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Exploring Higher Education Students' Self-Efficacy: How Self-Efficacy Dimensions Influence Numeracy

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Abstract

Numeracy is associated with students' self-efficacy, and it is crucial to examine the elements affecting numeracy proficiency, particularly behavior, including self-efficacy. A lack of research amalgamates both dimensions, encompassing the reciprocal impacts and the impact of contextual factors like gender and educational background. This study seeks to ascertain the influence of mathematics self-efficacy aspects on numeracy among elementary school teacher education students in the Yogyakarta region. The sampling method employed was non-probability sampling, specifically utilizing a convenience sampling methodology with a sample size of 215. The data analysis employed Structural Equation Modeling – Partial Least Squares (SEM–PLS). This study identifies the "strength" dimension of self-efficacy in numeracy as the most influential factor affecting an individual's numeracy skills. Frequent exposure to consistent and relevant learning experiences enhances students' confidence in decision-making when confronted with numeracy challenges. The "strength" of students' mathematics self-efficacy can be affected by various aspects, such as pleasant learning experiences, social support, and achievements in solving mathematical obstacles. Students who frequently confront and successfully resolve mathematical issues experience increased confidence as they trust in their capacity to tackle analogous tasks in the future. If this conduct is consistently exhibited during the student's study period, the numeracy component may enhance and serve as a valuable resource for future teachers.

Keywords: mathematics self-efficacy; numeracy; higher education

Introduction

Numeracy is an essential skill that all individuals, even college students, must master. Students enrolled in the Elementary School Teacher Education Program (PGSD) must attain proficiency in numeracy since their future position as educators is crucial in developing foundational arithmetic skills in mathematics. Numeracy encompasses not only the capacity to count but also the comprehension, analysis, and application of mathematical concepts in daily life, including data-informed decision-making and problem-solving (PIAAC Numeracy Expert Group, 2009). Nonetheless, the findings of an international survey on numeracy assessments within the Programme for the -

International Assessment of Adult Competencies (PIAAC), conducted by the Organisation for Economic Co-operation and Development (OECD), reveal that Indonesia's numeracy skills remain below the global average.

An overview of numeracy competencies derived from data collected by Skills Matter: Subsequent findings from the Survey of Adult Skills conducted between 2014 and 2015 indicate that Indonesian individuals aged 16 to 65 possess numeracy skills that are below the average of 30 other participating nations. The outcomes of this examination were executed by PIAAC, a program dedicated to the evaluation and analysis of adult competencies. Indonesia's score of 210 significantly lags behind the average score of 263 among 34 countries (OECD, 2016). This signifies a significant difficulty in mathematics instruction, including at higher education levels.

The OECD claims that the numeracy framework is underpinned not just by mathematical skills and knowledge, encompassing confidence and attitudes, but also by behaviors and experiences associated with numeracy and global contextual awareness (OECD, 2009). An individual's beliefs and attitudes are intricately connected; beliefs are a fundamental aspect of self-efficacy. Self-efficacy is contingent upon an individual's confidence in their capabilities within particular contexts (Liu et al., 2022). Individuals with confidence in their capabilities typically exhibit elevated self-efficacy. An individual with self-confidence may surmount obstacles and do things effectively. Consequently, self-efficacy in mathematics is correlated with the ability to confront numeracy assessments (Salsabilah & Kurniasih, 2022; Tout et al., 2021). This relationship serves as a component that can affect an individual's response to numeracy questions.

Bandura's social cognitive theory underpins the comprehension of self-efficacy's significance in the learning process. Self-efficacy is considered a motivational characteristic that significantly influences academic achievement (Bandura, 1994). Understanding the variables that significantly impact self-efficacy in numeracy is crucial for developing more effective educational management and learning strategies. Bandura's theory posits that self-efficacy comprises three primary dimensions: magnitude, strength, and generality (Bandura, 1997). Magnitude indicates the perceived difficulty of a task that an individual believes they can do; strength indicates the degree to which that belief endures in the face of obstacles; and universality pertains to the applicability of that belief across diverse situations or contexts (Schunk & DiBenedetto, 2021).

