

Measurement Model and Adaptation of Self-Efficacy toward Mathematics Reasoning among University Students

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ABSTRACT

Mathematics self-efficacy is generally defined as individuals' beliefs or perceptions regarding their mathematical abilities. The aim of this quantitative study was to conduct a validity analysis of a self-efficacy instrument toward mathematics reasoning among 184 undergraduate public university students. Students clearly distinguished between their self-efficacy in doing and understanding mathematics reasoning and their self-efficacy in accomplishing assignments in their university mathematics lesson. In these quantitative studies, self-efficacy which demonstrated convergent and discriminant validity was performed, which corresponded to the Bandura theory and included three dimensions: course self-efficacy, exam self-efficacy, and future self-efficacy. The research design utilized casual correlation technique to investigate the effect of self-efficacy on mathematics reasoning. The reliability analysis of Cronbach Alpha internal consistency reliability revealed that self-efficacy instrument that was constructed was extremely reliable and can be utilized by researchers to measure university students' self-efficacy toward mathematical reasoning.

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1. Introduction

1.1 Introduce the Problem

Mathematical reasoning learning is one of the areas in which students face greater difficulties in solving mathematics problems and this problem has occurred as early as the first years of basic education (Hwang et al., 2017). The circumstance of poor performance in mathematics reasoning is implied by a low-efficiency belief scheme, which complicates engaging themselves and required putting in more effort to learn. According to Halim et al. (2021) & Reyes (2019), the younger generation of Malaysians still have a problem with mathematics, and nearly half of them are already experience anxiety.

Gürefe & Bakalım (2018) found that individual use mathematics in two distinct ways in their daily life: they apply known formulas or procedures to solve standard problems, or they confront perplexing problems using conventional mathematical approaches (e.g., generalizing and simplifying; looking for patterns; reasoning by analogy; exploring specific cases; translating to another setting) (Hunter, 2017). Educators pay less attention to students' reasoning ability, or in other words, the methods used are less varied, which in turn, makes student motivation difficult, and students' learning patterns are simply memorized and mechanistic (Sukirwan et al., 2018).

In aspects of worldwide research context, 8 of the 11 research utilised comparable methods to assess self-efficacy. The Multi-dimensional Scales of Perceived Self-Efficacy (Bandura, 1993; n=2), Academic Self-Efficacy Scale (Gürefe & Bakalım, 2018; May, 2009; n n=2) and Student Efficacy Scale (Halim et al., 2021; n=2) were the most commonly. On the contrary, there was no identical instrument used to evaluate self-

efficacy in a single area; each research employed a particular instrument connected to a specific domain under review (Reyes, 2019; Singh et al., 2020).

Cronbach's alpha for worldwide measures of self-efficacy varied from .72 to .93 (Mahasneh & Alwan, 2018; May, 2009), and for particular measures of self-efficacy ranged from .71 to .92 (Blondeau & Awad, 2018; Çelik & Koçak, 2018). Two instruments did not disclose the reliability of their self-efficacy measures (Reyes, 2019; Singh et al., 2020). More study is also required to determine the suitable application of self-efficacy belief measures to explore the correlations to academic performance (Blondeau & Awad, 2018; Gürefe & Bakalım, 2018; Halim et al., 2021; Mahasneh & Alwan, 2018; Yin et al., 2020). Three of the five studies that employed self-efficacy belief measures were unable to reveal non-significant values for the strength of the relationship between self-efficacy and mathematics achievement (Reyes, 2019; Sides & Cuevas, 2020; Singh et al., 2020).

The novelty from these studies is that they make a new inference on undergraduate students' self-efficacy toward mathematics reasoning, which leads to a new knowledge discovery in mathematics education. The researcher must identify the depth of evaluation of self-efficacy and mathematical reasoning in these studies because it defines the sort of statistical analysis that can be conducted and the inferences that can be derived from the findings.

2. Literature Review

2.1 Self-efficacy

The term self-efficacy is explained as belief in one's capacity to cope or grow in order to attain one's goals or objectives (Bandura, 1993). The development of a student's self-efficacy in his or her own abilities is directly linked to his or her eventual academic performance (Mahasneh & Alwan, 2018; Sides & Cuevas, 2020). In mathematics lesson, students made a clear distinction between their sense of self-efficacy in doing and understanding mathematics or their sense of self-efficacy in completing tasks such as tests and assignments. According to the study of Singh et al. (2020), students' perceptions of their general mathematical reasoning abilities were unrelated to the current mathematics course they were taking, but they appeared to be heavily influenced by their previous mathematics experiences.

