Jurnal Penelitian dan Evaluasi Pendidikan
Volume 29, No. 2, December 2025 (228-239)
Online: http://journal.uny.ac.id/index.php/jpep

The academic self-efficacy scale in mathematics using Confirmatory Factor Analysis (CFA)

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ARTICLE INFO

Article History
Submitted:
20 June 2025
Revised:
2 December 2025
Accepted:
23 December 2025

Keywords
confirmatory factor analysis; reliability; self-efficacy; validity

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ABSTRACT

The development of an academic self-efficacy instrument is considered necessary for one's ability to manage and complete a series of actions required to accomplish a task. This study aims to develop and test the validity and reliability of the self-efficacy instrument, specifically the Academic Self-Efficacy Questionnaire, comprising 15 items across three dimensions, each with five indicators. The research method in this study involved developing an instrument in six stages. Participation in this study consisted of 203 junior high school and *Madrasah Tsanawiyah* (MTs) students. Participation was spread across 51 students (25.1%) in Grade VII, 100 students (49.3%) in Grade VIII, and 52 students (25.6%) in Grade IX. Based on the analysis results, it was found that the 15 items developed were fit because they met eight model fit criteria, including Chi-square = 90.45 < 2df (df = 79), p-value = 0.17802 (≥ 0.05), RMSEA= 0.027 (≤ 0.05), NFI = 0.99 (≥ 0.9), CFI = 1 (≥ 0.9), IFI = 1 (≥ 0.9), GFI = 0.94 (≥ 0.9), AGFI = 0.91 (≥ 0.9), PGFI = 0.62 (≥ 0.6), NNFI = 1.00 (≥ 0.9). Thus, the questionnaire developed is in accordance with the planned dimensions, which reflect the variable of self-efficacy in a valid, reliable, and significant manner, supported by behavioural indicators for each dimension. Therefore, this instrument can be used for further measurement.

To cite this article (in APA style):
Nu'man, M., Putri, D. A., & Nafisah, F. D. (2025). The academic self-efficacy scale in mathematics using Confirmatory Factor Analysis (CFA). *Jurnal Penelitian dan Evaluasi Pendidikan*, *29*(2), 228-239. https://doi.org/10.21831/pep.v29i2.87347

INTRODUCTION

Self-efficacy is an essential factor that influences students' readiness and success in learning. According to Bandura (1977), self-efficacy refers to an individual's belief in their ability to achieve specific goals. Individuals with high self-efficacy are generally more persistent, less easily influenced by obstacles, and able to bounce back after failure (Fismasari et al., 2025). Those with low self-efficacy tend to doubt themselves quickly and give up easily. Self-efficacy also influences academic achievement, career, social relationships, and mental health (Mujanah, 2020). In learning, academic self-confidence helps students choose the right strategies and increase perseverance (Schunk, 1991; Zimmerman, 2000). Based on these findings, researchers concluded that self-efficacy is a crucial element that must be considered in efforts to enhance the effectiveness of the learning process and improve student academic outcomes.

Self-efficacy plays a crucial role in learning mathematics, a subject often perceived as challenging. Students with high self-efficacy tend to be more effective in solving complex mathematical problems (Krawitz et al., 2025; Suciati et al., 2022; Zhao & Ma, 2025). Bandura (1977) classifies self-efficacy into three dimensions: task difficulty level (magnitude), strength of belief (strength), and generality (generality). Pajares and Miller (1994) define mathematical self-efficacy as a student's belief in their ability to master mathematical concepts and skills. Usher

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and Pajares (2006) emphasise that mathematical self-efficacy is a student's belief in their ability to master concepts and solve mathematical problems. Therefore, strengthening mathematical self-efficacy is an essential aspect in helping students become more confident and effective in tackling mathematical tasks.

