link between the constructs (Bandura, 1993). The improvement of a student's self-efficacy in their own skills is closely related to academic achievement (Mahasneh & Alwan, 2018). Students established a clear contrast in their mathematics courses between their feelings of self-efficacy in practicing and comprehending mathematics and their sense of self-efficacy in completing activities such as examinations or assignments (Drysdale & McBeath, 2018). Blotnicky et al. (2018) observed that the perspectives of the students on their mathematical aptitude were irrelevant to their present mathematics coursework; however, they did seem to be affected by one's prior experiences in mathematical endeavors.

Reasoning necessitates the use of procedures to generalize mathematical occurrences and/or the formulation of hypotheses concerning mathematical equations. Overall, reasoning is concerned with the reflective processes through which students develop and improve their mathematical knowledge (Zayyadi & Kurniati, 2018). Additionally, one issue with the efficacy of learning is that some students revealed that the learning difficulties were done in such a way that they could include their classroom assessment grade and still get a good mark. Yet, the pupils were unconcerned about their mathematics homework since they believed they could still obtain a high score on it (Liu et al., 2020). Similarly, students were worried about their assignments since they believed they had the tools to do them all. Students who feel they have mastered skills and accomplished complex tasks, on the other hand, have higher efficacy beliefs (Gurefe & Bakalim, 2018).

Mathematical reasoning has generally been found as a vital component of learning and problem solving, but the relationship between reasoning and the domain in which reasoning is engaged has raised questions about the specific and universal nature of learning (Singh et al., 2020). Generalization is a type of reasoning in which numerous contexts are involved; however, the focus is not primarily on the context, but also on patterns, processes, structures, and links between the contexts. In mathematics, there are various stages of reasoning: recognizing patterns, forming conjectures, offering evidence, and providing unproven arguments (Agustyaningrum et al., 2019). Students seemed to believe that their learning would ready them for whatever faced their path. Students that do inadequately in mathematics will cultivate negative feelings and attitudes that they will require in their future careers (Celik & Kocak, 2018). Students felt a significant deal of pressure to maintain their academic excellence throughout their university years in order to fulfil graduation requirements and be eligible for upcoming courses offered. Students' anxiousness over grades is sometimes justified by their fear of losing eligibility for academic scholarships. For jobs that are connected to mathematical reasoning, this fear causes them to avoid it in the future (Blotnicky et al., 2018).

Metacognitive Awareness

Metacognitive awareness is described as a phenomenon that presents itself in a variety of ways that occur when individuals interact with circumstances and occurrences in their real-life experiences (Adinda et al., 2021). Metacognitive information will assist individuals in organizing, monitoring, and sequencing their learning so that productivity gains may be achieved efficiently (Asy'ari et al., 2022). Furthermore, Moxon (2022) mentioned that "critical reflection is a process of in-depth analysis that reveals implausible concepts, assumptions, expectations and makes our own reflection apparent".

Flavell (1979) introduced the concept of "metacognition". Flavell (1979) defined metacognitive knowledge as "knowledge and cognition about cognitive phenomena" and considered it to be the learner's comprehension of their own cognition. As a result of Flavell's (1979) research, other researchers decided to understand metacognitive and describe it as a concept of varying dimensions. This instance demonstrated that the idea may have several metacognitive components. Many connotations have emerged in this circumstance. Asy'ari et al. (2022) did considerable research on the metacognition, which was defined by Flavell (1979) as being used by learners in the case of planned learning and problem-solving, awareness and regulation of cognitive processes. Metacognitive knowledge, as described by Karaoglan Yilmaz (2022) is "knowledge about distinct components of an individual's thinking processes" and "modifying capabilities of individuals about cognitive operations in order to understand more effectively."

Brown (1978) defines metacognitive knowledge as "knowledge about diverse qualities of an individual's thinking processes and applying people skills regarding cognitive activities to grasp more effectively". Individual's knowledge of their own cognitive processes and techniques, as well as their aptitude to monitor and regulate these processes, is referred to as metacognitive knowledge. Individuals must monitor, evaluate, and reflect on their own learning and cognitive processes under this strategy. The reflective thinking qualities required for this procedure too must be considered (Khodaei et al., 2022). Furthermore, Robillos and Bustos (2022) assert that the reflective process is a dialectic between thinking and action at the foundation of the evolutionary change in approach, which necessitates fundamental transformations in ideas, attitudes, and norms about teaching and learning if change is to be achieved through reflection.

