

Bridging belief and practice: Resilience as a mediator between self-efficacy and mathematical modelling instruction in Malaysia

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ABSTRACT

Teaching mathematical modelling is essential, promoting key 21st century competencies such as problem-solving, logical thinking, and interdisciplinary reasoning. However, alongside the growing expectation for teachers to implement mathematical modelling effectively, they continue to face a range of challenges that hinder their integration into classroom practice. This study examines the mediating role of modelling resilience in the relationship between self-efficacy and teaching modelling instruction among mathematics teachers. A correlational design employing structural equation modelling was used to analyse the relationships and mediating effects within the framework. The study involved a sample of 300 mathematics teachers in Selangor using a clustered sampling method. The findings indicate that both self-efficacy and modelling resilience are positively associated with mathematical modelling instruction. We found that while modelling resilience partially mediates these effects, while there is no moderation effect of teaching experience between self-efficacy and mathematical modelling instruction. This study highlights the potential of self-efficacy and modelling resilience factors to foster mathematical modelling instruction.

Keywords: mathematical modelling instruction, modelling resilience, self-efficacy, teaching

INTRODUCTION

Mathematics is a fundamental tool for interpreting and exploring nature, rather than solely reflecting external reality. It plays a role as a conceptual framework that allows us to understand nature and apply logical reasoning, rooted in specific assumptions about its application (Hendriyanto et al., 2023). The past decade has witnessed numerous coordinated efforts aimed at advancing mathematical modelling by considering the growing global significance of mathematics in contemporary science, technology, and daily life (Hidayat et al., 2021). Mathematical modelling plays a vital conceptual role within the curriculum, offering a structured approach to enriching mathematics practices (Leong, 2014). It extends more than solving real-life problems, providing deeper insights into the implementation of mathematical concepts (Mohd Saad et al., 2023). Integrating mathematical modelling across disciplines enables the growth of a contextually meaningful understanding of mathematical concepts (Hidayat et al., 2023). Teaching mathematical modelling is essential, as it connects mathematics with real-world contexts, promoting key 21st century skills including problem-solving, logical thinking, and interdisciplinary reasoning (Maaß et al., 2019). The growing attention on mathematical modelling instruction in countries such as Germany, Turkey and Hong Kong underscore its importance and widespread integration in mathematics education over the past half-decade.

However, teachers continue to face a range of challenges that hinder the integration of mathematical modelling into classroom practice alongside the growing expectation for them to implement mathematical modelling effectively. Cognitively, many mathematics teachers demonstrate low level of modelling competency due to foundational knowledge gaps, which hinder their ability to grasp and implement modelling tasks effectively (Bukari & Govender, 2024; Kannadass et al., 2023). This issue is worsened by limited conceptual understanding and difficulties in connecting mathematical concepts to real-world applications in meaningful ways (Zeytun et al., 2024). Pedagogically, many teachers demonstrate a limited understanding of pedagogical content knowledge, particularly related to modelling tasks, concepts, and processes (Greefrath et al., 2022). Insufficient training and limited exposure to constructivist approaches further hinder teachers' ability to promote student engagement and encourage active participation in constructing mathematical knowledge (AlAli & Al-Barakat, 2024). Additionally, educators often face task-related challenges, such as aligning modelling tasks with their prior teaching methods and designing appropriate tasks, as developing teaching competencies are time consuming (Wickstrom & Arnold, 2023). A lack of discomfort and confidence to handle modelling lessons are also common, particularly among teachers with minimal prior exposure to modelling-based instruction and

limited real-world experience, which may contribute to reduced self-efficacy (Zeytun et al., 2024). This reduced self-efficacy frequently drives teachers to rely on traditional, procedural teaching methods rather than exploratory, student-centered strategies. When learning and teaching take place in passive environments, teachers are also less likely to develop resilience in mathematical modelling.