By comprehending these three aspects, especially the roles of scale, strength, and generality, educators can create more effective learning strategies to enhance each component (Khageswar Bhati & Sethy, 2022). Educators can implement incremental challenges (magnitude), foster resilience in overcoming obstacles (strength), and promote the application of confidence across diverse learning environments (generality) (Liem et al., 2008).

The approach to learning that is undertaken can be one way to enhance students' self-efficacy regarding the skills they wish to improve (Ferdinand et al., 2024). The selection of strategies that support the development of self-efficacy in students is essential so that they can have a positive impact on their confidence in facing mathematical challenges in various situations.

There is a deficiency in exploratory studies that identify the specific characteristics that most significantly affect the enhancement of students' numeracy, especially in higher education within the Yogyakarta region. Theoretical and practical investigation underscores the significance of self-efficacy in facilitating successful mathematics learning (Ramadhani, 2020). Prior research predominantly emphasizes the overall effect of self-efficacy without distinctly isolating the effects of its three basic elements. Moreover, there remains a paucity of studies directly correlating those dimensions of self-efficacy with numeracy outcomes.

This study addresses the impact of mathematical self-efficacy on students' numeracy exam outcomes. Research delineating the specific characteristics of self-efficacy that most significantly influence numeracy skills, particularly among higher education students in areas such as Yogyakarta, remains scarce.

Understanding the situation of students is crucial for preparing human resources that will influence future generations (Alfa Agustina & Rahayuningsih, 2018). The expectation is that students, as prospective educators, will be better equipped to implement optimal adjustments in accordance with their advanced abilities (Clarke, 2024). This study seeks to examine the impact of mathematical self-efficacy on the numeracy skills of university students in the Yogyakarta region. The research findings are expected to provide valuable insights into the impact of mathematics self-efficacy on students' numeracy. In addition, these findings may inform the selection of strategies to enhance the quality of mathematics education at the higher education level.

The mathematics self-efficacy test performed on 215 early semester students across three universities in the Yogyakarta region revealed that the students' levels of mathematics self-efficacy were predominantly classified as low. These findings underscore the necessity of further investigating the dimensions of self-efficacy, specifically strength (confidence intensity), magnitude (perceived task difficulty), and generality (confidence application across contexts), to ascertain which dimension most profoundly influences numeracy test outcomes (Calaguas & Consunji, 2022). This comprehension is anticipated to facilitate a more comprehensive discourse regarding the elements that affect students' numeracy abilities.

The research aims to empirically evaluate the impact of each self-efficacy factor on the numeracy skills of early semester students in Yogyakarta. This project aims to discover the factors that most significantly influence numeracy and to investigate innovations in higher education, including ways for enhancing self-efficacy that can be incorporated into the learning process. This study's findings are expected to enhance the creation of more effective learning strategies aimed at enhancing students' self-efficacy and numeracy skills.

Research Methods

This research used a quantitative design to investigate the impact of self-efficacy on numeracy. A cross-sectional research approach was employed, facilitating data collection at a singular moment in time. This design effectively presents a concise summary of the correlation between self-efficacy and numeracy outcomes. This study aims to provide insights into the broader dimensions of self-efficacy on numeracy.

This research uses Partial Least Squares Structural Equation Modeling, utilizing SmartPLS software for data processing. PLS-SEM is a statistical method appropriate for examining intricate correlations in datasets, as it does not necessitate data normality and can accommodate multicollinearity. compared to conventional regression-based methods, PLS-SEM facilitates the concurrent estimate of both the measurement model, which delineates the link between latent variables and observed indicators, and the structural model. This research aims to explain the impact of each dimensions of self-efficacy on an individual's numeracy through the application of this method.

Participants

The population in this research consists of pre-elementary school teacher education students who are currently enrolled in universities in the Yogyakarta region. Having the criteria of being from an accredited superior university and currently in the early semesters (1 and 3). The sampling in this study uses random sampling, employing a convenience sampling approach. Samples/students who are ready, willing, and have received permission to participate in the research are included based on the convenience sampling approach, which considers ease of access, such as suitable schedules or approval from the course instructor involved.