Furthermore, one difficulty with students' learning effectiveness is that some students discovered that the learning problems were actually intended in such a setting that they could include their homework assignment scores while still achieving a reasonable outcome. However, the students were not very concerned with their mathematics assignment, as they thought that they could still get a good grade on the assignments (Yin et al., 2020). Likewise, pupils were unconcerned about their tasks since they thought they had the resources to finish them all. On the other hand, students who believe that they have mastered skills and completed difficult assignments typically have higher efficacy beliefs (Gürefe & Bakalım, 2018).

Instead of examining their abilities to perform mathematics in their future occupations, students seemed to have believed that their course content would prepare them for whatever that they will face in the future and that students who do poorly in mathematics would retain negative feelings and attitudes which they would need (Çelik & Koçak, 2018). To fulfill degree requirements and be eligible for prospective academic programs, students felt a great amount of stress to maintain excellent grades throughout their university career paths. Students' fear of losing their academic scholarship eligibility is a common justifiable reason for their stress over grades for which mathematical reasoning skills are associated, leading them to avoid it in the future (Blondeau & Awad, 2018).

2.2 Mathematics Reasoning

In this research, mathematics reasoning questions instrument has been adapted from Calvin & Duane (2002) as a tool to assess the reasoning performance of these students along with mathematics skills. In addition, to the four topics which were selected from mathematics reasoning which have been used as a measurement analysis, there were four mathematics reasoning topics of geometry which were chosen critical thinking; sets and whole numbers; fraction.

These topics were measured in these studies because several mathematic reasoning questions refer to current learning practice and students could draw on their experiences with their learning course and instructor. According to previous research, deductive reasoning skills are related to mathematical abilities. It is indeed possible to reach conclusions through deductive reasoning by following the steps in a logical chain of reasoning in which each step "follows necessarily" from the previous step (Kolloosche, 2021). Students' motivation to understand mathematics reasoning and evaluate mathematical generalisability leads to

inductive and deductive reasoning. Fostering and explaining deductive reasoning in the lesson may have a substantial influence on mathematics learning.

In order to examine patterns and adequately understand mathematical structures, an individual's mathematical reasoning skills are required. The capacity of students to express their reasoning for each interpretation is fundamental to the knowledge extraction. Strong assertions may be used to design the implementation of mathematical concepts. Furthermore, one of the key goals of learning approaches is to acquire the aptitude to have logical reasoning for inferring mathematical outcomes (Maiti, 2017).

3. Method

The method of this study is by using the quantitative and non-experimental design, which adapted the instruments of mathematics reasoning (Calvin & Duane, 2002) and self-efficacy questionnaire (May, 2009) for undergraduate students in public universities around Klang Valley.

3.1 Sample Study

This research included 184 students from a public university in Klang Valley, Malaysia. The researcher utilized the random sample methodology since it is the most effective sampling method. The following demographic characteristics were investigated in order to represent the profile of studies respondents: (a) gender (b) current course. In terms of student gender, there were 75 female students (40.8 %) and 109 male students (50.2%). As for the syllabus stream, 159 of the participants (86.4%) were mathematics and scientific stream, while 25 participants (13.6%) were non-mathematics and science stream.

3.2 Instrument

The mathematical reasoning research instrument was modified from a prior study conducted by Calvin & Duane (2002). The questions on mathematical reasoning were divided into four categories, which included geometry; fractions; sets and whole numbers; critical thinking. The level of mathematical reasoning skills exhibited by students will be determined by their mathematics reasoning achievement scores. This study also used an adaptation of the May (2009) Self-Efficacy Instrument. The self-efficacy questionnaire consisted of 13 items, with the components in the dimensions of efficacy of assessment, efficacy of course, and efficacy of future.

3.3 Procedure

Before sending the instrument to the respondents in the sample, the researcher needed consent from the lecturers involved in the study. To complete the application process, it is then sent to the Dean of the relevant faculty, together with the study's purpose and research instrument. Following approval, the researcher contacted the course instructor to seek permission to administer the instrument to the students in their class, as well as to schedule an implementation time. Before handing over the instruments to the respondents, the researcher explained how to complete the items and the purpose of the research. Respondents were given 30 minutes to complete both the instrument and the accompanying questionnaire.