Valid and reliable measurement of academic self-efficacy in mathematics is crucial to obtain an accurate representation of student beliefs and design effective learning interventions (Andayani & Madani, 2023; Kampmane, 2025; Meza & González, 2020; Nurhasanah et al., 2025). Recent research indicates that self-efficacy plays a crucial role in academic success. In the context of biology, the university developed a learning strategy self-efficacy instrument that proved to be psychometrically valid and stable (Wang et al., 2023). Wijaya (2024) found that low self-efficacy among final-year students led to decreased motivation, increased anxiety, and a lack of confidence in completing academic tasks, which, in turn, affected their performance. In the context of mathematics, it was found that high school students' self-efficacy was moderate and varied across groups, although it was not significantly correlated with problem-solving (Baiduri & Usmiyatun, 2025). Research by Vogelsanger et al. (2025) shows that self-efficacy is strongly related to mathematical modelling abilities. Students who are more confident in their abilities tend to have clearer and more focused plans.

Based on the above research, no study has specifically examined self-efficacy among junior high school students in Indonesia, particularly in mathematics learning, using *Confirmatory Factor Analysis* (CFA). Previous studies have primarily focused on measuring self-efficacy at higher levels of education, such as high school/vocational school and college, leaving self-efficacy among junior high school students relatively unexplored.

Although the concept of self-efficacy has been extensively researched, this study focuses on the construct validity of the academic self-efficacy measurement scale, specifically designed for mathematics. The CFA approach was employed to assess the factor model's suitability using empirical data, thereby ensuring that each indicator accurately represented the dimensions of academic self-efficacy being measured (magnitude, strength, and generality). Therefore, this study aims to analyse the construct validity of the academic self-efficacy instrument in mathematics using CFA. The results of this study are expected to provide practical contributions by offering valid and reliable measurement instruments that educators can use to identify student needs and design more effective learning interventions, particularly to enhance motivation and achievement in mathematics.

RESEARCH METHOD

The development of the academic self-efficacy scale instrument was carried out by following the steps proposed by Caroline et al. (2025) namely, stage 1: establishing the conceptual framework of the instrument and its objectives, stage 2: construction and organisation of items and instrument structure, stage 3: selecting expert validators, stage 4: content validation by experts and revision based on expert input, stage 5: instrument testing and construct validation, and stage 6: final questionnaire.

The Stage of Establishing the Conceptual Framework of the Instrument and Objectives

The instrument produced was an academic self-efficacy questionnaire. The questionnaire consisted of 15 statement items with five answer choices: Always (O), Often (P), Sometimes (Q), Once (R), and Never (S). The conceptual framework of self-efficacy, as outlined by Bandura (1977), comprises three main dimensions: magnitude, strength, and generality. In addition, according to Suherman (2024), three aspects of self-efficacy namely level, generality, and strength. The conceptual framework of self-efficacy is then used as a construction basis, an

ISSN (print) 2685-7111 | ISSN (online) 2338-6061

10.21831/pep.v29i2.87347

indicator based on Nielsen et al., (2017) and Zyl et al. (2022): (1) being confident in their ability to complete specific tasks, (2) being confident in their ability to motivate themselves to take the necessary actions to complete tasks, (3) being confident in their ability to work hard, persistently, and diligently, (4) being confident in their ability to face obstacles and difficulties, and (5) being confident in their ability to complete tasks that are broad or narrow (specific) in scope.

The Stage of Construction and Organisation of Items and Instrument Structure

Five indicators, organised into three dimensions, are presented in Table 1.

Table 1. Result of Self-Efficacy Synthesis Indicator and Item

No.	Dimension	Indicator	Item	Code
1.	Magnitude	Confident in completing tasks (A)	Completing problems	A1
			Trying one is best	A2
			Completing tasks on time	A3
		Confident in motivating others to take action to complete tasks (B)	Enthusiasm for learning	B1
			Daring to ask questions and discuss	B2
			Initiative in facing difficulties	B3
2.	Strength	Confident in one's ability to work hard, persistently, and diligently (C)	Always trying	C1
			Consistent hard work and practice	C2
			Optimism in learning	C3
		Confident in one's ability to overcome obstacles and difficulties (D)	Awareness of time constraints	D1
			Calmness and willingness to try	D2
			Courage in facing heavy workloads	D3
3.	Generality	Confident in solving problems in various situations (E)	Time management	E1
			Resilience in facing heavy workloads	E2
			Self-confidence	E3

The Stage of Selecting Expert Validators

The next stage was expert content validation. The self-efficacy questionnaire scale was validated by six experts, all of whom were mathematics teachers and lecturers.