Data collection in this study was conducted using a quantitative approach with instruments in the form of questionnaires and tests. The questionnaire was used to measure students' mathematical self-efficacy, which includes indicators of confidence in completing mathematical tasks, overcoming difficulties, and applying mathematics in life. Numeracy tests were administered to assess students' numeracy based on the PIAAC framework created by the OECD.

The data also included information on school background Senior High school (SH)/Vocational high school (VS) /Madrasah Aliyah High School (MAS) and gender to examine their relationship and influence on the variables of numeracy and self-efficacy. The entire data collection process was carried out according to standardized procedures to ensure the validity and reliability of the research results.

The Mathematics Self-Efficacy Questionnaire assesses students' mathematics self-efficacy, encompassing the aspects of magnitude, strength, and generality. According to Bandura's theory, self-efficacy can be assessed by a questionnaire that includes the dimensions of magnitude, strength, and generality (Bandura, 1997). The instrument employed in this study comprises statements formulated and utilized by Han and May in their research, rendering the self-efficacy under investigation relevant to the domain of mathematics learning (Han et al., 2015; May, 2009). Every item in the questionnaire has been validated, achieving a Cronbach’s alpha of 0.93.

The numeracy test instrument is designed with reference to the standards of student numeracy competence, covering aspects of conceptual understanding, problem-solving, and application in everyday contexts (Clarke, 2024).The data collection tool used to obtain students' numeracy is an essay-type question that refers to the numeracy

dimensions presented by PIAAC, including the mathematical content dimension that encompasses various concepts such as numbers, measurement, data, statistics, as well as geometry and spatial relationships. This dimension highlights the mathematical knowledge required to solve numerical problems. Second, the cognitive process dimension, which focuses on the ability to identify, interpret, analyze, and apply quantitative information to solve problems or make decisions. Each item of the numeracy statement has undergone a validation process with a Cronbach's alpha of 0.928. (Futri, 2022).

The demographic data presented here elucidates the features of the sample population, providing context for the analysis of the link between mathematical self-efficacy and numeracy.

Table 1
Sample Demographic Data

Item	**Category**	**Σ**	**Percent**
University	Universitas Negeri Yogyakarta	81	37,67%
	Universitas PGRI Yogyakarta	65	30,23%
	Universtas Sarjanawiyata Tamansiswa	69	32,10%
Total		215	100%
Gender	Woman	175	81,40%
	Man	40	18,6%
Total		215	100%
Background	HS	147	68,37%
	VS	42	19,54%
	MAS	26	12,09%
Total		215	100%