Teachers need to develop various competencies to teach effectively (Hidayat et al., 2025), including a thorough understanding of the modelling processes to overcome the challenges of integrating mathematical modelling (Wang et al., 2023). Implementing high-quality and strategic teaching practices is also crucial to support the cultivation of strong mathematical modelling abilities. Researchers from countries such as Australia, Germany, Hong Kong, the United States, Turkey, Singapore, Austria, and Denmark have explored different aspects of teaching mathematical modelling. Their work contributed to the development of frameworks that outline important dimensions to support effective modelling instruction. While previous studies have highlighted cognitive, motivational, and contextual influences on teaching modelling, there is a remaining significant gap in the literature regarding how self-efficacy and modelling resilience shape teachers' instructional practices in mathematical modelling. Most of the existing research explored issues related to students from high school level, with limited investigation into how teachers' self-belief (self-efficacy) and their ability to adapt and persevere through instructional challenges (modelling resilience) relate to their classroom practices in delivering mathematical modelling. Furthermore, little research has focused explicitly on mathematics teachers, especially studies that explore the interaction between crucial psychological factors such as self-efficacy, modelling resilience, and teaching practices related to mathematical modelling. The proposed hypotheses seek to highlight the interconnections among these variables, thereby helping to identify which factors should be prioritised to foster a more effective teaching and meaningful learning environment. Hence, this study aims to investigate how modelling resilience mediates the relationship between self-efficacy and teaching modelling practices among mathematics teachers. This research contributes valuable insights to the existing body of knowledge by acknowledging the psychological challenges that mathematics teachers face in teaching mathematical modelling and offering latest data on the factors influencing teaching modelling practices. Accordingly, three primary research questions are proposed as follows:

1. Is there any relationship between self-efficacy, modelling resilience and teaching modelling practices among mathematics teachers in Selangor?
2. Is there any role of modelling resilience as a mediator in the relationship between self-efficacy and teaching modelling practices among mathematics teachers in Selangor?
3. Is there any role of teaching experience as a moderator in the relationship between self-efficacy and teaching modelling practices among mathematics teachers in Selangor?

LITERATURE REVIEW

Mathematical Modelling

In recent times, modelling and modelling competences have been the focus of considerable research (Cevikbas et al., 2022). In the context of mathematics education, mathematical modelling involves designing learning activities that encourage students to impose their mathematical understanding to solve problems drawn from real-life situations (Araújo & Lima, 2020). It typically emphasises the use of mathematics to interpret, describe, and make sense of phenomena that extend beyond the mathematical domain (Leung, 2019). Mathematical modelling supports students in making sense of real-world situations by first identifying key issues or assumptions, converting them into mathematical expressions, and then interpreting and evaluating the solutions within the original context (Leung & Tan, 2020). It goes beyond merely solving practical problems and is recognised as a complex skill that helps students recognise the meaningful application of the mathematics they learn in real-life situations (Mohd Saad et al., 2023). The core structure of the mathematical modelling cycle remains consistent with Blum's original model (1996), which originates from a real-world problem and concludes with the presentation of results, comprising seven steps (Yahya & Maat, 2022). If the solution does not correspond to the original problem or adequately address it, certain steps may require revision and refinement, making the process inherently iterative (Asempapa & Brooks, 2020).

Mathematical modelling competency encompasses a range of key sub-competencies that are essential for successfully engaging with each phase of the modelling cycle (Kaiser, 2007). Wang et al. (2023) identify five essential sub-competencies in mathematical modelling: simplifying, mathematizing, working mathematically, interpreting results, and validating outcomes. Along the same lines, Özbek and Köse (2022) highlight that mathematical modelling competency consists of several interconnected stages, including recognising real-world problems, simplifying them, developing mathematical models, and explaining the resulting solutions. Despite the challenges involved in teaching and learning modelling, it provides a means for teachers to communicate more effectively with students and boost their motivation (Arseven, 2015). Increased exposure to mathematical modelling lessons allows teachers to improve their instructional strategies and boost their modelling resilience and confidence in engaging with modelling tasks, while also helping students strengthen their mathematical thinking skills. This is particularly important given that the impact of mathematical modelling extends well beyond its conventional definition, offering applications across diverse contexts (Lehmann, 2024). A large volume of research has focused on the factors that influence mathematical modelling competency.

