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STEM Self-Efficacy Among High-Achieving STEM Leavers: A Confirmatory Factor Analysis Validation Study

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ABSTRACT - STEM education plays a critical role in developing a skilled workforce, yet declining enrolment and high attrition rates remain persistent global concerns. Notably, STEM attrition is not limited to low-performing students, as high-achieving individuals may also leave STEM pathways despite meeting academic requirements. This study aimed to validate the measurement structure of STEM self-efficacy among high-achieving STEM-qualified students who transitioned out of the STEM stream. Grounded in Expectancy-Value Theory (EVT) and Social Cognitive Career Theory (SCCT), the study employed a quantitative cross-sectional design. Data were collected from 351 high-achieving STEM stream students who were academically eligible for STEM-related post-secondary programmes but enrolled in non-STEM foundation programmes across selected Malaysian public universities. The instrument comprised domain-specific measures of science, mathematics, and engineering self-efficacy adapted from established scales. Following a prior exploratory phase, Confirmatory Factor Analysis (CFA) using IBM SPSS AMOS 22.0 was employed to validate the measurement model. The findings supported a three-factor structure of STEM self-efficacy, with science, mathematics, and engineering self-efficacy emerging as distinct but related constructs. The measurement model demonstrated satisfactory fit, strong factor loadings, adequate convergent and discriminant validity, and high composite reliability. These results confirm that STEM self-efficacy is a multidimensional construct that varies across domains. Importantly, the findings suggest that high-achieving students may exhibit uneven confidence across STEM domains, which may influence their decision to leave STEM pathways. This study contributes to the literature by providing a validated instrument for measuring STEM self-efficacy among high-achieving STEM leavers and offers insights for designing targeted academic counselling, STEM pathway guidance, and early intervention to improve STEM retention.

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INTRODUCTION

STEM education plays a critical role in preparing students for a rapidly evolving, technology-driven world by fostering essential skills such as critical thinking, problem-solving, creativity, and adaptability (Doly, 2024; Suherman et al., 2025). It promotes STEM literacy through the integration of science, technology, engineering, and mathematics knowledge, enabling individuals to address complex societal and workplace challenges (Falloon et al., 2020; Tytler, 2020). STEM education is also associated with workforce readiness, innovation, and economic growth, contributing to broader developmental goals, including the Sustainable Development Goals (Doly et al., 2024; Jamali et al., 2022; Nhat et al., 2024). Consequently, increasing student participation in STEM has become a priority for many countries seeking to strengthen their future STEM workforce.

Despite its recognised importance, declining participation in STEM remains a global concern. Studies have reported lower-than-expected student interest and achievement in STEM despite substantial educational investments (Kayan-Fadlelmula, 2022). At the tertiary level, high attrition rates continue to be observed, with students leaving STEM programmes due to academic challenges, limited support systems, financial constraints, and concerns regarding teaching quality (Müller et al., 2024; Sithole et al., 2017). Furthermore, disparities in STEM participation persist across gender and geographic contexts, with unequal access to STEM opportunities contributing to differences in enrolment and retention (Saw & Agger, 2021; Witteveen & Attewell, 2020). These challenges have prompted researchers and policymakers to seek a better understanding of the factors influencing students' decisions to enter, remain in, or leave STEM pathways (Mohamad Marzuki et al., 2019).

The issue is particularly concerning in Malaysia, where declining participation in STEM is evident as early as the upper secondary level. Research has documented a reduction in student enrolment in STEM-related subjects, particularly Additional Mathematics, which serves as an important gateway to many STEM programmes (Chuan et al., 2021; Chuan et al., 2025). Factors such as academic performance, self-efficacy, gender, peer influence, socioeconomic background, limited instructional resources, insufficient teacher readiness in technology integration, and low awareness of STEM career opportunities have been identified as contributors to declining STEM participation (Chuan et al., 2021; Chuan et al., 2025; Huzir et al., 2025; Riduan & Othman, 2024; Yusof et al., 2025). Negative perceptions of STEM subjects as difficult and cognitively demanding further discourage students from pursuing STEM-related pathways (Yusof et al., 2025).

More importantly, evidence suggests that STEM attrition is not limited to students with poor academic performance. Yaacob et al. (2024) reported that many students who fulfil the academic requirements for STEM programmes nevertheless choose to enrol in non-STEM programmes at the post-secondary level. This phenomenon is particularly noteworthy because these students have already demonstrated their academic capability through strong performance in STEM-related subjects and are fully eligible to continue their studies in STEM fields. Their decision to leave the STEM pathway therefore cannot be adequately explained by academic ability alone. Understanding why academically qualified students voluntarily opt out of STEM is crucial, as their departure represents a loss of potential STEM talent and may undermine national efforts to strengthen STEM participation and workforce development.

The decision to pursue or leave STEM pathways is shaped by a complex interaction of cognitive, motivational, social, and contextual factors (Arif et al., 2019). Among these factors, self-efficacy has consistently emerged as one of the most influential predictors of students' educational choices, academic engagement, persistence, and achievement (van Aalderen-Smeets et al., 2019; van de Hurk et al., 2019). Self-efficacy refers to an individual's belief in their capability to successfully perform tasks and achieve desired outcomes. Students with strong STEM self-efficacy are generally more willing to engage with challenging STEM subjects, persist when encountering difficulties, and consider STEM-related educational and career pathways (Dorfman & Fortus, 2019). Conversely, students who doubt their capabilities may avoid STEM opportunities even when they possess the academic qualifications necessary for success.

Given the importance of self-efficacy in shaping STEM-related decisions, accurate measurement of this construct is essential. Although various self-efficacy instruments have been developed and applied in STEM education research, many were designed for general student populations or specific disciplinary contexts. Consequently, their suitability for assessing STEM self-efficacy among high-achieving

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students who voluntarily leave STEM pathways remains unclear. This group represents a unique population because their educational choices cannot be explained solely by academic achievement, suggesting that psychological factors such as self-efficacy may play an important role in their decision-making process.

Furthermore, while previous studies have examined factors associated with STEM participation and attrition, limited attention has been given to validating STEM self-efficacy instruments specifically for high-achieving STEM-qualified students who choose non-STEM educational pathways. The absence of a validated domain-specific instrument may limit researchers' ability to accurately investigate the role of self-efficacy in STEM attrition among this population. Establishing the validity and reliability of such an instrument is therefore a necessary step toward advancing research on STEM educational choices and attrition.

Accordingly, this study aims to validate a STEM self-efficacy instrument for use among high-achieving STEM-qualified students who choose not to continue in STEM educational pathways. By providing evidence of the instrument's psychometric properties, this study contributes to the development of robust measurement tools for future research and offers a stronger foundation for understanding the psychological factors underlying STEM attrition among academically capable students.