Source: Personal Document

Result

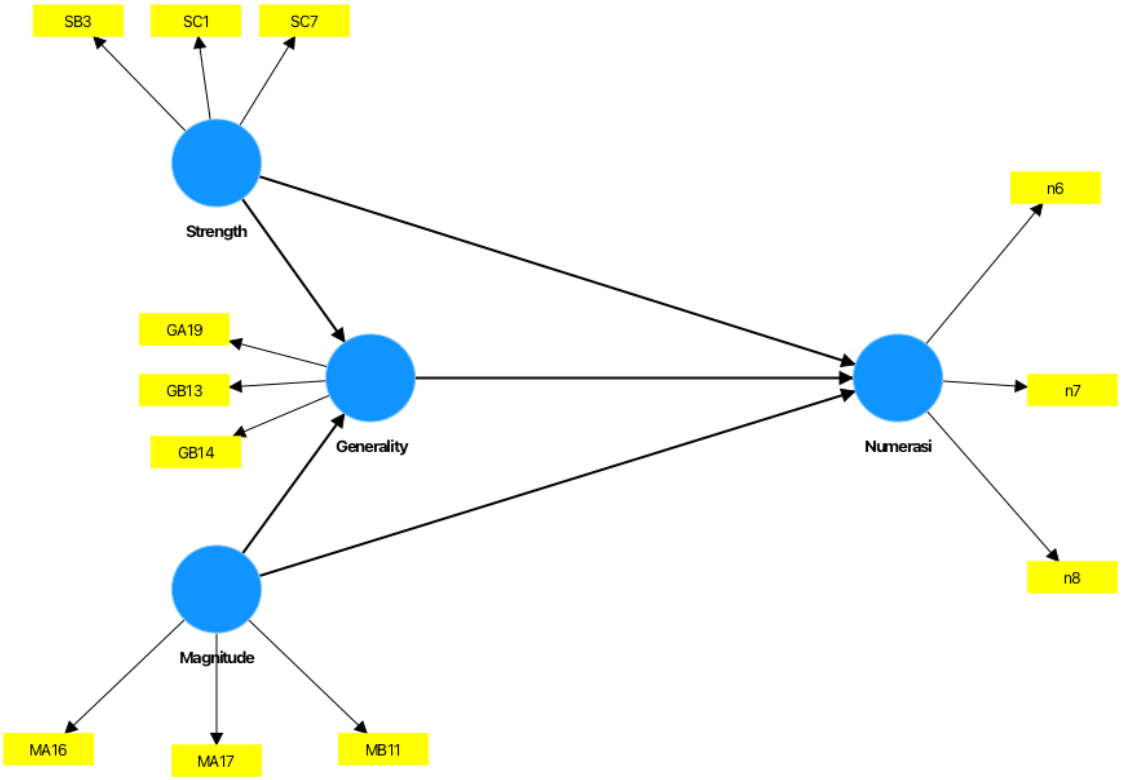

Figure 1
Research Model
Source: Personal Document

Figure 1 illustrates the research paradigm employed in this work, which seeks to ascertain the function of each dimension of the mathematical self-efficacy construct. Partial Least Squares is employed in this research due to the presence of latent variables that can be quantified by their indicators, enabling the author to conduct precise and comprehensive analyses (Sarstedt et al., 2024).

The final findings of this research belong to four theories, which include:

H1: The strength dimensions of self-efficacy considerably impact to improve of numeracy skills among students in elementary school teacher education programs.

H2: The magnitude dimensions of self-efficacy considerably impact to improve of numeracy skills among students in elementary school teacher education programs.

H3: The generality dimensions of self-efficacy modulate of the strength dimensions on the numeracy of elementary school teacher education students.

H4: The generality dimension of self-efficacy modulates of the magnitude dimension on the numeracy of elementary school teacher education students.

Evaluation Of The Measurement Model (Outer Model**)**

Before doing hypothesis testing in PLS-SEM, it is essential to assess data validity and dependability by initially evaluating the outer model. Assessment of the Measurement Model (Outer Model). The outer model delineates the link between latent variables and their indicators, defining how each indicator corresponds to its hidden variable. The examination performed on the outer model according with Ghozali & Latan (2015) include:

Convergent Validity

Convergent validity testing can be conducted by examining the outer loading values for each construct indicator. The expected outer loading value is above 0.7, but when the research is exploratory in nature, outer loading above 0.6 is still recommended for use. Convergent Validity measures the validity of reflective indicators as variable measures, which can be seen from the outer loading of each variable indicator. An indicator is said to have good reliability if its outer loading value is above 0.70.

Table 2
Outer Loading

Dimensions/Variabels	Indicator	Item	Outer Loading
SE – M	View On the Task	MA16	0.848
		MA17	0.883
	Learning Process	MB 11	0.859
SE – S	Facing Failure	SB3	0.855
	Study Persistence	SC1	0.864
		SC7	0.748
SE – G	Response To Context	GA19	0.761
	Problem Handling	GB13	0.783
		GB14	0.781
N	Numeracy	N6	0.640
	Numeracy	N7	0.878
	Numerasi	N8	0.722

Note:
1. SE – M : self efficaccy – magnitude
2. SE – S : self efficacy – strength
3. SE – G : self efficacy – generality
4. N : Numeracy

Source: Personal Document

The results shown in Table 2 illustrate that each variable has a good outer loading value, except for the numeracy item N6, which is still below 0.7. However, since this is an exploratory study, the data is still relevant to be considered in the analysis calculations.