Teaching Modelling Practices

Over time, the teaching of mathematical modelling has become increasingly widespread in secondary schools around the world. Teaching modelling is often more open-ended and complex, requiring the integration of real-world knowledge and

contexts into mathematics teaching (Blum & Borromeo Ferri, 2009). To address these challenges, adjustments to both curriculum and teaching practices are necessary. High-quality instruction is crucial not only for the effective delivery of mathematical modelling (Jabar et al., 2022) but is also seen as a promising approach for creating meaningful learning experiences that foster the enhancement of students' modelling skills and self-efficacy (Hidayat et al., 2025). Greefrath et al. (2022) highlighted that effective instruction in mathematical modelling demands specialized pedagogical content knowledge along with a thorough understanding of the modelling process.

As a guide for teachers, researchers have proposed frameworks that address key dimensions including pedagogy, task design, and assessment systems to support effective modelling instruction. For example, Wess et al. (2021) proposed a framework that identifies the essential knowledge teachers require to effectively facilitate modelling activities. These include understanding instructional strategies, modelling processes, design of modelling activities, and the underlying goals and viewpoints. Geiger et al. (2021) highlight that modelling tasks ought to be open in nature and integrate both mathematical understanding and real-world context, while also emphasising the importance of task relevance. Tekin Dede and Bukova Güzel (2023) developed a descriptive framework centered on the implementation phase of modelling instruction, starting with introductory activities and ending with monitoring students' engagement in modelling tasks. They also proposed a separate assessment framework designed to guide the evaluation of student performance, including aspects such as sharing solutions, reflecting on results, evaluating modelling skills, and formulating informed instructional decisions.

Prior research underscores the challenges of teaching mathematical modelling and emphasises the necessity of teachers to possess a diverse skill set that surpasses basic mathematical proficiency. One key challenge is the limited experience and exposure to modelling problems, which can hinder teachers' development in this area. Evidence suggests that teachers' self-efficacy beliefs are strongly associated with their instructional practices, including their approaches to and the effort they invest in teaching mathematical modelling (Holzberger et al., 2013). In this context, teachers with strong self-efficacy are more inclined to persevere through the challenges of modelling instruction—an attribute closely associated with modelling resilience. Adaptive intervention competence is recognized as an essential skill, encompassing the ability to adjust instruction to students' needs, deliver targeted support, and foster independent problem-solving during the modelling process (Gerber et al., 2023). Combining pedagogical expertise, adaptable teaching methods, and student-centered strategies contributes to a well-rounded and effective approach to teaching mathematical modelling.

Self-Efficacy

Self-efficacy reflects a person's conviction in their ability to successfully carry out specific tasks across various situations (Maaß et al., 2019). People with strong self-efficacy tend to invest more effort and persist in the face of difficulties (Schunk, 1991). In the context of mathematics education, self-efficacy specifically refers to a teacher's belief in their ability to teach and interact effectively with mathematical content. Research has consistently linked strong self-efficacy beliefs among teachers to various positive outcomes, such as increased student motivation (Zee & Koomen, 2016), improved academic achievement, enhanced classroom interactions (Perera & John, 2020) and higher levels of professional engagement (Durksen et al., 2017). Moreover, Zee and Koomen (2016) found that self-efficacy beliefs can partly shape the instructional strategies and behaviours teachers adopt to support student learning. Teachers who possess high levels of self-efficacy generally exhibit stronger skills in classroom management, are more open to using innovative teaching practices, and achieve greater success in actively involving students in the learning process (Abu-Tineh et al., 2011). Confident teachers demonstrate a willingness to explore new teaching methods that respond to students' varying needs, often prefer student-centered and constructivist methods over traditional instructional approaches and implement modelling-focused pedagogical practices in the classroom (Holzberger et al., 2013).

In the context of Malaysian schoolteachers, self-efficacy can be defined operationally as their awareness of their personal competence, behavioural control, and confidence when engaging in mathematical modelling activities. Prior studies have demonstrated that strong self-efficacy enhances educators' professional competence, underscoring the importance of self-belief in achieving instructional goals. Teachers with greater self-efficacy are generally more confident in handling classroom challenges and more proficient in their teaching methods (Li, 2023). Moreover, self-efficacy has been shown to exert an indirect influence on student achievement, mediated by the instructional strategies teachers adopt and the classroom environments they create (Guo et al., 2012). Although the impact of self-efficacy on general teaching practices is well established, studies specifically exploring its role in teaching mathematical modelling remain scarce (Murphy & Ingram, 2023). Supporting this research direction, Ergene and Ergene (2024) found that individuals with higher self-efficacy in mathematical modelling tend to achieve better performance, highlighting the importance of self-efficacy in fostering resilience during modelling tasks.