Metacognitive Awareness & Mathematics Reasoning

According to Lestari and Jailani (2018), mathematical aptitude is linked with the capacity to reason logically. An example of deductive reasoning is when a conclusion is reached from the logic of preceding stages in a logical chain of reasoning. Mathematics learners' desire to understand mathematics and assess its validity leads to deductive and inductive reasoning. Developing and exploring deductive reasoning in the mathematics lesson might have a significant impact on arithmetic learning. (Agustyaningrum et al., 2019). Furthermore, metacognition strategies could be beneficial to college or university students (Tak et al., 2021). Individuals may understand metacognitive capabilities in trying to improve their learning (Khodaei et al., 2022; Moxon, 2022). Students will be more likely to use a range of methods for learning, problem solving, and reasoning. Similarly, Robillos and Bustos (2022) argue that comprehensive metacognitive knowledge in education is required. Additionally, Wafubwa and Csíkos (2022) mentioned that metacognitive awareness is a process of interaction between decision-making at the foundation of the evolutionary change in approach, which necessitates fundamental transformations in ideas, attitudes, and beliefs about students learning if change is to be achieved through reflection (Wafubwa et al., 2022).

Reasoning is described as "the process of obtaining conclusions based on evidence or articulated assumptions". Reasoning entails applying techniques to generalize mathematical occurrences or forming assumptions about mathematical relationships (Olson & Johnson, 2022). Ultimately, reasoning focuses on reflective methods through which students develop and improve their mathematical knowledge. Besides that, metacognitive awareness in mathematical knowledge distinguishes cognitive knowledge from cognitive regulation (Syaiful et al., 2022). There are three types of metacognition knowledge: declarative knowledge (knowledge of what they are learning), conditional knowledge (experience of why and when to understand), and procedural knowledge are all examples of knowledge (knowledge about when and why to understand). Conversely, cognitive regulation is composed of the following subcomponents that enhance the process: planning, monitoring, and evaluation (Karaoglan Yilmaz, 2022).

Several definitions and terminologies have been used to describe mathematical reasoning. Reasoning-and-proving refers to a set of actions that study if and why "facts operate" in various mathematical fields such as algebra and geometry (Widya et al., 2019). Conditional knowledge refers to the learner's understanding of why and when he or she is applying mathematics reasoning learning. Declarative knowledge refers to a learner's understanding of what he or she considers is mathematics reasoning learning. Procedural knowledge refers to the learner's understanding of how she or he uses methods while applying mathematics reasoning learning (Mohammadi et al., 2022).

Moreover, cognition regulation refers to individuals' attempts to control and influence the trajectory of their cognitive activity. Self-correcting activities serve as early antecedents to these stages, which arise as a consequence of domain-specific learning. Cognitive regulation comprises reality testing and a range of other behavioral patterns for coordinating and directing conscious efforts to solve issues and learn, such as predicting an action or occurrence, monitoring present activity, and validating action outcomes (Akben, 2020).

Metacognitive Awareness and Self-Efficacy

Self-efficacy research in academic contexts have generally focused on two main aspects. Another research explored the correlation between efficacy beliefs, fields of study, and career paths, especially in science and mathematics (Blotnicky et al., 2018; Drysdale & McBeath, 2018; May, 2009; Tak et al., 2021). The second field of research has looked at the link between efficacy beliefs, related psychological dimensions, and academic accomplishment (Aprisal & Abadi, 2018; Celik & Kocak, 2018; Mahasneh & Alwan, 2018). Several research in the area of mathematics accomplishment employed structural education modelling or path analysis to identify the significant elements that influence mathematics performance directly or indirectly via mathematics self-efficacy (Blotnicky et al., 2018; Gurefe & Bakalim, 2018; Liu et al., 2020; Mahasneh & Alwan, 2018; Tak et al., 2021) and metacognitive awareness (Adinda et al., 2021; Robillos & Bustos, 2022; Syaiful et al., 2022; Wafubwa & Csíkos, 2022).

The current research found high variability across metacognitive awareness research, which is consistent with earlier research (Mohammadi et al., 2022; Moxon, 2022; Robillos & Bustos, 2022; Tak et al., 2021; Wafubwa & Csíkos, 2022). However, the Cronbach's alpha value which were >0.70 for the self-efficacy toward mathematics research (the path equivalent to prior unidirectional meta-analyses) compares well to the values of 0.72-0.93 found in the sole review that included comparable data (Aprisal & Abadi, 2018; Blotnicky et al., 2018; Liu et al., 2020). Meanwhile, all reported Cronbach's alpha are liability coefficients for metacognitive awareness measures were >0.70, with all except one reaching =0.94 (Karaoglan Yilmaz, 2022). Nonetheless, using the same meta-regression method as with the moderators, metacognitive awareness reliability was investigated as a possible continuous moderator of the six pooled correlations (Adinda et al., 2021; Karaoglan Yilmaz, 2022; Moxon, 2022; Robillos & Bustos, 2022; Wafubwa & Csíkos, 2022).