Content Validation By Experts and Revision Based on Expert Input

Validity is a measure that indicates the level of validity of an instrument. According to Fontana et al. (2015), instrument validity questions the extent to which measurements accurately measure what they are intended to measure. Validators evaluate questionnaires based on three dimensions: presentation, suitability of indicators with statements, and language. All items are considered valid, as evidenced by Aiken's V coefficient values equation ≥ 0.80 with six validators. In addition to conducting assessments, experts also provided suggestions on several items they considered to have shortcomings in word choice. The revision results included "I often ask questions and discuss when I encounter difficulties in solving mathematical problems" to "I dare to ask questions and discuss when I encounter difficulties in solving mathematical problems".

Instrument Testing and Construct Validation Stage

The trial used Google Forms to distribute questionnaires to students, facilitating data collection and analysis (Hamad et al., 2022; Pimthong & Williams, 2020). Participation in this study consisted of 203 *Madrasah Tsanawiyah* (MTs) students located in Indonesia. Participation was selected randomly using a sampling method. The participants were distributed across grade VII (51 students, 25.1%), grade VIII (100 students, 49.3%), and grade IX (52 students, 25.6%).

ISSN (print) 2685-7111 | ISSN (online) 2338-6061

10.21831/pep.v29i2.87347

The validity and reliability of the indicator (item) constructs for the latent constructs were tested using CFA. CFA is a widely trusted analytical approach for assessing the construct validity of a measuring instrument, particularly in psychology, education, and the social sciences (Umar & Nisa, 2020). The instrument's validity and reliability were assessed using CFA.

According to Hair et al. (2014), CFA is conducted not only through construct validity testing but also through Construct Reliability (CR) testing, because it aims to test the load factor (> 0.5) and t-count (> 1.96). In this regard, Chin and Newsted (1998) and Nu'man et al. (2021) believe that loading factor values ≥ 0.5 are acceptable, while loading factor values below ≤ 0.5 can be excluded from the model. Regarding reliability, Fornell and Larcker (1981) state that a construct has good reliability if its CR value is ≥ 0.70 and its variance extracted (VE) value is ≥ 0.50. The reliability value of this construct can be calculated using Formula (1) (Hair et al., 2014; Retnawati, 2016), while the variance extraction value uses Formula (2) (Hair et al., 2014), in which CR = Construct Reliability, VE = Variance Extracted, SLF = Each item's standard loading factor value, and E = Each item's error value. The data obtained were then analysed using CFA with LISREL version 8.80.

$$CR = \frac{(\sum SLF)^2}{(\sum SLF)^2 + (\sum e)} \quad \text{..... (1)}$$

$$VE = \frac{\sum SLF^2}{\sum SLF^2 + (\sum e)} \quad \text{..... (2)}$$

Final Survey Stage

The final item selection stage is carried out by taking items with loading factor values below ≥ 0.5 and the CR value is ≥ 0.70, and the variance extracted (VE) value is ≥ 0.50.

FINDINGS AND DISCUSSION

Findings

The researchers conducted a CFA to assess the validity and suitability of a proposed model construct. The variables used in this study are self-efficacy variables which consist of five indicators, namely Magnitude: being confident that they can complete specific tasks, Magnitude: convinced that they can motivate themselves to take the actions needed to complete the task, Strength: believing that he can try hard, persevere and persevere, Strength: believing that he can face obstacles and difficulties, Generality: thinking he can complete tasks that have a broad or narrow (specific) size. Each self-efficacy construct consists of several items. The CFA test was conducted on data totalling 203, and the analysis was performed using LISREL version 8.80. The results of the CFA analysis are presented in Figure 1.

First, the researchers tested the model generated in the CFA analysis. Based on Figure 1, the model does not fit because it has not met the specified criteria, including a Chi-Square value of 257.98 > 2df (df = 85), a p-value of 0.00000 < 0.05, and an RMSEA value of 0.100 < 0.08.