Modelling Resilience

In educational settings, mathematical modelling resilience refers to a positive emotional attitude toward mathematical modelling, a sense of control while engaging in modelling activities, and the belief that one's knowledge and skills in modelling can develop and be progressively enhanced over time. This perception is not static; rather, it is dynamic and influenced by time and potential (Hutauruk & Priatna, 2017). Kookan et al. (2013) outlines four interconnected factors that form the foundation of modelling resilience: value, struggle, development, and resilience. The value factor highlights the significance attributed to modelling in reaching personal or academic goals, connecting closely with motivation and self-regulation. The struggle factor reflects the belief that challenges are a natural part of modelling. The development factor reflects the belief that mathematical knowledge can grow and evolve over time. Finally, resilience centres on the ability to respond constructively to challenges, grounded in both educational and psychological perspectives. Modelling resilience is characterised as a process or outcome that supports effective coping when confronted with challenges in mathematical modelling. This concept carries considerable pedagogical value, particularly in assisting teachers and students as they navigate the complex demands of modelling.

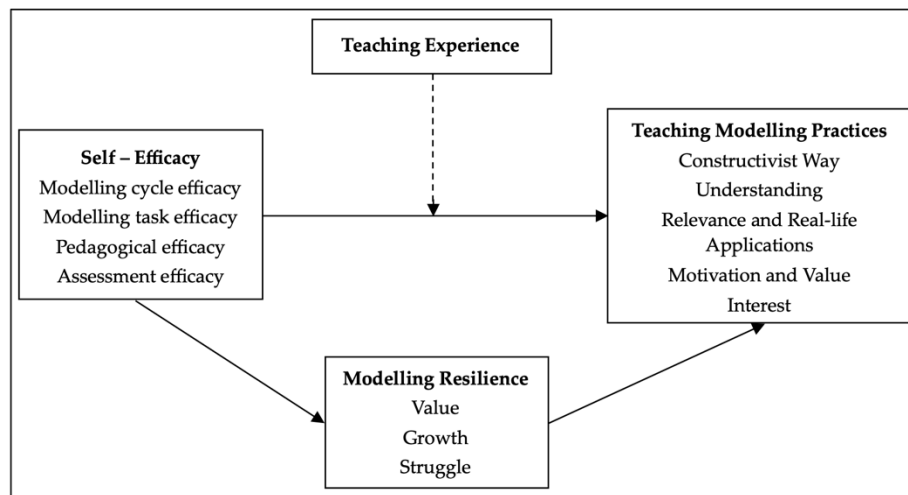


Figure 1. Research model (Source: Authors' own elaboration)

Consequently, fostering modelling resilience calls for ongoing instructional support and a learning environment that promotes exploration, reflection, and collaboration. These elements form the groundwork in exploring how individuals perceive and cultivate resilience within mathematical modelling.

The development of mathematical modelling resilience is influenced by a combination of psychological factors—both cognitive and affective—and social or environmental influences (Xenofontos & Mouroutsou, 2023). Psychological factors encompass self-efficacy, and persistence (Oktay et al., 2021). Social-environmental factors—including classroom dynamics, teaching practices, and collaborative learning environments—also hold a crucial role (Chirkina et al., 2020). For example, fostering student discourse and reducing teacher-centered instruction can significantly enhance resilience in engaging with mathematics. Mota et al. (2016) emphasises that the relationship between mathematical competence and resilience is shaped by instructional strategies, integration of technology, and cognitive skills, reinforcing the crucial role of effective teaching practices in promoting resilience. Furthermore, modelling resilience is linked to positive academic outcomes, increased engagement, and strengthened self-efficacy (Scrine, 2021). However, despite these associations, empirical research directly examining the relationship between teacher self-efficacy and modelling resilience remains limited. While broader research suggests that self-efficacy contributes to the development of resilience and positively influences teaching performance (Razmjoo & Ayoobiyan, 2019), studies specifically examining mathematics teachers' modelling resilience are still scarce. Higher resilience is associated with greater self-efficacy, while elevated levels of teacher self-efficacy and resilience are directly connected to effective teaching practices. This underscores a significant research gap, as exploring the relationship between self-efficacy and modelling resilience may inform the design of more effective teaching approaches and targeted professional development.