LITERATURE REVIEW

Students' decisions to pursue, persist in, or leave STEM pathways are influenced by a complex interaction of personal, cognitive, and contextual factors. Although personality traits such as openness to experience have been associated with greater interest in STEM fields, cognitive factors appear to play a more direct role when students make actual academic and career decisions (Coenen et al., 2021). Among these cognitive factors, self-efficacy has consistently emerged as one of the strongest predictors of STEM-related educational choices, persistence, and attrition (van Aalderen-Smeets et al., 2019; van de Hurk et al., 2019). However, understanding the role of self-efficacy in STEM attrition requires a broader theoretical perspective that integrates both motivational and career-development frameworks.

Expectancy-Value Theory and STEM Attrition

Expectancy-Value Theory (EVT) proposes that students' educational choices are influenced by their expectations for success and the value they attach to a task or domain. According to this theory, students are more likely to pursue and persist in activities when they believe they can succeed and perceive the activity as valuable (Eccles & Wigfield, 2020). Within STEM education, students who have strong confidence in their ability to perform STEM-related tasks are more likely to enrol in STEM programmes, remain engaged in STEM learning, and consider STEM-related careers. Conversely, students who doubt their ability to succeed may avoid STEM pathways despite possessing the academic qualifications required for success.

From an EVT perspective, self-efficacy contributes directly to students' expectations for success. Consequently, students with lower levels of STEM self-efficacy may perceive STEM subjects as overly difficult or beyond their capabilities, increasing the likelihood of programme switching or attrition. This perspective helps explain why some academically capable students choose to leave STEM pathways even when their prior academic achievement suggests they are well prepared for STEM-related study.

Social Cognitive Career Theory and STEM Attrition

While EVT explains how expectations for success influence educational decisions, Social Cognitive Career Theory (SCCT) provides a more comprehensive explanation of how self-efficacy shapes academic and career pathways. SCCT proposes that self-efficacy influences interests, outcome expectations, goals, and ultimately educational and career choices (Lent et al., 1994). According to this framework, students who believe they can successfully perform STEM-related tasks are more likely to develop positive interests in STEM, establish STEM-related goals, and persist when encountering challenges.

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Numerous studies have supported the central role of self-efficacy within SCCT. Higher levels of self-efficacy have been associated with stronger STEM interests, greater persistence, and increased likelihood of degree completion, whereas lower self-efficacy has been linked to higher dropout rates and programme switching (Aryee, 2019; Cabell, 2021). Furthermore, self-efficacy is strengthened through supportive learning environments, mentoring relationships, and positive academic experiences, which in turn increase students' intentions to remain in STEM pathways (Apriceno et al., 2020; Sachmpazidi et al., 2025).

Together, EVT and SCCT provide complementary explanations for STEM attrition. EVT emphasises the role of self-efficacy in shaping expectations for success, whereas SCCT explains how self-efficacy influences interests, goals, and persistence. Both theories suggest that students may leave STEM not solely because of academic inability, but because they perceive themselves as less capable of succeeding in STEM-related domains.

STEM Self-Efficacy as a Multidimensional Construct

Although self-efficacy is often discussed as a general psychological construct, Bandura (1997) argued that self-efficacy is inherently domain-specific and should be assessed within the context of particular tasks and activities. Consequently, students may possess high confidence in one academic domain while demonstrating lower confidence in another. This distinction is particularly important in STEM education because STEM encompasses multiple disciplines requiring different knowledge, skills, and problem-solving approaches.

Research has increasingly recognised STEM self-efficacy as a multidimensional construct rather than a single global belief. Students may demonstrate different levels of confidence in science, mathematics, and engineering activities, reflecting the unique demands of each domain (Baldwin et al., 1999; Kranzler & Pajares, 1997; Mamaril et al., 2016). For example, a student may feel highly confident in mathematical problem-solving yet report lower confidence in engineering design tasks or scientific investigations. Treating STEM self-efficacy as a unidimensional construct may therefore obscure important differences in students' perceptions of their capabilities across STEM domains.

The multidimensional nature of STEM self-efficacy is particularly relevant when examining STEM attrition among high-achieving students. Academic achievement alone may not fully capture students' confidence in performing science-, mathematics-, and engineering-related tasks. High-achieving students may demonstrate excellent academic performance while simultaneously experiencing lower confidence in specific STEM domains, leading them to reconsider STEM-related educational pathways. Studies have shown that psychosocial factors, including low self-efficacy and impostor feelings, can contribute to STEM attrition even among academically capable students (Bradford, 2020; Tao & Gloria, 2019). Similarly, gender differences in STEM self-efficacy have been observed despite comparable academic achievement, contributing to differential persistence rates in STEM fields (Pedersen & Nielsen, 2023).

Research Gap

Despite growing evidence supporting the importance of STEM self-efficacy in educational decision-making and persistence, relatively little attention has been given to validating multidimensional STEM self-efficacy instruments among high-achieving STEM-qualified students who subsequently choose non-STEM pathways. Existing studies have primarily focused on general student populations, current STEM students, or single STEM disciplines. Consequently, it remains unclear whether the multidimensional structure of STEM self-efficacy is appropriate for students who possess the academic qualifications for STEM study but voluntarily leave STEM pathways.

Given the central role of self-efficacy within EVT and SCCT, establishing a valid and reliable multidimensional measure of STEM self-efficacy is essential for understanding STEM attrition among academically capable students. Therefore, the present study seeks to validate a STEM self-efficacy instrument comprising science self-efficacy, mathematics self-efficacy, and engineering self-efficacy dimensions among high-achieving STEM-qualified students who choose non-STEM educational pathways.

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OBJECTIVE OF THE STUDIES

Given gaps in the literature, particularly the limited focus on high-achieving students who exit STEM pathways, this study aims to validate the measurement structure of STEM self-efficacy within this population. While previous research has extensively examined self-efficacy as a predictor of STEM persistence, there remains a lack of validated instruments that capture domain-specific self-efficacy among academically qualified students who choose to leave STEM.

Specifically, this study seeks to examine whether STEM self-efficacy can be reliably conceptualised as a multidimensional construct comprising science, mathematics, and engineering domains. Using Confirmatory Factor Analysis (CFA), the study aims to evaluate the construct validity, convergent validity, discriminant validity, and reliability of the measurement model. By establishing a robust, valid measurement structure, this study provides a foundation for subsequent analyses investigating the role of self-efficacy and other psychological factors in STEM attrition among high-achieving students.

METHODS AND MATERIALS

Research Design

This study employed a quantitative cross-sectional research design to examine the measurement properties of STEM self-efficacy among high-achieving students who transitioned out of the STEM stream. The primary objective was to validate the factor structure of a multidimensional STEM self-efficacy instrument using Confirmatory Factor Analysis (CFA) within a covariance-based structural equation modelling (CB-SEM) framework.