Next, the modification index must be revealed to obtain suggestions for improving the model. In Figure 2, item statement C2 ('With hard work and consistent practice, I am confident that I can understand the Equation System material well') seems similar to item statement E2 ('despite many tasks, I am confident that I can still complete the Equation System material') on the generality dimension: confident that I can solve problems in various situations (E).

Based on Table 2, the Chi-square value is 90.45 < 2df (df = 79), p-value = 0.17802 > 0.05 (suitable), and RMSEA = 0.027 < 0.08. Overall, the LISREL output shows the GOF (Goodness of Fit) values in Table 2.

ISSN (print) 2685-7111 | ISSN (online) 2338-6061

10.21831/pep.v29i2.87347

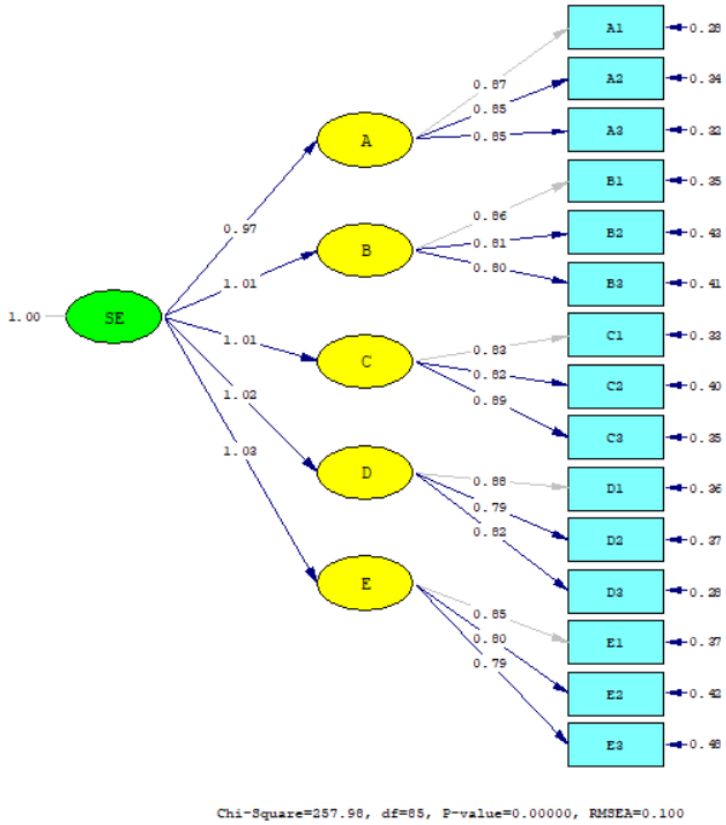

Figure 1. CFA Output (Standardised Solution)