Mediating Role of Modelling Resilience

Recent studies underscore the critical influence of resilience as a mediator in improving educational outcomes, particularly in mathematical contexts. Mathematical resilience, described as the capability to persist and adapt when confronting mathematical challenges, has been shown to positively influence individuals' attitudes toward problem-solving, including those encountered in mathematical modelling (Simacon & Veloria, 2022). Simacon and Veloria (2022) further demonstrated that mathematical resilience serves as a mediating factor between reflective thinking skills and attitudes toward mathematical modelling, indicating that students with greater resilience tend to approach problem-solving with confidence and sustained perseverance. Similarly, Moke et al. (2018) observed that self-efficacy alone was not sufficient to predict competitiveness, and resilience fully mediated this relationship, underscoring its pivotal role in influencing performance-related behaviours. Agtarap and Miranda (2022) echoed this finding by demonstrating that mathematical resilience serves as a mediator between self-concept and mathematics performance, suggesting that cultivating resilience in students may contribute to enhanced academic achievement. These findings reinforce the understanding that resilience plays a pivotal role not only in strengthening cognitive abilities but also in shaping the motivational and emotional factors essential to effective learning.

Building on this concept within teaching practice, Li (2023) found that teacher resilience serves as a full mediator between self-efficacy and emotion regulation on teacher burnout, highlighting its critical role in mitigating professional stress. This underscores resilience as a vital psychological resource that not only buffers against negative outcomes but also enhances teaching effectiveness. Similarly, resilience significantly shapes professional attitudes and teaching self-efficacy, especially in the context of challenging educational environments. However, despite extensive research on general mathematical resilience, limited attention has been directed toward modelling resilience, particularly its mediating role between teachers' self-efficacy in mathematical modelling and their implementation of modelling practices in the classroom. This emerging construct can serve as an intermediary between teachers' self-belief and their capacity to deliver effective modelling instruction. Therefore, drawing on existing theoretical and empirical evidence, this study proposes that modelling resilience acts as a mediator between self-efficacy and teaching modelling practices, offering a novel contribution to the discourse on resilience in mathematics education. Accordingly, **Figure 1** illustrates the research model derived from previous studies.

MATERIALS AND METHODS

Research Design and Population

A correlational approach was employed to study the relationships among modelling resilience, self-efficacy, and teaching modelling practices among mathematics teachers in Selangor. This research design facilitates the implementation of the research methodology by linking empirical data directly to the research questions, thus offering a thorough comprehensive overview of the outcomes (Shanmugam & Hidayat, 2022; Silverman, 2021). As this approach examines relationships between variables without manipulation, it is appropriate for exploring the mediating role of modelling resilience in the relationship between self-efficacy and teaching modelling practices. Existing research offers various perspectives on the population of secondary school mathematics teachers in Selangor. This study focuses on teachers from nine districts: Klang, Kuala Langat, Kuala Selangor, Hulu Langat, Gombak, Petaling, Hulu Selangor, Sabak Bernam, and Sepang. Selangor was chosen as the study location because it has a high concentration of schools implementing the Kurikulum Standard Sekolah Menengah (KSSM) curriculum. According to the statistics of Ministry of Education, Selangor has approximately 3,909 secondary school mathematics teachers, of whom 816 are Form Five mathematics teachers teaching the KSSM curriculum. Secondary-level mathematics teacher was chosen, as the study specifically targets public and private school teachers who teach Mathematical Modelling, a Form Five topic within the KSSM syllabus.