METHOD

The methodology utilized in this research is by using the non-experimental and quantitative design, in which metacognitive awareness inventory was derived from Rahman et al. (2014) and Schraw and Dennison (1994) as a measurement to assess students' metacognitive awareness. Meanwhile, self-efficacy inventory was derived from May (2009) as a measure to assess students' self-efficacy.

Sample Study

In this research, there were 184 participants from few local universities located in Klang Valley, Malaysia. The researchers selected random sampling as their technique of choice since it is the most efficient sampling method publicly known. The following demographic factors were explored in order to indicate the gender and stream of research participants. In terms of participant gender, there were 75 female students (40.8%) and 109 male students (50.2%). As for discipline stream, 159 of the participants (86.4%) were scientific and mathematics stream undergraduates, whereas 25 (13.6%) were non-science and mathematics stream participants in the research.

Instrument

Metacognitive awareness inventory was derived from Rahman et al. (2014) and Schraw and Dennison (1994) as a measurement to assess students' metacognitive awareness. The measure had 30 questions that addressed two aspects of metacognitive awareness: cognitive regulation and metacognitive knowledge. This self-efficacy instrument was adapted from research by May (2009). The self-efficacy questionnaire has 13 questions, including dimensions in the efficacy of course, efficacy of assessment, and efficacy of future.

Procedure

The researcher requested permission from the lecturers engaged in the research before distributing the instrument to the respondents. To effectively begin the application procedure, the researcher applied letter to the Dean of the respective faculty, together with the objective of the research and instrument. After obtaining approval, the researcher contacted the course instructor to acquire permission to distribute the instrument to the participants involved and to set up a time for implementation. The researcher explained how to complete tasks and the objective of the research before distributing the instruments to the respondents. Respondents had 60 minutes to complete the mathematics reasoning instrument as well as the associated self-efficacy and metacognitive awareness questionnaire.

Data Analysis

To investigate the construct of the instrument, this research used exploratory component analysis using principal component analysis with varimax rotation. If appropriate, an inference about an individual may be generated based on analysis results in a construct (Cohen et al., 2017). The usability of an instrument is characterized by its ability to contribute to the research's relevance, which is determined by its validity characteristics. If the research data comprises data dropouts, normality analysis or outliers, exploratory factor analysis should be carried out (Cohen et al., 2017).

Three approaches are used in an exploratory factor analysis:

1. The Kaiser-Guttman criteria (eigen value >1),
2. Parallel analysis or screen plot to assess the number of exploratory factor analysis components.

The number of identified variables can be determined more legitimately using this technique than with any other. Furthermore, in order to establish the significance of the data in the research, the exploratory factor analysis should give particular attention to the Kaiser-Meyer-Olkin (KMO) revealing. KMO values of approximately 1 should be observed in exploratory factor analysis, showing that the factors are accurate and distinct from one another. Finally, the Bartlet sphericity test findings may be utilized to indicate the existence of a factorability correlation between the items in the research (Hair et al., 2019).

Various loading factor values ranging from 0.30 to 0.60 were used to compare the exploratory factor analysis outcomes. In order to perform the research, the purpose is to choose the optimal exploratory factor analysis size in terms of both empirical and theoretical parallels to the research. The researcher takes into consideration:

1. items having a loading factor smaller than a substantial loading factor's size,
2. items with a high loading factor but a low communality value,
3. items that are massively skewed by two or more of the factors (cross-loading), and
4. items that satisfy the research hypothesis while selecting whether to retain or eliminate an item based on factor analysis findings (Hair et al., 2019).