4. Data Analysis

The study employed an exploratory factor analysis using Principal Component Analysis with Varimax Rotation to explore the instrument's construct. An inference may be formed about a person based on test results in a construct if it is suitable (Cohen et al., 2017). An instrument's usability is defined by its capacity to contribute to the study's relevance, which is decided by its validity qualities. Exploratory factor analysis should be conducted if the research data involves data dropouts, outliers, and normality analysis (Cohen et al., 2017).

An exploratory factor analysis is conducted using three methods: i) the Kaiser-Guttman criterion (eigen value > 1), ii) a screen plot or parallel analysis to identify the number of exploratory factor analysis components that is determined. With this strategy, the number of detected factors may be determined in a more legitimate way than with any else. Furthermore, the exploratory factor analysis should pay special attention to the Kaiser-Meyer-Olkin (KMO) indicator in order to determine the relevance of the data in the research. In exploratory factor analysis, KMO values approaching 1 should be seen, indicating that the factors are accurate and different from one another. Ultimately, the results of the test Bartlett sphericity can be used to demonstrate the presence of a factorability relationship between the variables analysed (Hair et al., 2019).

The results of the exploratory factor analysis were compared using various loading factor sizes ranging from 0.3 to 0.6. The purpose of this strategy is to choose the appropriate exploratory factor analysis size based on both empirical and theoretical parallels to the study in order to carry out the research. When deciding whether or not to keep or discard an item as a result of the factor analysis results, the researcher considers a few items,

i) item that meet the principle presented in the study; ii) items with a significant loading factor but a low communality value; iii) items with a loading factor less than the size of a significant loading factor; iv) items that are heavy on two or more factors (cross-loading). The researcher considers items that are significant on two or more variables (Hair et al., 2019).

Following the exploratory factor analysis, an instrument reliability analysis is performed. The degree of consistency between numerous measurements of a property is measured as reliability (Hair et al., 2019). To establish the degree of instrument reliability in the study, the researcher conducted a Cronbach Alpha reliability analysis. The approach, as well as methodologies often employed by other academics, can assist researchers in determining whether the measuring objects are the same. According to Hair et al. (2019), in order to determine the degree of inconsistency in the instrument that has been developed, two factors must be met; i) the Cronbach Alpha value exceeding 0.7; ii) the correlation between items with items surpassing the value of 0.3.

5.Results and Finding

An exploratory factor analysis was carried out by the researcher using the Principal Component Analysis method and the Varimax Rotation in analysis to define whether the instrument that had been constructed was valid or not. In the case of the items in Table 1, the kurtosis and skewness values were in the range of -1.00 and +1.0, indicating that the data was in accordance with the normality assumption (Hair et al., 2019).

Table 1. Analysis of standard deviation, mean, kurtosis & skewness

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

Kaiser-Meyer-Olkin (KMO) indicators were used to examine the data in this study, with values near one being indicative of factors that are both accurate and distinct (Tabachnick & Fidell, 2007). An exploratory factor analysis was performed to determine the significance of item validation in the self-efficacy construct. All of the goods have a KMO value of 0.714, indicating that they are acceptable in analysis. The Barlett test was similarly significant [$\chi^2=5125.821$], $p<.05$, indicating that the hypothesis that the correlation matrix was in the identity matrix was not correct was rejected. Initial findings showed that communality varied from 0.530 to 0.724, and that eigenvalues were found for three different indicators. Table 2 contains a detailed description of each item.

Table 2. Exploratory Factor Analysis of Data Study

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

D11	.802	.714
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The validation factor analysis findings were utilized to construct a Goodness-of-Fit model, which contained the statistical goodness-of-fit value, χ^2 , and the root mean square error of approximation (RMSEA). Model acceptance is indicated by RMSEA values less than 0.08, whereas model rejection is indicated by values greater than 0.10 in the RMSEA (Browne & Cudeck, 1992). In conjunction with the analysis, the Comparative Fit Index (CFI) and the Tucker-Lewis Goodness of Fit Index (TLGI) were utilised (TLI). When it comes to both indices, a value of greater than 0.90 is considered to be a reasonable result (Browne & Cudeck, 1992).