The sample size calculated using Slovin's formula which provides flexibility to accommodate the researcher's specified confidence level and acceptable margin of error. According to the calculations, a total of 268 respondents was estimated as the required sample, assuming a population of 816 and a 5% margin of error. However, a total of 300 mathematics teachers in Selangor were recruited as the sample using a clustered sampling technique. The clusters used for sampling are the school districts where the teachers work. The clustered sampling design was implemented at the district level, as participant selection followed the Ministry of Education's allocation framework. A cluster sampling approach was adopted due to logistical and administrative constraints associated with accessing respondents across multiple districts. This approach allowed efficient data collection while maintaining representation of the target population, as clusters were selected in accordance with the Ministry of Education's allocation framework. Therefore, the sampling design preserved population coverage while improving feasibility of data collection. A larger sample improves the accuracy of the findings and minimizes sampling error. There are 235 men (78%) and 65 women (22%), according to the demographics of the respondents. 60 Chinese (20%), 71 Indians (24%), 162 Malays (54%), and 7 people from other ethnic groups (2%), make up the ethnic population. Of the respondents, 92 (31%) have 0–5 years of teaching experience, 132 (44%) have 6–10 years, and 76 (25%) have 11 years or more.

Instrument

As part of the respondents' profiles, the study gathers information on secondary school mathematics teachers in Selangor, specifically their gender, ethnicity, academic qualifications, and years in the teaching profession. Responses for all study constructs were collected using a six-point Likert scale. The self-efficacy scale comprises 19 items and covers the following dimensions: modelling cycle efficacy (4 items), modelling task efficacy (5 items), pedagogical efficacy (5 items), and assessment efficacy (5 items). This instrument was adopted from Hidayat et al. (2024). The modelling resilience scale contains 18 items, encompassing three dimensions: value (7 items), struggle (7 items), and growth (4 items). This scale was adapted from Kookan et al. (2013) Mathematical Resilience Scale, with modifications made to fit the scope of this study. The teaching modelling practices scale comprises 34 items. The dimensions measured include constructivism (8 items), understanding (6 items), relevance and real-life applications (6 items), motivation and value (8 items), and interest (6 items). This scale was adapted from Asempapa and Brooks (2020) and modified to align with the specific objectives of this study.

Self-efficacy scale, modelling resilience scale and teaching modelling practices scale were included in the research questionnaire (see Appendix A) after being adopted and adapted to suit the context of this study. The original instruments were modified according to experts review to ensure practical suitability and respondents' understanding. Firstly, the grammar of the overall items was reviewed, and modifications were made to replace contractions, such as *aren't* with *are not* and *won't* with *would not*, to enhance the face validity and professional tone of the instrument. Secondly, three items from Kookan's Mathematical Resilience scale, one under the value sub-construct and two under the growth sub-construct, were removed because several experts considered them irrelevant for measuring teachers' modelling resilience. Besides that, several items were revised as requested by the experts by inserting the term 'modelling' before 'mathematical' to better measure mathematics teachers' modelling resilience. Experts' reviews were considered, and the questionnaire was revised (see Appendix B). Before distributing the finalised questionnaire to respondents, a back-to-back translation was carried out. A Malay Language expert reviewed and translated the questionnaire to Malay language. Then, a lecturer with a strong background in English language translated the document (i.e., Malay version) into English. The validity of the translation was checked and verified.

After finalising the research questionnaire, a pilot test was conducted using the Statistical Package for the Social Sciences (SPSS) to examine the Cronbach's alpha coefficients based on 30 responses received via an online link. Cronbach's alpha was computed to assess the questionnaire's internal consistency, with values above 0.70 considered acceptable for reliability (Cohen et al., 2018). The Cronbach's alpha coefficients from the pilot study indicate that all sub-constructs of modelling self-efficacy, modelling resilience, and teaching modelling practices surpass the acceptable reliability threshold of 0.70, demonstrating good reliability, with values ranging from 0.72 to 0.94. Specifically, the alpha coefficients for the self-efficacy construct were 0.95, for modelling resilience were 0.92, and for teaching modelling practices were 0.91. The results confirm the reliability of the instruments for testing the research hypotheses.