The validation of the instrument followed a two-stage process. In the first stage, Exploratory Factor Analysis (EFA) was conducted and reported in a previous study involving high-achieving STEM-qualified students who chose non-STEM educational pathways (Yaacob et al., 2024). The EFA identified a three-factor structure consisting of Science Self-Efficacy, Mathematics Self-Efficacy, and Engineering Self-Efficacy. The present study represents the second stage of the validation process and employed CFA to verify the stability and construct validity of the factor structure identified in the exploratory phase.

CB-SEM was selected because it is theory-driven and suitable for testing measurement models involving established latent constructs (Hair et al., 2019). The use of CFA allows for the assessment of construct validity, including unidimensionality, convergent validity, discriminant validity, and reliability, which are essential for validating psychological constructs in behavioural research.

Participants and Sampling

The target population comprised qualified STEM-stream students who had demonstrated academic eligibility to pursue STEM-related post-secondary programmes but subsequently enrolled in non-STEM foundation programmes.

Qualified students were operationally defined as those who obtained at least:

- Grade B in Mathematics; and
- Grade C in Additional Mathematics, Physics, Chemistry, and Biology in the SPM examination.

The sampling frame consisted of eligible students enrolled in foundation programmes at six Malaysian public universities: Universiti Teknologi MARA (UiTM), Universiti Malaya (UM), Universiti Sains Islam Malaysia (USIM), Universiti Pertahanan Nasional Malaysia (UPNM), Universiti Utara Malaysia (UUM), and International Islamic University Malaysia (IIUM). Based on institutional enrolment records, a total of 1,684 students fulfilled the eligibility criteria and formed the target population.

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A proportionate stratified sampling approach was employed to ensure that each participating university was represented according to its proportion within the overall population. The required sample size was determined based on Cohen's (1988) power analysis guidelines and recommendations for Structural Equation Modelling (SEM), which generally suggest a minimum sample size of between 150 and 200 respondents for models involving multiple latent constructs (Hair et al., 2016; Kline, 2015; Awang et al., 2018). To accommodate potential data loss during screening and cleaning procedures, an additional 20% buffer was incorporated (Kyriazos, 2018). Consequently, a target sample size of 377 respondents was established.

The proportional allocation of respondents across the six participating universities is presented in Table 1.

Table 1. Proportionate Allocation of Respondents Across Participating Universities

University	Population Size	Percentage (%)	Required Sample Size (n=313)	Sample Size + 20% Buffer
Universiti Teknologi MARA (UiTM)	534	31.7	100	120
International Islamic University Malaysia (IIUM)	752	44.6	140	168
Universiti Malaya (UM)	142	8.4	27	32
Universiti Pertahanan Nasional Malaysia (UPNM)	65	3.9	12	15
Universiti Utara Malaysia (UUM)	108	6.4	20	24
Universiti Sains Islam Malaysia (USIM)	83	4.9	15	18
Total	**1,684**	**100.0**	**314**	**377**

As shown in Table 1, the sample allocation reflected the relative contribution of each university to the overall population. Larger institutions, such as IIUM and UiTM, which together accounted for more than three-quarters of the eligible population, were allocated correspondingly larger sample sizes. Conversely, universities with smaller population proportions were assigned smaller sample quotas. This proportional allocation ensured that the sample adequately reflected the structure of the target population and reduced the likelihood of institutional over- or under-representation.

To operationalise the sampling procedure, separate Google Form links were created for each participating university. Responses were monitored continuously, and each survey link was deactivated once the targeted number of respondents for that institution had been reached. This procedure ensured adherence to the predetermined sampling quotas and maintained the integrity of the proportional sampling design.

A total of 377 questionnaires were returned. Following data screening procedures, including univariate and multivariate outlier analyses, 351 valid responses were retained for the final CFA.

Instrumentation

The instrument used in this study was a multidimensional STEM self-efficacy scale adapted from established instruments to reflect domain-specific STEM competencies.

The scale comprised three dimensions:

- Science Self-Efficacy (five items), adapted from Baldwin et al. (1999);
- Mathematics Self-Efficacy (three items), adapted from Kranzler and Pajares (1997); and
- Engineering Self-Efficacy (four items), adapted from Sze et al. (2022).

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All items were measured using a 10-point Likert scale ranging from 1 (strongly disagree) to 10 (strongly agree), consistent with recommendations for measuring psychological constructs (Leong et al., 2016).
Content validity was established through expert review involving two professors and three senior lecturers specialising in STEM education, psychology, research methodology, and educational measurement. The instrument was translated into Bahasa Malaysia using a parallel translation procedure and subsequently verified by two language experts to ensure linguistic and cultural appropriateness.

Data Collection Procedure

Data were collected through an online questionnaire administered using Google Forms. Screening questions were included at the beginning of the survey to verify respondents' eligibility based on their SPM results and current programme of study. Only respondents who satisfied all inclusion criteria were retained for analysis.
Participation was voluntary and respondents were informed about the purpose of the study. Confidentiality and anonymity were maintained throughout the data collection process.

Data Screening and Preliminary Analysis

Prior to CFA, the data were screened to ensure suitability for multivariate analysis. The screening process included examinations of missing data, outliers, and normality.

As all questionnaire items were configured as mandatory responses within Google Forms, no missing data were detected. Univariate outliers were identified using boxplots and 22 extreme cases were removed. Multivariate outliers were subsequently examined using Mahalanobis Distance and 4 cases exceeding the critical threshold were excluded. Following data screening, the final sample comprised 351 respondents.

Normality was assessed using skewness statistics. Following Awang et al. (2015), skewness values within ±1.0 were considered indicative of acceptable normality.

Confirmatory Factor Analysis

CFA was conducted using IBM SPSS AMOS version 22.0 to validate the measurement model of STEM self-efficacy. The analysis followed the two-step approach recommended by Hair et al. (2019), whereby the measurement model was evaluated prior to any structural model assessment.

Model fit was evaluated using multiple fit indices representing absolute, incremental, and parsimonious fit categories. The indices included Chi-square (χ^2), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Chi-square divided by degrees of freedom (χ^2/df).

Construct Validity and Reliability

Construct validity was assessed through model fit, factor loadings, convergent validity, and discriminant validity. Convergent validity was evaluated using Average Variance Extracted (AVE) and Composite Reliability (CR), whereas discriminant validity was assessed using the Fornell-Larcker criterion. Internal consistency was evaluated using Composite Reliability values.

RESULTS

Data Screening and Preliminary Analysis

Prior to conducting Confirmatory Factor Analysis (CFA), the dataset was screened to ensure its suitability for multivariate analysis. A total of 377 questionnaires were collected from eligible respondents across the six participating universities. As all questionnaire items were configured as mandatory responses within Google Forms, no missing data were detected.

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Univariate outliers were examined using boxplots and extreme cases were removed from the dataset. Subsequently, multivariate outliers were assessed using Mahalanobis Distance, and cases exceeding the critical threshold were excluded. Following the screening process, 351 valid responses were retained for further analysis.