The fit model values in this study's instrument met the specified criteria after modification. Any items with a loading factor of less than 0.60 were discarded by the researcher. The following are the findings of CFA analysis:

Table 3. *Goodness of Fit Index of data study*

Statistic Fit	Explanation	Value
χ^2/df	Model vs. Saturated	1.879
GFI	Comparative Fit Index	0.760
RMSEA	Root Mean Square Error of Aproximation	0.690

The elements that have a loading factor of less than 0.40 are retained in the research instrument because they represent an edge (Rosna & Azlina, 2008). The chi-square correspondence indices of the model (Chi Square/df = 1.879, CFI = 0.821, GFI = 0.760, and RMSEA = 0.69) (Markus, 2012). This shows that the final model meets all the data analysis research's requirements. Subsequently, the degree of reliability of the questionnaire design was assessed using a reliability analysis utilising the Cronbach Alpha reliability technique.

Table 4. *Preliminary study data after adjustment subjected to exploratory factor analysis*

Item	Loading Factor	Factor	CR	AVE	Cronbach Aplha
D1	.530	Self-Efficacy Course	0.797	0.567	.789
D3	.678				
D4	.659				
D6	.724				
D7	.683				
D9	.701	Assessment	0.785	0.691	.774
D10	.713				
D5	.615	Future	0.769	0.699	.712
D11	.697				

Table 4 summarizes the Cronbach alpha factor loadings for the various subscales of self-efficacy, which range from 0.712 to 0.789. An alpha value of 0.70 is recommended by Awang (2018) to fulfill the Cronbach Alpha requirement. The construct validity for self-efficacy is in the ranges between 0.770 and 0.7970. This demonstrates that the self-efficacy components have fulfilled the criteria. The criteria must have a value of 0.60 or greater in order to satisfy the Construct Validity (CR) requirement (Awang, 2018).

Consequently, Average Variance Extracted (AVE) for items self-efficacy value varied from 0.56 to 0.69, indicating that it fulfills the requirements. Awang (2018) stated that the Average Variance Extracted (AVE) value should be less than 0.50 in order to be perceived acceptable for statistical analysis. In general, the validation factor analysis of constructs self-efficacy meets all of the requirements.

6. Discussion

The purpose of this study was to understanding the relationship between mathematics reasoning and self-efficacy among university students. The implementation of SEM was necessitated by the study purpose since it permits testing of conceptual assertions about the relationship between the constructs (Gürefe & Bakalım, 2018). On either hand, study finding that constructs of self-efficacy has a positive impact on mathematics reasoning achievement.

The direct effect of self-efficacy finding is relatively consistent with earlier study findings (Çelik & Koçak, 2018; Gürefe & Bakalım, 2018; May, 2009; Yin et al., 2020). To be more specific, the current finding that self-efficacy variable is linearly related with previous study and significant relationship self-efficacy in dimension of course self-efficacy (Mahasneh & Alwan, 2018; Sides & Cuevas, 2020), exam self-efficacy (Gürefe & Bakalım, 2018; Yin et al., 2020), and future self-efficacy (Blondeau & Awad, 2018; Çelik &

Koçak, 2018) toward mathematics reasoning performance. Therefore, mathematics reasoning assessments was assist undergraduate students with their understanding self-efficacy in university mathematics learning.

7. Implication and Suggestion

The studies on self-efficacy evaluation have significant contribution to mathematical reasoning. On either hand, there are findings that suggest that self-efficacy has a positive impact on mathematics reasoning achievement. Negative outcomes in mathematics reasoning achievement can be observed, particularly when the individual has low self-efficacy (Tak et al., 2021). The findings of the current study indicated that high self-efficacy has an impact on their mathematics reasoning performance. Thus, it can be suggested that the course learning outcomes be restructured or whether a new module be developed to gain the skills their self-regulation in order to improve their mathematics reasoning skills. It is also recommended that various mathematics thinking and problem-solving skills are applied for self-improvement in order to improve students' mathematical reasoning skills.

8. Conclusion

In this study, university students were asked to participate to produce a model about their own self-efficacy in the context of mathematical reasoning. On the premise of the exploration of exploratory elements, the variables of self-efficacy were split into three dimensions, namely self-efficacy in course; assessment; and future.

Except for the elimination of four items from the scale, all variables retain the characteristics of factors developed by research studies based on research concept and the perspectives of professional educators. Cronbach Alpha internal consistency reliability analysis revealed that the instrument that was constructed was highly reliable. The study found that the instrument created has strong psychometric properties and can be utilized by researchers to measure university students' self-efficacy in mathematical reasoning and reasoning abilities.

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