Table 1. Descriptive outputs

Constructs	Skewness	Kurtosis	Mean	Standard deviation	Self-efficacy	Modelling resilience	Teaching modelling practices
Self-efficacy	.130	1.092	4.313	.354	1	.339**	.286**
Modelling resilience	.837	1.546	4.166	.393		1	.475**
Teaching modelling practices	.046	-1.001	4.865	.543			1

Data Analysis

Descriptive statistics and Pearson correlation coefficients were computed using SPSS (version 29.0) to examine relationships among the latent variables and to identify potential multicollinearity, with values below 0.900 considered acceptable (Kline, 2023). Skewness (± 2.0) and kurtosis (± 8.0) were used to assess univariate normality (Kline, 2023). Structural Equation Modelling (SEM) was conducted using AMOS to test the hypothesized model (Idris et al., 2023). Reliability and convergent validity were evaluated through composite reliability (CR > 0.60), Cronbach's alpha (> 0.70), and average variance extracted (AVE > 0.50), while discriminant validity was assessed through the Fornell-Larcker criterion and the heterotrait-monotrait (HTMT) ratio (< 0.900). Next, the structural model was evaluated to assess the model fit and the hypothesized relationships. Multiple indices were used to assess the model fit: chi-square ($p > .05$), comparative fit index (CFI > 0.900), Tucker-Lewis Index (TLI > 0.900), root mean square error of approximation (RMSEA < 0.080), and goodness of fit index (GFI > 0.900). Mediation analysis was conducted using a 5,000-subsample bias-corrected accelerated bootstrapping method to improve precision.

To examine the moderating effect of teaching experience on the relationship between self-efficacy and teaching modelling practices, a moderation analysis was conducted using multiple regression. Prior to analysis, the independent variable (self-efficacy) and the moderator (teaching experience) were mean-centered to reduce potential multicollinearity. An interaction term (teaching experience \times self-efficacy) was then generated by multiplying the moderator and centered independent variable. First, the independent variable and moderator were included into the regression model. Next, the interaction term was added to test the moderating effect. A statistically significant interaction term indicates the presence of moderating effect ($p < .05$). A simple slope test was conducted to further interpret significant interaction effects by examining the relationship between self-efficacy and teaching modelling practices at low ($-SD$), mean, and high ($+1SD$) levels of teaching experience. This approach facilitated understanding of how the strength of the relationship varied across different levels of teaching experience.

RESULTS

Descriptive Results

The descriptive findings for self-efficacy and modelling resilience in relation to teaching modelling practices are presented in **Table 1**.

The results in **Table 1** show mathematics teachers exhibited moderate to high level of proficiency in self-efficacy, modelling resilience, and teaching modelling practices, with mean scores of 4.313, 4.166, and 4.865, respectively. Skewness values, ranging from 0.046 to 0.837, were within the acceptable limit of ± 2.0 , while kurtosis values, varying from -1.001 to 1.546, were within the acceptable threshold of ± 8.0 . The analysis also indicated positive correlations among the variables. Self-efficacy showed a positive correlation with modelling resilience ($r = 0.339$, $p < .01$) and teaching modelling practices ($r = 0.286$, $p < .01$). Likewise, modelling resilience demonstrated a direct positive relationship with teaching modelling practices ($r = 0.475$, $p < .01$).

The intraclass correlation coefficients (ICC) and design effects (DEFF) showed that most of the variability in teaching modelling practices (ICC = 0.015, DEFF = 1.89), self-efficacy (ICC = 0.012, DEFF = 1.71), and resilience (ICC = 0.020, DEFF = 2.18) was attributable to within-group differences rather than between-group differences. The low ICC and DEFF values indicate that group membership had minimal impact, suggesting that analyses assuming independent observations are appropriate, and that further clustering or multilevel analyses are not required (Haddad et al., 2012). Although the data were collected using a clustered sampling design at the district level, ICC indicated low between-district variance (0.012–0.020), suggesting that most variability was at the individual level. The DEFF ranged from 1.71 to 2.18, with one variable slightly exceeding the commonly referenced threshold of 2.0. Based on these indicators, clustering was not explicitly modelled in the primary SEM analyses. However, the presence of a modest clustering effect is acknowledged, and the results should be interpreted with this limitation in mind. To assess the potential for common method bias, Harman's single-factor test was conducted. The results indicated that the first factor accounted for 37.34% of the total variance, which is below the commonly referenced threshold of 50%. While this suggests that common method bias is unlikely to be a serious concern in the present study, it is acknowledged that Harman's single-factor test has limitations and does not fully rule out the presence of method variance. Therefore, the results should be interpreted with appropriate caution, and additional procedural controls (e.g., anonymity and item separation) were applied during data collection to reduce potential bias (Podsakoff et al., 2003).