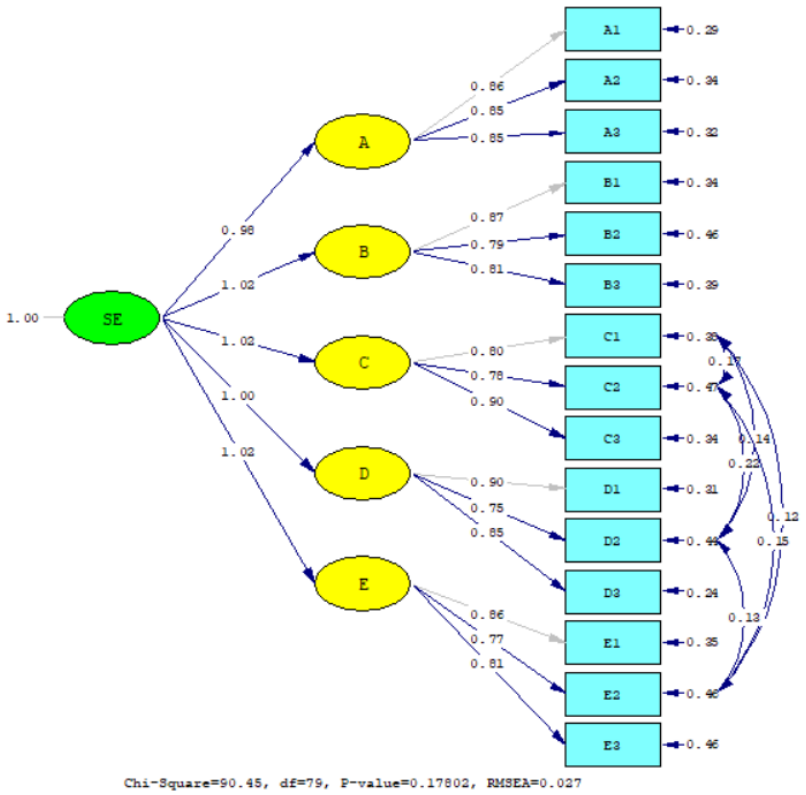

Figure 2. CFA Modification Output (Standardised Solution)

ISSN (print) 2685-7111 | ISSN (online) 2338-6061

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Table 2. Goodness of Fit of the CFA Model

Number	GOF Indicator	Acceptable Index	Model Index	Explanation
1	Chi-Square	$two < 2$ df	$two 90.45 < 2(79)$	Good Fit
2	Probability (p-value)	≥ 0.05	0.17802	Good Fit
3	RMSEA (Root Mean Square Error of Approximation)	≤ 0.08	0.027	Good Fit
4	RMSR (Root Mean Square Residual)	≤ 0.5	0.027	Good Fit
5	NFI (Normed Fit Index)	≥ 0.9	0.99	Good Fit
6	CFI (Comparative Fit Index)	≥ 0.9	1.00	Good Fit
7	IFI (Incremental Fit Index)	≥ 0.9	1.00	Good Fit
8	GFI (Goodness of Fit Index)	≥ 0.9	0.94	Good Fit
9	AGFI (Adjusted Goodness of Fit Index)	≥ 0.9	0.91	Good Fit
10	PGFI (Parsimony Goodness of Fit Index)	≥ 0.6	0.62	Good Fit
11	NNFI (Non-Normed Fit Index)	≥ 0.9	1.00	Good Fit

Table 2 shows that all indicators meet the criteria for good model fit, indicating that the model is valid or "fit." Then, based on the analysis results, Table 3 shows that the CFA output in the standardized solution indicates that all indicators have a loading factor ≥ 0.40, namely 0.98 for indicator A, 1.02 for indicator B, 1.02 for indicator C, 1.00 for indicator D, and 10.2 for indicator E. Thus, it can be said that the five indicators are valid for describing the academic self-efficacy model.

The following analysis examined the construct validity of each academic self-efficacy item. CFA analysis was performed from the latent dimension construct to the indicators mentioned in Table 4. An item was accepted if its factor loading was > 0.5. Table 4 shows that the factor loadings of the 15 items are > 0.7, where construct E2 has the lowest factor loading of 0.77 and constructs C3 and D1 have the highest factor loadings of 0.90. High factor loading values indicate that the developed items are closely related to the hypothesised latent constructs, namely magnitude, strength, and generality.

Table 3. Analysis results of the 2nd Order CFA Construct Validity of SRL (Latent-Aspect)

No.	Dimension	Indicator	Loading Factor	t-Value	Remark
1.	Magnitude	Confident in completing tasks (A)	0.98	14.48	Significant
		Confident in motivating others to take action to complete tasks (B)	1.02	14.86	Significant
2.	Strength	Confident in one's ability to work hard, persistently, and diligently (C)	1.02	13.80	Significant
		Confident in one's ability to overcome obstacles and difficulties (D)	1.00	15.12	Significant
3.	Generality	Confident in solving problems in various situations (E)	1.02	14.61	Significant

The next step is to check the reliability of the prepared academic self-efficacy instrument. Construct stability (CR) and Variance Extracted (VE) to assess the instrument's reliability. The results of CR and VE calculations are shown in Table 4. The self-efficacy instrument is reliable if all dimensions have CR and VE values ≥ 0.7 and ≥ 0.5, respectively. In Table 4, the CR values for the four dimensions of the self-efficacy instrument range from 0.70 to 0.90, indicating that they meet the minimum limit of 0.70. Dividing the root-mean-square loading factor by the number of indicators yields the VE, which indicates the ability of the latent variable values to represent the observed data. The greater the VE value, the better it explains the indicators' values in measuring latent variables. The analysis results in Table 4 show that the VE values for the four dimensions of self-efficacy range from 0.60 to 0.74, indicating that they meet the

ISSN (print) 2685-7111 | ISSN (online) 2338-6061

10.21831/pep.v29i2.87347

minimum VE criteria of 0.5. Thus, the five dimensions of academic self-efficacy are reliable and valid. The results also confirm that the instrument is highly consistent and can be used in various diverse samples.