Normality was evaluated using skewness statistics. All items demonstrated skewness values within the acceptable range of ±1.0, indicating that the data were approximately normally distributed and suitable for CFA (Awang et al., 2015).

Measurement Model Assessment

The development of the STEM self-efficacy measurement scale followed a two-step validation process, including an Exploratory Factor Analysis (EFA) and a Confirmatory Factor Analysis (CFA). The initial EFA phase, reported in a prior study, identified a three-dimensional structure comprising self-efficacy in science, mathematics, and engineering. These findings provided empirical support for the construct's dimensionality and served as the basis for the present confirmatory analysis.

In this study, CFA was conducted using IBM SPSS AMOS version 22.0 to validate the measurement model. STEM self-efficacy was specified as a second-order construct, represented by three first-order dimensions: Science Self-Efficacy, Mathematics Self-Efficacy, and Engineering/Technology Self-Efficacy. Confirmatory Factor Analysis (CFA) was conducted using IBM SPSS AMOS version 22.0 to validate the measurement model of STEM self-efficacy. The model comprised three latent constructs: Science Self-Efficacy, Mathematics Self-Efficacy, and Engineering Self-Efficacy.

The initial measurement model did not achieve satisfactory fit, as some indices fell below recommended thresholds (Hair et al., 2019). Therefore, based on the recommendation by Adnan and Zakaria (2019), model refinement was undertaken by examining Modification Indices (MI) and standardized factor loadings. Items with low factor loadings (below 0.50) and those exhibiting redundancy (MI > 10) were considered for removal. This process was conducted cautiously to ensure that theoretical meaning was preserved.

After several iterations, the final measurement model achieved acceptable fit (Figure 1). The revised model comprised 12 items: five measuring science self-efficacy, three measuring mathematics self-efficacy, and four measuring engineering/technology self-efficacy. All retained items demonstrated satisfactory factor loadings of 0.60 or higher.

The model fit indices indicated a good fit: $\chi^2/df = 3.101$ (< 5.0), RMSEA = 0.077 (< 0.08), CFI = 0.967 (> 0.90), and TLI = 0.956 (> 0.90). These results confirm that the proposed measurement model adequately represents the underlying structure of STEM self-efficacy among high-achieving students. From a measurement perspective, the retention of three distinct domains is consistent with the earlier exploratory findings and reinforces the multidimensional nature of STEM self-efficacy. This suggests that students' confidence is not uniform across STEM disciplines, but varies depending on their experiences and perceived competence in each domain.

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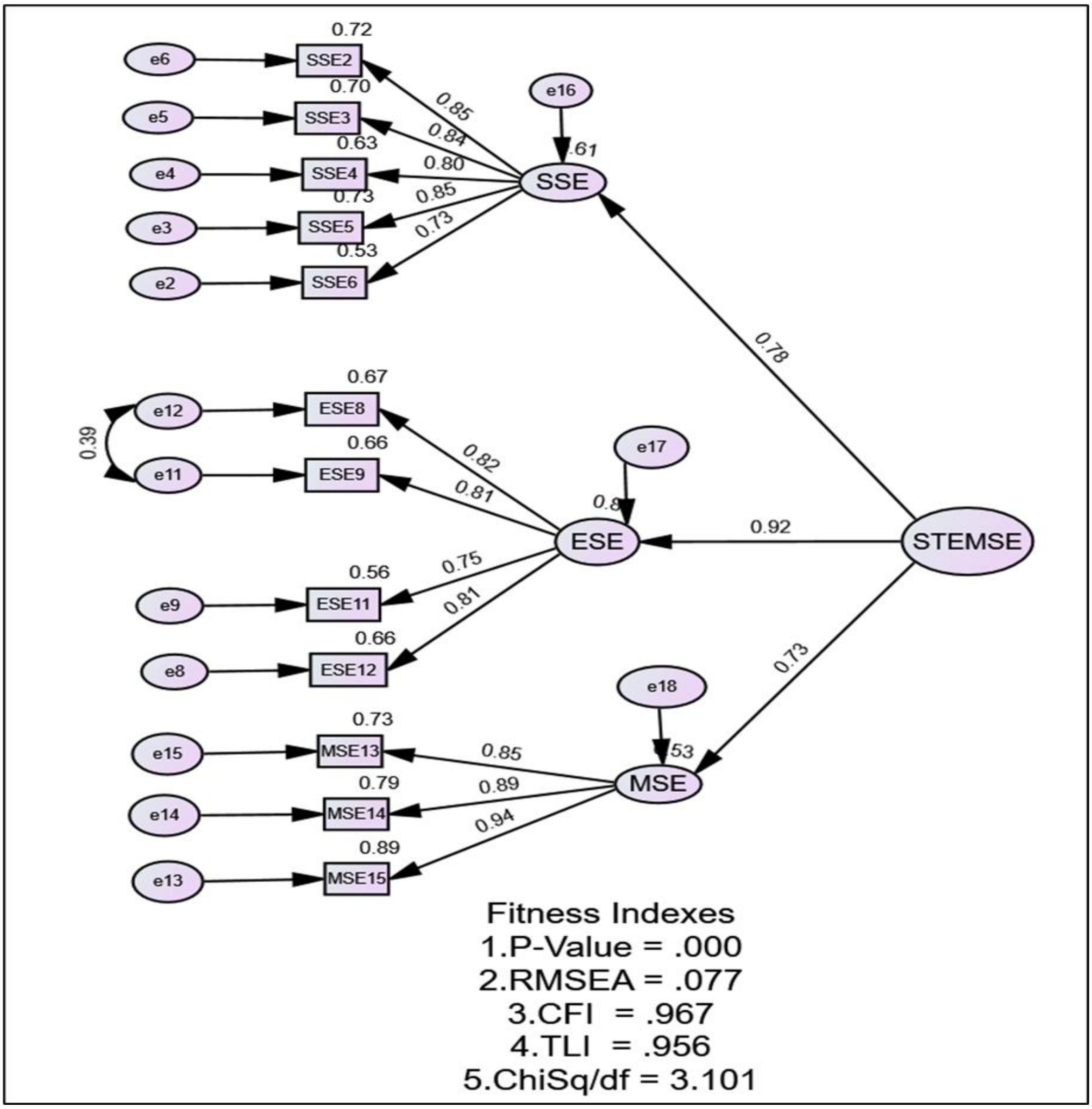

Figure 1. The Final Measurement Model of STEM Self-efficacy

Model Fit Evaluation

The final measurement model demonstrated satisfactory fit across absolute, incremental, and parsimonious fit indices. The chi-square to degrees of freedom ratio (χ^2/df) was 3.101, which satisfied the recommended threshold of less than 5.00. The Root Mean Square Error of Approximation (RMSEA) was 0.077, indicating acceptable absolute fit. Incremental fit indices also exceeded recommended thresholds, with a Comparative Fit Index (CFI) of 0.967 and a Tucker-Lewis Index (TLI) of 0.956. These results indicate that the final measurement model adequately represents the underlying structure of STEM self-efficacy among high-achieving students who transitioned out of STEM educational pathways.