An instrument reliability analysis is conducted after the exploratory factor analysis. Reliability is defined as the degree of consistency between multiple measurements of reliability (Hair et al., 2019). A Cronbach's alpha reliability analysis was done by the researchers to determine the degree of instrument reliability of the investigations. The strategy, as well as other researchers' approaches, may help researchers determine whether or not the measurement items are the same. According to Hair et al. (2019), two variables must be satisfied in order to assess the degree of consistency in the constructed instrument:

1. The correlation between items with a value larger than 0.3 and
2. The Cronbach's alpha value greater than 0.7.

Table 1. Analysis of kurtosis, skewness, mean, & standard deviation (SD) for self-efficacy

Item	Kurtosis	Skewness	Mean	SD
D1	-.607	-.168	3.77	.838
D2	.340	-.714	3.96	.858
D3	.071	-.344	3.84	.800
D4	-.588	-.262	3.74	.873
D5	.656	-.781	3.86	.898
D6	-.508	-.195	3.90	.769
D7	.099	-.647	4.13	.776
D8	.369	-.637	4.10	.747
D9	.421	-.732	3.96	.852
D10	.592	-.570	3.73	.816
D11	.619	-.523	3.91	.763
D12	.115	-.645	3.54	.963
D13	.093	-.545	3.68	.946

Table 2. Analysis of mean, standard deviation (SD), kurtosis, & skewness for metacognitive awareness

Item	Mean	SD	Kurtosis	Skewness
C1	3.96	.712	.980	-.496
C2	3.72	.737	-.211	-.161
C3	3.52	.754	.114	-.095
C4	3.65	.767	-.620	-.247
C5	3.95	.773	.033	-.479
C6	3.86	.835	.078	-.479
C7	3.71	.762	-.328	-.124
C8	3.74	.779	-.441	-.712
C9	3.62	.846	.393	-.339
C10	4.12	.759	-.221	-.507
C11	3.92	.829	.372	-.835
C12	3.92	.816	.052	-.764
C13	3.79	.717	-.107	-.210
C14	3.64	.749	.370	-.395
C15	3.89	.819	.875	-.693
C16	3.94	.733	.087	-.832
C17	4.04	.781	.750	-.911
C18	3.94	.762	.078	-.722
C19	3.78	.803	-.507	-.152
C20	3.72	.833	-.108	-.302
C21	3.82	.728	-.144	-.225
C22	3.89	.746	.629	-.460
C23	3.80	.728	-.032	-.282
C24	3.64	.704	-.314	.077
C25	3.89	.784	.532	-.551
C26	3.92	.779	-.241	-.358
C27	3.90	.743	-.284	-.236
C28	3.58	.877	.135	-.399
C29	3.76	.815	.090	-.392
C30	3.81	.797	.137	-.363

RESULTS AND FINDINGS

The researcher conducted an exploratory component analysis utilizing the varimax rotation and principal component analysis methods to determine the instrument that had been developed was valid. In the case of the items in **Table 1** and **Table 2**, the kurtosis and skewness values were between -1.00 and +1.0, showing that the data complied with the expectation of normality (Hair et al., 2019).

Table 3. Exploratory factor analysis of self-efficacy

Item	Factor	Communalities	Component	% of variance	Eigenvalue
D1	Self-efficacy course	.598	.530	60.629	7.882
D3		.659	.678		
D4		.739	.659		
D6		.727	.724		
D7		.727	.683		
D8	Assessment	.752	.690	7.766	1.010
D2		.698	.675		
D9		.748	.701		
D10		.721	.713		
D5	Future	.663	.615	36.500	1.460
D11		.723	.697		
D12		.706	.564		
D11		.802	.714		

Table 4. Exploratory factor analysis of metacognitive awareness

Item	Factor	Communalities	Component	% of variance	Eigenvalue
C1	Declarative knowledge	.532	.591	35.763	10.729
C2		.762	.591		
C3		.639	.493		
C4		.640	.604		
C5		.606	.573		
C6	Procedural knowledge	.742	.584	6.334	1.900
C7		.737	.610		
C8		.755	.469		
C8		.686	.528		
C10	Conditional knowledge	.727	.439	5.019	1.506
C11		.695	.487		
C12		.667	.543		
C13		.683	.614		
C14		.662	.532		
C15	Planning	.651	.635	4.498	1.349
C16		.685	.567		
C17		.630	.548		
C18		.530	.507		
C19		.621	.530		
C20	Monitoring	.701	.504	4.318	1.295
C21		.701	.652		
C22		.689	.544		
C23		.660	.553		
C24		.702	.605		
C25		.642	.463		
C26	Evaluation	.553	.553	3.466	1.040
C27		.567	.597		
C28		.605	.526		
C29		.621	.634		
C30		.682	.613		

The data in this research was examined using KMO indicators, with values approximately 1 indicating variables that are both exact and distinct (Tabachnick & Fidell, 2007). An exploratory factor analysis was used to evaluate the impact of item reinforcement in the domains of self-efficacy and metacognitive awareness. All of the items have a KMO value greater than 0.7, indicating that they are suitable for analysis.