Table 4. Self-efficacy, Academic Validity and Reliability from the CFA Results

Dimension	Indicator	Construct	Error Var	Std Loading	Validity Category	CR	VE	Reliability Category
Magnitude	Confident in completing tasks (A)	A1	0.29	0.86	Valid	0.83	0.70	Reliable
		A2	0.34	0.85	Valid			
		A3	0.32	0.85	Valid			
	Confident in motivating others to take action to complete tasks (B)	B1	0.34	0.87	Valid	0.77	0.63	Reliable
		B2	0.46	0.79	Valid			
		B3	0.39	0.81	Valid			
Strength	Confident in one's ability to work hard, persistently, and diligently (C)	C1	0.38	0.80	Valid	0.85	0.74	Reliable
		C2	0.47	0.78	Valid			
		C3	0.34	0.90	Valid			
	Confident in one's ability to overcome obstacles and difficulties (D)	D1	0.31	0.90	Valid	0.81	0.67	Reliable
		D2	0.44	0.75	Valid			
		D3	0.24	0.85	Valid			
Generality	Confident in solving problems in various situations (E)	E1	0.35	0.86	Valid	0.75	0.61	Reliable

Discussions

This study aims to empirically analyse the characteristics of academic self-efficacy of junior high school students using the CVA approach. The development of effective, user-friendly instruments is crucial for collecting accurate, reliable data in educational assessments (Liu et al., 2023). The instrument designed must undergo validation testing to ensure it accurately measures what it is intended to measure. In the validity test, input and suggestions are incorporated through revisions in accordance with expert statements. After revisions and refinements, the questionnaire is considered valid when the Aiken index is 0.8. (Aiken, 1985) and can be used for the next stage: field testing. The test was conducted on 203 junior high school and MTs students in Indonesia. Based on the analysis results, the 15 items developed were found to fit the model because they met the criteria. The criteria used were 11 criteria (Subando et al., 2023) with a Chi-square value of = 90.45 < 2df (df = 79), p-value = 0.17802 > 0.05 (acceptable), RMSEA 0.027 0.08, and Goodness of Fit Index (GFI) of 0.94 > 0.90 (Schermelleh-Engel et al., 2003). In general, the calculated values fall within the specified range, indicating that the Goodness of Fit (GFI) has been met and suggesting a good fit. As a result, the study demonstrates that the model is suitable, indicating that the instrument's construct is suitable and appropriate for this assessment model.

The second CFA test indicates that the five-dimensional self-efficacy model is likely to fit the data well. The test results show that the magnitude dimension, as reflected in the belief that it can complete the task, is represented by three measurement items: item A1, namely completing the problem, and item A2, namely trying the maximum. This finding aligns with Bandura's (1977) research, which found that self-efficacy beliefs are positively related to maximum effort in completing tasks. In addition, Mitchell et al. (2021) noted that high self-efficacy tends to lead to greater effort in academic studies (Azar, 2013). Regarding item A3, specifically completing assignments on time, these findings align with existing research. Students with higher self-efficacy tend to procrastinate less (Utaminingsih & Hermasari, 2024).

The second dimension is magnitude, with an indicator that can motivate themselves, which consists of three items that meet the expected validity and reliability criteria (B)—for item

ISSN (print) 2685-7111 | ISSN (online) 2338-6061

10.21831/pep.v29i2.87347

B1, namely looking for challenges so that the spirit of learning, B2, namely daring to ask questions, and B3, namely initiative in facing difficulties. These findings are based on the views expressed by Zhao and Ma (2025) that students with high self-efficacy tend to set challenging goals.