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Table 3. Model Fit Indices for the Final Measurement Model

Fit Category	Index	Recommended Threshold	Obtained Value	Decision
Absolute Fit	RMSEA	< 0.08	0.077	Achieved
Incremental Fit	CFI	> 0.90	0.967	Achieved
Incremental Fit	TLI	> 0.90	0.956	Achieved
Parsimonious Fit	χ^2/df	< 5.00	3.101	Achieved

Convergent Validity and Reliability

Convergent validity was assessed using Average Variance Extracted (AVE), whereas reliability was evaluated using Composite Reliability (CR). As shown in Table 4, the AVE values ranged from 0.637 to 0.799, exceeding the recommended threshold of 0.50 (Fornell & Larcker, 1981). Similarly, the CR values ranged from 0.854 to 0.923, surpassing the recommended minimum value of 0.70 (Hair et al., 2019).

All standardized factor loadings ranged from 0.73 to 0.94, indicating that the retained items adequately represented their respective constructs. These findings provide evidence of satisfactory convergent validity and internal consistency for all dimensions of the STEM self-efficacy construct.

Table 4. CR and AVE for the STEM Self-efficacy

Construct	Sub-dimension/Item Label	Factor Loading	CR (> 0.700)	AVE (> 0.500)
STEM self-efficacy	Science	0.78	0.854	0.663
	Mathematic	0.92		
	Eng/Tech	0.73		
Science self-efficacy	SSE 2	0.85	0.910	0.671
	SSE 3	0.84		
	SSE 4	0.80		
	SSE 5	0.85		
	SSE 6	0.73		
Tech/Eng self-efficacy	ESE 8	0.82	0.875	0.637
	ESE 9	0.81		
	ESE 11	0.75		
	ESE 12	0.81		
Mathematic self-efficacy	MSE 13	0.85	0.923	0.799
	MSE 14	0.89		
	MSE 15	0.94		

Discriminant validity

Discriminant validity was assessed using the Fornell–Larcker criterion. This approach requires that the square root of the AVE for each construct exceeds its correlations with other constructs.

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As shown in Table 5, the square root of the AVE values was 0.819 for Science Self-Efficacy, 0.894 for Mathematics Self-Efficacy, and 0.800 for Engineering Self-Efficacy. These values exceeded the corresponding inter-construct correlations, which ranged from 0.57 to 0.72.

Although the correlation between Science Self-Efficacy and Engineering Self-Efficacy was relatively high (r = 0.72), it remained below the recommended threshold of 0.85, indicating that the constructs were related but empirically distinct.

These results provide evidence that the three dimensions of STEM self-efficacy demonstrate adequate discriminant validity.

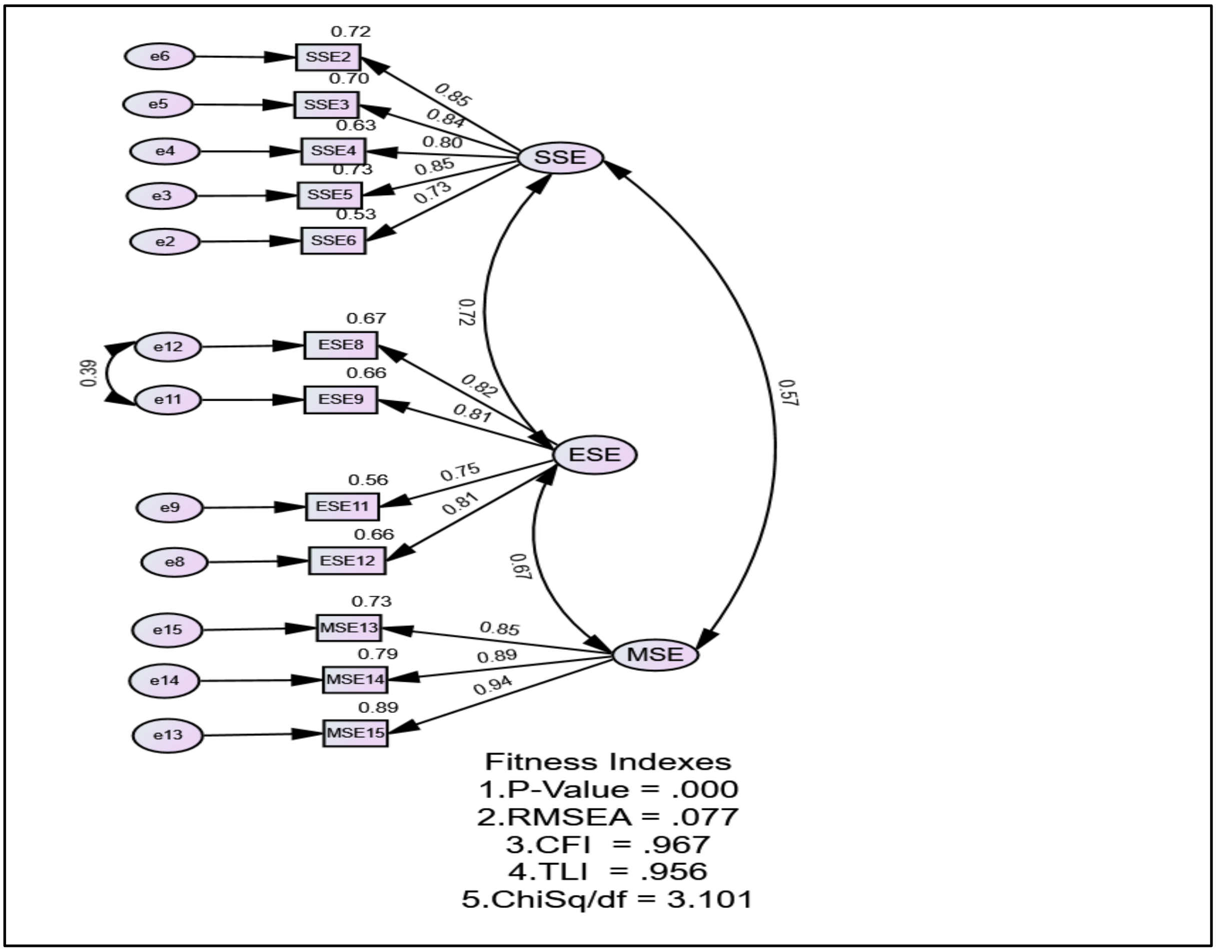

Figure 2. The inter-correlation construct value

Table 5. Discriminant Validity Assessment Using the Fornell–Larcker Criterion

Construct	SSE	ESE	MSE
SSE	**0.819**	0.72	0.57
ESE	0.72	**0.800**	0.67
MSE	0.57	0.67	**0.894**

Note. Diagonal values (bold) represent the square root of AVE.