The Barlett test was similarly significant [χ^2=5125.821], p<.05, demonstrating that the hypothesis of the correlation analysis as a component of the identity matrix was incorrect. Initial results revealed that communality ranged from 0.530 to 0.724, and eigenvalues for 3 dimensions self-efficacy indicators were determined. Meanwhile, preliminary research revealed that communality ranged from 0.530 to 0.762, and eigenvalues for six separate measures of metacognitive awareness were identified. Each component is described in detail in **Table 3** and **Table 4**.

The outcomes of the validation factor analysis were used to establish a goodness-of-fit model, which included the root mean square error of approximation (RMSEA) and the statistical value of goodness-of-fit, χ^2. RMSEA values less than 0.08 indicate model acceptance;

Table 5. Goodness of fit index of self-efficacy and metacognitive awareness

Statistic fit	Value	Explanation
χ^2/df	1.879	Model vs. saturated
GFI	0.760	Comparative fit index
RMSEA	0.690	Root mean square error of approximation

Table 6. Preliminary research data after adjustment subjected to exploratory factor analysis for self-efficacy

Item	Factor	Cronbach's alpha	Loading factor	AVE	CR
D1	Self-efficacy course	.789	.530	.567	.797
D3			.678		
D4			.659		
D6			.724		
D7			.683		
D9	Assessment	.774	.701	.691	.785
D10			.713		
D5	Future	.712	.615	.699	.769
D11			.697		

Table 7. Preliminary research data after adjustment subjected to exploratory factor analysis for metacognitive awareness

Item	Factor	Cronbach's alpha	Loading factor	AVE	CR
C1	Declarative knowledge	.770	.591	.972	.810
C2			.591		
C3			.493		
C4			.604		
C5			.573		
C7	Procedural knowledge	.712	.610	.527	.713
C9			.610		
C12	Conditional knowledge	.726	.543	.772	.817
C13			.614		
C14			.532		
C15	Planning	.775	.635	.903	.813
C16			.567		
C17			.548		
C19			.530		
C20	Monitoring	.741	.504	.594	.805
C22			.544		
C23			.553		
C24			.605		
C26	Evaluation	.714	.553	.667	.789
C27			.597		
C28			.526		
C29			.634		
C30			.613		

while RMSEA values more than 0.10 imply model rejection (Browne & Cudeck, 1992). The comparative fit index (CFI) and Tucker-Lewis goodness of fit indexes (TLGI) were used in conjunction with the research. A number higher than 0.90 is regarded to be a respectable outcome for both indexes (Browne & Cudeck, 1992). After modification, the fit model values in this research instrument fulfilled the specified requirements. The researcher eliminated items which have a loading factor of less than 0.60 (**Table 5**).

The following are the conclusions of CFA research: Items with a loading factor of less than 0.40 are not retained in the research instrument since they constitute an edge (Rosna & Azlina, 2008). According to the model's chi-square correspondence indices (RMSEA=0.69, GFI=0.760, CFI=0.821, Chi-square/df=1.879), this demonstrates that the final model meets all of the conditions for the research investigation. Following that, the reliability of the questionnaire design was evaluated using the Cronbach's alpha reliability approach (Markus, 2012).

The Cronbach's alpha factor loadings for the different self-efficacy subscales vary from 0.712 to 0.789, as shown in **Table 6**. Meanwhile, **Table 7** illustrates the Cronbach's alpha factor loadings for the different metacognitive awareness items, which vary from 0.712 to 0.775. Awang (2018) recommends an alpha value of 0.70 to meet the Cronbach's alpha criteria. Self-efficacy has construct validity ranging from 0.769 to 0.797, while metacognitive awareness has construct validity ranging from 0.713 to 0.817. This shows that the self-efficacy and metacognitive awareness components satisfied the requirements. To meet the construct validity (CR) criterion, the criteria must have a value of 0.60 or above (Awang, 2018).

Ultimately, the self-efficacy average variance extracted (AVE) values varied between 0.56 and 0.69 and metacognitive awareness AVE values varied between 0.53 and 0.97 which indicates that it meets the requirements. According to Awang (2018), the value of the AVE should be less than 0.50 in order for it to be regarded as suitable for statistical analysis. Generally, the validation factor analysis of self-efficacy and metacognitive awareness components fulfills all of the criteria.