Furthermore, the third dimension is strength, which indicates that individuals can try hard, persevere, and persist in facing learning challenges (C), as reflected in three measurement items. Item C1 is always trying, item C2 is consistent hard work and practice questions, and item C3 is optimism in learning. The findings align with Pajares (1996) statement that children with high levels of self-confidence solve more problems correctly and redo more of the issues they miss, regardless of their ability level.

The fourth dimension is strength, with an indicator that measures the self's ability to withstand obstacles and difficulties (D), represented by three measurement items. Item D1 is resistance to processing time, item D2 is calm and trying to try, and item D3 is courage to face the task load. These findings align with research by Shengyao et al. (2024), which shows that students with higher levels of self-efficacy are better prepared to face challenges and engage in complex learning tasks.

The last, or fifth, dimension is the generality dimension, which indicates the belief that individuals can solve problems across various situations or contexts. This dimension is represented by three measurement items: E1, which measures time management; E2, which measures resilience in facing task loads; and E3, which measures self-confidence. According to Guslina (2023), high self-efficacy typically applies to specific, more challenging tasks.

The validity of the academic self-efficacy construct is supported by the fact that the model is based on Albert's theory. The experts who contributed to this study (Bandura, 1977; Nielsen et al., 2017; Zyl et al., 2022), reviewed all items for their relevance to one's ability to organise and carry out a series of actions necessary to complete a relatively stable set of tasks. The CFA results support the scale's construct validity because the model postulated by the theory is consistent with the data. The subscales are significantly correlated, indicating that the fifth dimension is related to the construct of one's ability to organise and carry out a series of actions necessary to complete mathematical tasks. There are three dimensions of self-efficacy consisting of five indicators. The first dimension is magnitude, which comprises two indicators: confidence in completing the task and confidence in motivating oneself to perform the actions necessary to complete it. The second dimension is strength, which consists of two indicators: confidence in one's ability to work hard, be persistent, and persevere, and confidence in one's ability to endure obstacles and difficulties. The third dimension is generality, indicated by confidence in solving problems across various situations.

The findings of this study have significant implications for mathematics teachers seeking to enhance their students' academic self-efficacy. Self-efficacy instruments that have been proven valid and reliable can be used by teachers as diagnostic tools to assess students' levels of self-confidence before and after learning. The use of these instruments enables teachers to identify students who require additional support, design more personalised learning strategies, and utilise the measurement results as part of formative assessment to evaluate the effectiveness of the learning process. Thus, these instruments serve as supporting tools in creating a learning environment that is more responsive and oriented towards students' needs, while encouraging their independence in solving mathematical problems.

However, this academic self-efficacy instrument still has several limitations in terms of construct coverage. In addition, this study used a sample limited to junior high school and MT's students in Indonesia. The instrument's focus remains at the level of general academic self-efficacy, thereby opening opportunities for further research to develop more specific instruments for particular fields of mathematics, such as geometry, algebra, or statistics. Future research could involve samples of elementary and high school students and could also consider other variables that contribute to students' academic self-efficacy.

ISSN (print) 2685-7111 | ISSN (online) 2338-6061

10.21831/pep.v29i2.87347

CONCLUSION

This study successfully developed and validated an academic self-efficacy instrument through Confirmatory Factor Analysis (CFA), resulting in a scale that is theoretically and empirically valid. This instrument comprises five indicators across three main dimensions: magnitude, strength, and generality, with all items meeting high validity and reliability criteria. These findings make a significant methodological contribution, especially in Indonesia, by providing a valid measurement instrument for self-efficacy grounded in Bandura's theory and demonstrating good model fit across various statistical indicators. Additionally, this instrument can be utilised by educators as a diagnostic tool in formative assessment to map students' self-confidence levels, design more adaptive learning interventions, and monitor student progress in the mathematics learning process. However, this study has limitations, particularly in its sample coverage, which included only junior high school/MTs students. Furthermore, the instrument's focus remains at the level of general academic self-efficacy, thereby opening the door for further research to develop more specific instruments for specific areas of mathematics, such as geometry, algebra, statistics, or data analysis and probability. Overall, the development of this instrument makes a significant contribution to educational evaluation practices, particularly regarding students' academic self-efficacy.

Conflict of Interests

The authors declare that they have no conflict of interest to disclose.

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