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Summary of Measurement Model

The CFA results indicate that the STEM self-efficacy instrument demonstrates satisfactory psychometric properties. The final measurement model achieved acceptable model fit, all retained items exhibited satisfactory factor loadings, and evidence was obtained for convergent validity, discriminant validity, and reliability. These findings support the suitability of the multidimensional STEM self-efficacy instrument for assessing Science Self-Efficacy, Mathematics Self-Efficacy, and Engineering Self-Efficacy among high-achieving students who transitioned out of STEM educational pathways.

DISCUSSION

The present study sought to validate the measurement structure of STEM self-efficacy among high-achieving students who transitioned out of the STEM stream using Confirmatory Factor Analysis (CFA). The findings indicate that the final measurement model achieved satisfactory model fit, with all retained items demonstrating acceptable factor loadings and the overall model satisfying the recommended goodness-of-fit criteria. These results provide empirical support for the psychometric adequacy of the STEM self-efficacy instrument within this unique population of academically qualified students who elected to pursue non-STEM educational pathways.

The validated model confirmed a three-factor structure comprising science self-efficacy, mathematics self-efficacy, and engineering self-efficacy. This finding is consistent with the earlier exploratory phase of this research, where Exploratory Factor Analysis (EFA) identified the same three dimensions with satisfactory factor loadings and internal consistency. The CFA therefore serves as a confirmatory step that strengthens confidence in the stability and robustness of the measurement structure. The sequential use of EFA and CFA is widely recognised as a rigorous approach to scale development and validation because it provides evidence that the underlying factor structure is both empirically supported and theoretically meaningful.

Beyond confirming the psychometric properties of the instrument, the findings contribute to the conceptualisation of STEM self-efficacy as a multidimensional construct. The satisfactory levels of construct validity, convergent validity, discriminant validity, and reliability indicate that science, mathematics, and engineering self-efficacy represent distinct yet related dimensions of students' confidence in STEM-related domains. This finding supports Bandura's (1997) argument that self-efficacy is domain-specific and should be assessed within particular contexts rather than treated as a generalised belief. Students may therefore possess different levels of confidence across STEM disciplines, reflecting variations in learning experiences, prior achievements, and perceived task difficulty.

The multidimensional structure identified in this study is particularly important for understanding STEM attrition among high-achieving students. Previous research has often focused on academic achievement as a primary predictor of STEM persistence. However, the existence of students who possess the academic qualifications necessary for STEM study but nevertheless choose non-STEM pathways suggests that academic ability alone cannot fully explain educational decision-making. The present findings suggest that high-achieving students may not perceive their capabilities uniformly across all STEM domains. For example, a student may demonstrate excellent academic performance overall while simultaneously reporting lower confidence in engineering-related tasks or advanced mathematical problem-solving. Such differences in domain-specific confidence may influence educational choices even when objective academic indicators suggest that the student is capable of succeeding in STEM.

This finding helps address an important gap in the STEM attrition literature. Much of the existing research has examined STEM persistence among current STEM students, whereas relatively little attention has been given to academically capable students who voluntarily leave STEM pathways. By validating a multidimensional STEM self-efficacy instrument specifically for this population, the present study provides a methodological foundation for future investigations into the psychological factors that contribute to STEM attrition among high-achieving students. The findings suggest that understanding

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STEM attrition requires consideration not only of academic performance but also of how students evaluate their capabilities across different STEM domains.

From a theoretical perspective, the findings provide support for both Expectancy-Value Theory (EVT) and Social Cognitive Career Theory (SCCT). According to EVT, students' educational decisions are influenced by their expectations for success and the value they attach to a particular domain. The identification of distinct self-efficacy dimensions suggests that expectations for success may vary across science, mathematics, and engineering, potentially influencing students' willingness to pursue STEM-related educational pathways. Similarly, SCCT emphasises the role of self-efficacy in shaping interests, goals, and persistence. The multidimensional nature of STEM self-efficacy observed in this study suggests that confidence in specific STEM domains may influence students' academic interests and career aspirations differently. Consequently, students may leave STEM pathways not because they lack academic ability, but because they perceive themselves as less capable of succeeding in particular STEM domains.

At the same time, the findings indicate that self-efficacy alone is unlikely to provide a complete explanation for STEM attrition among high-achieving students. Although the validated instrument offers a robust means of assessing domain-specific confidence, students' educational choices are also influenced by other factors highlighted in EVT and SCCT, including task value, outcome expectations, interests, social influences, and environmental support. Future studies should therefore employ the validated instrument within broader structural models to examine how STEM self-efficacy interacts with these factors in shaping educational decisions and STEM persistence.

IMPLICATION OF THE STUDY

The findings of this study have important implications for educational practice, academic counselling, STEM pathway guidance, and future research. First, the validation of STEM self-efficacy as a multidimensional construct suggests that educators should move beyond viewing confidence as a general academic characteristic. Instead, attention should be given to students' confidence levels within specific STEM domains. Interventions designed to strengthen self-efficacy may therefore be more effective when targeted toward particular areas such as science, mathematics, or engineering rather than adopting a generic approach.

Second, the findings have important implications for academic counselling and STEM pathway guidance. Educational decisions are often made based on academic achievement indicators such as examination grades and programme eligibility. However, the present study suggests that academically capable students may still experience lower confidence in specific STEM domains despite achieving strong academic results. Academic counsellors and career advisors should therefore consider students' domain-specific confidence profiles when providing guidance regarding post-secondary educational pathways. Identifying students who demonstrate strong academic performance but relatively lower confidence in particular STEM domains may help prevent premature withdrawal from STEM pathways. Third, the validated instrument may serve as an early screening tool for identifying students who are potentially at risk of STEM attrition despite possessing the academic qualifications required for STEM programmes. Early identification would allow educators, counsellors, and institutions to implement targeted interventions such as mentoring programmes, career exposure activities, mastery-based learning experiences, and confidence-building initiatives aimed at strengthening students' perceptions of their capabilities in specific STEM domains. Such interventions may be particularly beneficial during critical educational transition periods when students make decisions regarding upper secondary subject selection or post-secondary programme enrolment.

From a policy perspective, the findings suggest that efforts to increase STEM participation should extend beyond improving academic achievement alone. Policies aimed at strengthening STEM retention should also address psychological factors that influence educational choices, particularly domain-specific self-efficacy. By incorporating measures of STEM self-efficacy into student development programmes and STEM promotion initiatives, educational institutions may be better positioned to support students who are academically capable of succeeding in STEM but remain uncertain about their abilities within particular STEM disciplines.