DISCUSSION

The objective of this research was to examine the role of mathematical reasoning in understanding the correlation between metacognitive awareness and self-efficacy. The implementation of structural equation model was necessitated by the research objective due to the fact that it makes it possible to evaluate conceptual statements on the link between the constructs. Besides that, there are findings that self-efficacy and metacognitive awareness has a slight significance on mathematics reasoning performance. The current research findings indicated that high self-efficacy and metacognitive awareness has an effect on students' achievement in mathematical reasoning.

The focus of this research was to explore at how mathematical reasoning could assist other researchers to comprehend the link between metacognitive awareness and self-efficacy. The use of structural equation model was required by the research goal since it allows for the validation of conceptual assumptions about the relationship between the constructs. On the other hand, it indicates that self-efficacy and metacognitive awareness has impact on mathematical reasoning performance. According to the present research findings, high self-efficacy and metacognitive awareness have an influence on students' mathematical reasoning performance. Therefore, metacognitive awareness and self-efficacy assist undergraduate students to improve their understanding mathematical reasoning.

The findings showed weak but statistically significant relationship between students' metacognitive awareness and self-efficacy. Metacognitive awareness was shown to be substantially linked with self-efficacy in mathematical reasoning performance (Aprisal & Abadi, 2018; Liu et al., 2020; Mahasneh & Alwan, 2018). The direct effect of metacognitive awareness finding is relatively consistent with earlier research findings (Akben, 2020; Karaoglan Yilmaz, 2022; Robillos & Bustos, 2022; Wafubwa & Csíkos, 2022). However, some researches do not show a substantial association between metacognition awareness (Khodaei et al., 2022) and self-efficacy (Gurefe & Bakalim, 2018). As previously mentioned by Moxon (2022), the inconsistent results might be attributed to cultural difference. To be more specific, the data suggested that there was a significant relationship between metacognitive awareness and self-efficacy for Malaysian undergraduate students in mathematics reasoning performance.

Metacognitive awareness, as conscious cognitive experiences, accounts for a major aspect of the link between metacognitive knowledge and metacognitive experience in mathematical reasoning performance. This result is mainly consistent with the finding that emphasizes metacognitive experiences as "the missing link" in our understanding of self-efficacy (Aprisal & Abadi, 2018; Gurefe & Bakalim, 2018; Liu et al., 2020; Mahasneh & Alwan, 2018) and metacognitive process (Adinda et al., 2021; Karaoglan Yilmaz, 2022; Wafubwa & Csíkos, 2022). Metacognitive knowledge performs at the macro-level, as opposed to metacognitive experiences, which engages at the micro-level (Syaiful et al., 2022). Consequently, metacognitive awareness and self-efficacy are the areas in which undergraduate students are least focused (Blotnicky et al., 2018; Tak et al., 2021). This finding highlights the critical role that students' efficacy and feelings play on a given task in learning (Celik & Kocak, 2018; Drysdale & McBeath, 2018).

Suggestions and Implications

This research on self-efficacy and metacognitive awareness evaluation contribute to mathematical reasoning. Ultimately, there are findings that recommend that self-efficacy and metacognitive awareness has a positive impact on mathematics reasoning performance. The current research findings indicated that high self-efficacy and metacognitive awareness has an effect on their mathematics reasoning performance. This is also suggested that implementers of reasoning elements in mathematics lesson to boost their self-efficacy and metacognitive awareness in order to enhance undergraduate mathematical reasoning aptitude. This research suggests that further research should be conducted on model research with bigger and more varied student populations. Furthermore, it is recommended that learning approaches for the mathematics reasoning be varied to enhance students' self-efficacy and metacognitive awareness.

CONCLUSION

University students were requested to engage in this research on personal metacognitive awareness and self-efficacy in the setting of mathematical reasoning. On the basis of the research of exploratory aspects, the factors of self-efficacy were divided into three aspects, which are, efficacy of course; assessment; future. Meanwhile, Metacognitive Awareness demonstrates discriminant and convergent validity, which correlates to the six factors: declarative knowledge, conditional knowledge, procedural knowledge, monitoring, planning, and evaluation. Aside from the exclusion of 4 items from the self-efficacy questionnaire, all variables retain the characteristics of contributing factors by researchers who subscribe to a certain research theory and the perspectives of education professionals. The reliability research of Cronbach's alpha internal consistency reliability demonstrated that the developed metacognitive awareness and self-efficacy measure was very dependable. The research discovered that the constructed instrument has high psychometric qualities and can be used by researchers to assess undergraduate students' metacognitive awareness and self-efficacy in mathematical reasoning capabilities.

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