Average Variance Extracted (AVE)

AVE is one of the tests to see the validity of a construct. To test the measurement model, discriminant validity is examined by looking at the cross-loading value. The measurement of AVE value must be greater than 0.50 for each item.

Table 3
Average Variance Extracted (AVE)

Dimensions/ Variabel	Indicator	Item	Ave
SE – M	View on the task	MA16	0.745
		MA17	
	Learning process	MB 11	
SE – S	facing failure	SB3	0.713
	study persistence	SC1	
		SC7	
SE – G	Response to context	GA19	0.600
	Problem handling	GB13	
		GB14	
N	Numeracy	N6	0.567
	Numeracy	N7	
	Numeracy	N8	

Source: Personal Document

The results presented in table 3 suggest each variable possesses an AVE value exceeding 0.5, thus effectively completing the criteria.

Discriminant validity

Discriminant validity testing can be conducted by comparing cross-loading values. A correlation can be said to meet convergent validity if it has a crossloading value of < 0.7. The output shows that the cross loading provides a value above the recommended value, which is 0.7. Thus, the indicators used in this study have met the convergent validity.

Table 4
Cross loading

	SE – G	**SE – M**	**N**	**SE – S**
GA19	0.761	0.500	0.048	0.335
GB13	0.783	0.634	0.090	0.536
GB14	0.781	0.389	0.067	0.376
MA16	0.561	0.848	0.043	0.475
MA17	0.624	0.883	0.158	0.592
MB11	0.570	0.859	0.083	0.605
SB3	0.425	0.500	0.170	0.855
SC1	0.453	0.526	0.145	0.864
SC7	0.515	0.599	0.221	0.813
N6	0.033	0.013	0.640	0.091
N7	0.101	0.117	0.878	0.225
N8	0.048	0.095	0.722	0.127

Source: Personal Document

Table 4 demonstrates that each indicator shows the highest loading value for its corresponding latent variable when assessed with indications for other variables. Another approach to evaluate discriminant validity is to compare the square root of the average variance retrieved for each construct with the correlation between that construct and other constructs within the model.

Table 5
Value of the AVE Root

	SE – G	**SE – M**	**N**	**SE – S**
SE – G	0.775			
SE – M	0.679	0.863		
N	0.091	0.112	0.753	
SE – S	0.555	0.647	0.215	0.844

Source: Personal Document

Table 6
Value AVE dan AVE Root

Dimensi/variabel	**AVE**	**Root AVE**
SE – G	0.745	0.775
SE – M	0.713	0.863
N	0.600	0.753
SE – S	0.567	0.844

Source: Personal Document

From tables 5 and 6 above, it can be seen that the AVE root value is greater than the correlation values between constructs. If the AVE root value is greater than the correlation between a construct and other constructs in the model, it can be said that the discriminant validity value is met.

Table 6 above has shown that the square root of the AVE value is higher than the correlation value. For example, the SE – G construct has an AVE value of 0.745 and an AVE root of 0.775.

Based on these values, it can be concluded that the SE – G variable has a good level of discriminant validity and is declared valid. The same applies to the other variables, so it can be stated that all variables in this study have a sufficiently high level of discriminant validity.

Cronbach's Alpha and Composite Reliability

The reliability test is validated by Cronbach's alpha, indicating that a coefficient greater than 0.7 signifies that the questions or the concept is reliable. Nonetheless, if the Cronbach's alpha coefficient exceeds 0.6, the data remains pertinent for application. When Cronbach's Alpha is less than 0.6, the questions are deemed untrustworthy.

Composite dependability is employed to assess the reliability of a construct. The optimal value for composite reliability is 0.7. A composite reliability number exceeding 0.7 is deemed to indicate good reliability.

According to Table 7, the Cronbach's alpha values for two variables above 0.70; nevertheless, two additional variables with values below 0.70 may still be utilized due to the exploratory nature of this research.