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Finally, the validated measurement model provides a valuable tool for future research. The instrument can be incorporated into structural models examining the relationships among self-efficacy, motivation, interest, expectancy for success, subjective task value, and STEM attrition. This will facilitate a more comprehensive understanding of the psychological processes underlying educational decision-making among high-achieving students and contribute to the development of evidence-based strategies for improving STEM participation and retention.

CONCLUSIONS

This study validated a multidimensional STEM self-efficacy instrument among high-achieving students who transitioned out of STEM pathways. The findings confirm that STEM self-efficacy comprises three distinct but related domains: science, mathematics, and engineering self-efficacy. The measurement model demonstrated satisfactory validity and reliability, indicating that the instrument is suitable for assessing domain-specific confidence among academically qualified students who choose non-STEM pathways.

Beyond its methodological contribution, this study enhances understanding of STEM attrition by highlighting the role of domain-specific confidence in educational decisions. The findings suggest that high academic achievement alone may not ensure STEM persistence, as students' perceptions of their abilities can differ across STEM disciplines. Therefore, understanding why academically capable students leave STEM requires considering both academic performance and confidence beliefs.
By validating a multidimensional STEM self-efficacy instrument for a previously underexplored population, this study addresses an important gap in the literature and provides a basis for future research on the psychological factors underlying STEM attrition. The instrument offers researchers, educators, and policymakers a useful tool for identifying barriers to STEM persistence and developing interventions that support students in pursuing and remaining in STEM pathways.

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DECLARATION OF GENERATIVE AI

During the preparation of this work, the authors used CONSENSUS to enhance the clarity of the writing. After using the CONSENSUS, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

ETHIC STATEMENTS

Ethical approval for this study was obtained from the Research Ethics Committee, UiTM, under approval letter number REC/10/2023 (ST/MR/247). All research procedures strictly adhered to the approved ethical requirements, instruments and procedures, including informed consent, voluntary participation, confidentiality of participant data, and the right to withdraw from the study at any time without penalty.

REFERENCES

Adnan, M., & Zakaria, E. (2019). Model Pengukuran Kepercayaan Bakal Guru Matematik di Malaysia. *Jurnal Pendidikan Sains Dan Matematik Malaysia*, *3*(1), 1-11. https://ejournal.upsi.edu.my/index.php/JPSMM/article/view/2017

Apriceno, M., Levy, S., & London, B. (2020). Mentorship During College Transition Predicts Academic Self-Efficacy and Sense of Belonging Among STEM Students. *Journal of College Student Development*, 61, 643 - 648. https://doi.org/10.1353/csd.2020.0061.

https://doi.org/10.37134/jpsmm.vol16.1.7.2026

Arif, S., Iqbal, J., & Khalil, U. (2019). Factors influencing students' choices of academic career in Pakistan. FWU *Journal of Social Sciences*, 13(1), 35-47.

Aryee, M. (2019). College Students' Persistence and Degree Completion In Science, Technology, Engineering, and Mathematics (STEM): The Role Of Non-Cognitive Attributes Of Self-Efficacy, Outcome Expectations, And Interest.

Awang, Z., Afthanorhan, A., & Mamat, M. (2015). The Likert scale analysis using parametric based Structural Equation Modeling (SEM). *Computational Methods in Social Sciences*, 4(1), 13–21.

Awang,Z., Lim, SH & Zaimudin,NFS.(2018). Pendekatan mudah SEM-structural Equation Modeling. Bandar Baru Bangi,MPWS Rich Resources

Baldwin, J. A., Ebert-May, D., & Burns, D. J. (1999). The development of a college biology self-efficacy instrument for nonmajors. *Science Education*, 83(4), 397-408.

Bandura, A. (1997). Sources of self-efficacy. Self-efficacy: The exercise of control, 79-113.

Bradford, B. C., Beier, M. E., McSpedon, M., & Wolf, M. (2020, June). Examining STEM diagnostic exam scores and self-efficacy as predictors of three-year STEM psychological and career outcomes. In *2020 ASEE Virtual Annual Conference Content Access*.

Cabell, A. (2021). Career Search Self-Efficacy and STEM Major Persistence. *Career Development Quarterly*, 69, 158-164. https://doi.org/10.1002/cdq.12256.

Chuan, Z., Liong, C., Yusoff, W., Aminuddin, A., & Tan, E. (2021). Identifying factors that affected student enrolment in Additional Mathematics for urban areas of Kuantan district. *Journal of Physics: Conference Series*, 1988. https://doi.org/10.1088/1742-6596/1988/1/012047.

Chuan, Z., We, D., Akhmedov, A., Man, L., Hiae, T., & Hamizul, A. (2025). Fostering STEM Interest for Engineering: Determinants Impacting Additional Mathematics Enrollment in East-Coast Malaysia. *Jurnal Kejuruteraan*. https://doi.org/10.17576/jkukm-2025-37(2)-33.

Coenen, J., Borghans, L., & Diris, R. (2021). Personality traits, preferences and educational choices: A focus on STEM. *Journal of Economic Psychology*. https://doi.org/10.1016/j.joep.2021.102361.

Cohen, J. (1988). Statistical Power Analysis for the Behavioral Sciences (2nd ed.). Routledge. https://doi.org/10.4324/9780203771587

Dorfman, B., & Fortus, D. (2019). Students' self-efficacy for science in different school systems. *Journal of Research in Science Teaching*, 56(8), 1037–1059. https://doi.org/10.1002/tea.21542

Doly, F. (2024). Equipping Students for Future Jobs: The Essential Role of STEM Education. *International Journal of English Language, Education and Literature Studies (IJEEL)*. https://doi.org/10.22161/ijeel.3.5.7.

Eccles, J. S., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary educational psychology*, 61, 101859.

Falloon, G., Hatzigianni, M., Bower, M., Forbes, A., & Stevenson, M. (2020). Understanding K-12 STEM Education: a Framework for Developing STEM Literacy. *Journal of Science Education and Technology*, 29, 369-385. https://doi.org/10.1007/s10956-020-09823-x.

Fornell, C., and Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research* (18:1), pp. 39-50.
in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.498824.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2016). Multivariate Data Analysis(7th Edition) : Pearson Education Limited.

Hair JF, Sarstedt M, Ringle CM (2019). Rethinking some of the rethinking of partial least squares. *European Journal of Marketing*, 53(4), 566–584, doi: https://doi.org/10.1108/EJM-10-2018-0665

Huzir, N., Ahmad, N., Hassanuddin, N., Yusoff, S., Rosly, N., & Izni, N. (2025). Factors Affecting Students' Persistence To Enrol In STEM Education. *Malaysian Journal of Computing*. https://doi.org/10.24191/mjoc.v10i1.4546.

Idris, R., Govindasamy, P., & Nachiappan, S. (2023). Challenge and Obstacles of STEM Education in Malaysia. *International Journal of Academic Research in Business and Social Sciences*. https://doi.org/10.6007/ijarbss/v13-i4/16676.