Table 7
Croncbach Alpha dan Composite

Dimensi/ variabel	Indicator	Item	Cronbach Alpha	Composite Reliability
SE – M	View on the task	MA16	0.829	0.898
		MA17		
	Learning process	MB 11		
SE – S	facing failure	SB3	0.800	0.882
	study persistence	SC1		
		SC7		

SE – G	Response to context	GA19	0.679	0.818
	Problem handling	GB13		
		GB14		
Numeracy	Numeracy	N6	0.647	0.794
	Numeracy	N7		
	Numeracy	N8		

Source: Personal Document

The first assessment of the data's validity and reliability has been completed, confirming that the elements in the study analysis model are valid and reliable.

Evaluation Of The Structural Model (Inner Model)

The next stage is the structural model test (Inner Model) which aims to ensure that the developed model is appropriate and accurate. This testing is conducted by first performing a multicollinearity test, then testing the path coefficient by examining the P value, followed by observing the direct influence from the dimension to the latent variable (numerical) by looking at the f square value, and finally examining the mediation effect when there is a coefficient of determination (R^2), which indicates how well the independent variable explains the dependent variable (Hair Jr. et al., 2021).

To determine whether the hypothesis is accepted or rejected, an analysis of the p-value significance is required. Estimating measurements and standard errors in this method is no longer based on traditional statistical assumptions but on empirical observations through bootstrapping techniques. In this study, the hypothesis is considered accepted if the p-value < 0.05, whereas if the p-value > 0.05, the hypothesis is stated to be rejected.

Multicollinearity Test

The multicollinearity test can be conducted by examining the inner VIF value, with the criterion being inner VIF < 5.

Table 8
Multicollinearity Test

	SE – G	**SE – M**	**N**	**SE – S**
SE – G			1.938	
SE – M	1.721		2.309	
N				
SE – S	1.721		1.798	

Source: Personal Document

Based on table 8 Shows inner VIF < 5, then passes the multicollinearity test.

Significance Path Coefficient Test

Test the significance of the path coefficient by looking at the p-value; if the p-value < 0.05, it can be said to be significant/having an effect.

Table 9
Path Coefficient Complete

Hypothesis	Path Coefficient	p-value	95% Interval Path coefficient		f square
			2.5%	97.5%	
M → G	0.551	0.000	0.411	0.687	0.342
S → G	0.198	0.006	0.050	0.338	0.044
M → N	-0.032	0.779	-0.243	0.209	0.0
S → N	0.251	0.008	0.057	0.431	0.037
G → N	-0.026	0.790	-0.212	0.170	0.0

Source: Personal Document

Based on the results of Table 9 show that the only significant hypotheses are SE – M to SE – G, SE – S to SE – G, and SE – S to N, which means hypotheses 2 and 5 are rejected.

Moreover, the observation results on the p-value in the gender background category almost entirely do not differ significantly. However, the "strength dimension" of the male gender has a significance of 0.004.

The direct influence can be seen based on the f-square value, which is classified as follows: (0.02 low), (0.15 moderate), and (0.35 high).

Mediation Effects

The mediation effect in this research analysis can be reviewed through the p-value of the specific indirect effect. It is considered significant if the p-value <0.05.

Table 10
Specific Indirect Effect

	p-value
M → G → N	0.704
S → G → N	0.754

Source: Personal Document

In the sense that the hypothesis regarding the mediation of generality in numeracy is rejected. (not significantly influential).

R-Square

R-Square (R^2) in SmartPLS is a measure that indicates how much the independent variables can explain the dependent variable in the research model. In other words, R^2

shows the quantity of variance in the dependent variable explained by the independent variables, with the criteria: 0.19 (low),0.33 (moderate), 0.67 (high) (Chin, 1998).

Table 11
R-Square

	R-square
Generality	0.484
Numeracy	0.048

Source: Personal Document

The R-Square value for Generality, as indicated in Table 11, is 0.484. This number signifies that 48.4% of the variance in generality may be explained by strength and magnitude. The R-squared value for the numeracy variable is 0.048. The figure indicates that numeracy can be elucidated by each factor of self-efficacy by 4.8%.

Discussion

The data obtained in this study are the results of numeracy tests and the completion of Google Form questionnaires by 215 students of elementary school teacher education. This is consistent with what is shown in Table 1. The sample in this study was drawn from three universities in the Yogyakarta region.

The strength dimension in self-efficacy has a significant influence on the numeracy of elementary school teacher education students. The path coefficient results for the influence of the strength dimension on numeracy were obtained from a parameter coefficient of 0.251 with a p-value of 0.008, below the test criteria, indicating a significant influence. The strength or "dimension of strength" in mathematical self-efficacy in this study indicates that students who have strong confidence in their own mathematical abilities tend to face mathematical challenges with confidence, which ultimately can improve their performance in completing numeracy tests. In line with previous research, which has shown that students' confidence in their own abilities can influence their learning outcomes in mathematics (Ardi et al., 2019; Zhu & Meyer, 2022), It is shaped by the cultural setting and the educational framework within the learning environment.

The dimension of magnitude in self-efficacy does not significantly affect the improvement of numeracy among elementary school teacher education students. Based on the p-value magnitude in numeracy, which is 0.770, this result may occur due to the lack of positive response to self-confidence in completing more difficult tasks. In line

with previous research, the role of "magnitude" will provide a positive response to the level of task difficulty, indicating that students have an accurate assessment of the difficulty level of math tasks, whether easy or difficult (Siregar et al., 2023).

The general dimension of self-efficacy does not significantly impact the "magnitude" or "strength" of numeracy progress among higher education students. Considered in light of the p-values of 0.704 and 0.754. This suggests that students' confidence in utilizing numeracy exams across different contexts does not enhance the correlation between task difficulty (magnitude) or confidence intensity and numeracy proficiency. The findings suggest that task-specific self-efficacy in addressing specific numeracy tasks is more influential than overall self-efficacy. A person's self-assurance in their skills is contingent upon their comprehension of their competencies within a particular context that encompasses a wider and more varied range (Hanifah et al., 2021; Wardono et al., 2024). In this situation, students may have robust ideas in specific contexts; nevertheless, these beliefs are not extended to other numeracy scenarios, indicating that generality does not influence the relationship between "magnitude" and numeracy or "strength" and numeracy.

Students usually can handle easy to moderately challenging problems; nevertheless, when confronted with very complex questions, this confidence fails to enhance general numeracy, rendering the difficulty level insignificant in influencing test outcomes (Manlapaz et al., 2024). Similar generality represents the expression of beliefs across many circumstances. When generality is not a strong mediator, it suggests that confidence in certain tasks' "magnitude" and the intensity of belief "strength" do not adequately transfer across diverse settings to influence numeracy.

Enhancing student numeracy requires a targeted strategy that fosters self-efficacy in specific numeracy problems rather than depending on generic confidence. For solutions, the application may involve progressive practice with tasks of differing complexities (Yuttachai et al., 2024). Students can be assigned numeracy questions that progress from simple to complex levels, accompanied by immediate constructive comments from the educator. This analysis included moderation based on gender and educational background; nonetheless, the results did not reveal any significant differences. The discussion depends mostly on the collected data.

This study has multiple limitations requiring consideration. The sample in this study is confined to higher education students from one specific program. Hence, the conclusions may not be applicable to students from other fields or educational levels. This study has not examined additional elements that may affect numeracy skills, such as social support or the learning methodologies employed with students, despite the comprehensive testing of self-efficacy facets.

Conclusion

Based on the research that has been conducted, the results of the empirical analysis state that the component of mathematical self-efficacy dimensions strength" towards the numeracy of elementary school teacher education students has a p-value of 0.008, but the components of self-efficacy magnitude and generality do not have a significant effect on numeracy. This result can be interpreted as the "strength" of the dimensions of mathematical self-efficacy, which is an important role to be developed in activities that support this, such as giving assignments to students so that they can be confident in solving numeracy or mathematical problems.

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