Jamali, S., Ebrahim, N., & Jamali, F. (2022). The role of STEM Education in improving the quality of education: a bibliometric study. *International Journal of Technology and Design Education*, 33, 819-840. https://doi.org/10.1007/s10798-022-09762-1.

Kayan-Fadlelmula, F., Sellami, A., Abdelkader, N., & Umer, S. (2022). A systematic review of STEM education research in the GCC countries: trends, gaps and barriers. *International Journal of STEM Education*, 9, 1-24. https://doi.org/10.1186/s40594-021-00319-7.

https://doi.org/10.37134/jpsmm.vol16.1.7.2026

Kline, R. B. (2015). Principles and practice of structural equation modeling. London: Guilford publications.

Kranzler, J. H., & Pajares, F. (1997). An Exploratory factor Analysis of the Mathematics Self-Efficacy Scale—Revised (MSES-R). *Measurement and Evaluation in Counseling and Development*, 29(4), 215–228. https://doi.org/10.1080/07481756.1997.12068906

Kyriazos, T. (2018). Applied Psychometrics: Sample Size and Sample Power Considerations in Factor Analysis (EFA, CFA) and SEM in General. Psychology, 09, 2207-2230. https://doi.org/10.4236/psych.2018.98126.

Leong, M. W., Kannan, S., & Maulo, S. B. A. (2016). Principal technology leadership practices and teacher acceptance of School Management System (SMS). *Educational Leader (Pemimpin Pendidikan)*, 4, 89-103.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of vocational behavior*, 45(1), 79-122.

Mamaril, N. A., Usher, E. L., Li, C. R., Economy, D. R., & Kennedy, M. S. (2016). Measuring undergraduate students' engineering self-efficacy: A validation study. *Journal of Engineering Education*, 105(2), 366-395.

Mohamad Marzuki, A. H., Mhod Shukri, N., & Taha, H. (2019). Gaya pengajaran Grasha dalam kalangan pensyarah sains di Kolej Pra-Universiti di Pulau Pinang. *Jurnal Pendidikan Sains Dan Matematik Malaysia*, *9*(2), 16-24. https://doi.org/10.37134/jpsmm.vol9.2.3.2019

Müller, C., Kayyali, M., & Elzomor,, M. (2024). Board 139: Factors Affecting Enrollment, Retention, and Attrition of STEM Undergraduates at a Minority Serving Institution. *2023 ASEE Annual Conference & Exposition Proceedings*. https://doi.org/10.18260/1-2--42461.

Nhat, N., Oanh, T., & Hang, P. (2024). The Effect of Stem Education on Academic Performance: A Meta-Analysis Study. *International Journal of Learning, Teaching and Educational Research*. https://doi.org/10.26803/ijlter.23.11.9.

Pedersen, J., & Nielsen, M. (2023). Gender, self-efficacy and attrition from STEM programmes: evidence from Danish survey and registry data. *Studies in Higher Education*, 49, 47 - 61. https://doi.org/10.1080/03075079.2023.2220702.

Riduan, M., & Othman, Z. (2024). Examining challenges and strategies in implementing STEM education in Malaysian secondary schools: perspectives of teachers and students. *Jurnal Intelek*. https://doi.org/10.24191/ji.v19i2.26514.

Sachmpazidi, D., Van Dusen, B., & Henderson, C. (2025). Role of departmental support structures and self-efficacy on physics student persistence: An examination of students' experience from 19 physics graduate programs. *Physical Review Physics Education Research*. https://doi.org/10.1103/physrevphyseducres.21.010158.

Saw, G., & Agger, C. (2021). STEM Pathways of Rural and Small-Town Students: Opportunities to Learn, Aspirations, Preparation, and College Enrollment. *Educational Researcher*, 50, 595 - 606. https://doi.org/10.3102/0013189x211027528.

Sithole, A., Chiyaka, E., McCarthy, P., Mupinga, D., Bucklein, B., & Kibirige, J. (2017). Student Attraction, Persistence and Retention in STEM Programs: Successes and Continuing Challenges. *Higher Education Studies*, 7, 46-59. https://doi.org/10.5539/hes.v7n1p46.

Suherman, S., Vidákovich, T., Mujib, M., Hidayatulloh, H., Andari, T., & Susanti, V. (2025). The Role of STEM Teaching in Education: An Empirical Study to Enhance Creativity and Computational Thinking. *Journal of Intelligence*, 13. https://doi.org/10.3390/jintelligence13070088.

Sze, A. W. K., Hassan, N. C., Jaafar, W. M. W., Ahmad, N. A., & Arsad, N. M. (2022). Development of a STEM Self-Efficacy Scale for Malaysian Primary School Children: A Validity and Reliability study. *Asia-Pacific Social Science Review*, *22*(1). https://doi.org/10.59588/2350-8329.1436

Tao, K. W., & Gloria, A. M. (2019). Should I stay or should I go? The role of impostorism in STEM persistence. *Psychology of Women Quarterly*, *43*(2), 151-164.

Tytler, R. (2020). STEM Education for the Twenty-First Century. , 21-43. https://doi.org/10.1007/978-3-030-52229-2_3.

Van Aalderen-Smeets, S. I., Van Der Molen, J. H. W., & Xenidou-Dervou, I. (2018). Implicit STEM ability beliefs predict secondary school students' STEM self-efficacy beliefs and their intention to opt for a STEM field career. *Journal of Research in Science Teaching*, 56(4), 465–485. https://doi.org/10.1002/tea.21506

Van Den Hurk, A., Meelissen, M., & Van Langen, A. (2019). Interventions in education to prevent STEM pipeline leakage. *International Journal of Science Education*, 41(2), 150–164. https://doi.org/10.1080/09500693.2018.1540897

https://doi.org/10.37134/jpsmm.vol16.1.7.2026

Witteveen, D., & Attewell, P. (2020). The STEM grading penalty: An alternative to the “leaky pipeline” hypothesis. *Science Education*, 104, 714-735. https://doi.org/10.1002/sce.21580.

Yaacob, Z., Abdullah, N., Razali, F., & Aris, S. R. S. Exploratory Factor Analysis of Stem Self-Efficacy in The Context of Malaysian STEM Subjects’ High Performers. (2024). *International Journal of Academic Research in Business and Social Sciences*. 14(6). 302-312. https://doi.org/10.6007/ijarbss/v14-i6/21462

Yusuf, B., Rahim, N., Saraih, U., & Yusof, S. (2025). Why Is There A Lack Of Interest? A Decline In STEM Subject Selection Among Students From The Teachers’ Perspective. *International Journal of Education, Psychology and Counseling*. https://doi.org/10.35631/ijepc.1059002.

https://doi.org/10.37134/jpsmm.vol16.1.7.2026