Evidence for Reliability and Validity

In this study, heterotrait-monotrait (HTMT) ratio of correlations and the Fornell-Larcker criterion were conducted to examine the discriminant validity, with particular attention given to the sub-constructs of self-efficacy, modelling resilience, and teaching modelling practices. As presented in **Table 2**, the HTMT range was 0.399 to 0.679, all remaining less than the recommended benchmark of 0.900 for theoretically similar constructs, such as reflective ones. Additionally, all values meet the required

Table 2. Validity results

Fornell-Larcker criterion			
	Modelling resilience	Self-efficacy	Teaching modelling practices
Modelling resilience	0.685		
Self-efficacy	0.543	0.721	
Teaching modelling practices	0.659	0.475	0.924
Heterotrait-monotrait ratio (HTMT)			
	Modelling resilience	Self-efficacy	Teaching modelling practices
Modelling resilience			
Self-efficacy	0.602		
Teaching modelling practices	0.679	0.399	
Inner VIF values for collinearity assessment			
	Modelling resilience	Self-efficacy	Teaching modelling practices
Modelling resilience			1.419
Self-efficacy	1.000		1.419
Teaching modelling practices			

Table 3. Reliability outputs

Constructs	Sub-constructs	α	CR	AVE
Self-efficacy	MCE	0.878	.875	.703
	MT		.777	.538
	PE		.839	.566
	AE		.806	.581
Modelling resilience	V	0.874	.893	.545
	S		.877	.589
	G		.870	.691
Teaching modelling practices	C	0.979	.956	.731
	U		.814	.527
	RR		.921	.661
	MV		.942	.670
	I		.880	.551

Note: CR: Composite Reliability, AVE: Average Variance Extracted

standards for the Fornell-Larcker criterion. Results of our analysis revealed VIF values ranging from 1.000 to 1.419 across all endogenous and exogenous constructs, which falls well below the critical criterion of 5. This indicates that there were no collinearity issues within the model across all sub-constructs of self-efficacy, modelling resilience, and teaching modelling practices.

Furthermore, the measurement data's reliability was systematically evaluated through Cronbach's alpha and composite reliability (CR), as presented in **Table 3**. The study demonstrated strong internal consistency, as reflected in Cronbach's alpha values of 0.878 for self-efficacy, 0.874 for modelling resilience, and 0.979 for teaching modelling practices. All survey instruments demonstrated Cronbach's alpha and CR values exceeding the 0.7 benchmark, which verifies strong reliability. The CR values for the self-efficacy sub-constructs ranged between 0.777 and 0.875, for modelling resilience between 0.870 and 0.893, and for teaching modelling practices between 0.814 and 0.956. These overall CR values surpassed the suggested benchmark of 0.7, reflecting an acceptable reliability level (Hair et al., 2010). The AVE for self-efficacy sub-constructs ranged from 0.538 to 0.703, for modelling resilience from 0.545 to 0.691, and for teaching modelling practices from 0.527 to 0.731. These findings confirmed adequate internal consistency across all constructs, thus confirming convergent validity (Hair et al., 2010).

Measurement Model

The measurement model for self-efficacy revealed that its four sub-constructs aligned well with the empirical data: $\chi^2 = 438.011$, $\chi^2/df = 3.000$, RMSEA = 0.082, CFI = 0.887, TLI = 0.867. However, one item (MCE4) from modelling cycle efficacy, two items (MT1, MT2) from modelling task efficacy, two items (PE1, PE3) from pedagogical efficacy, and one item (AE3) from assessment efficacy had factor loadings below 0.70 and were removed from subsequent analyses. The improved measurement model of self-efficacy exhibited a satisfactory fit with the observed data, with all four sub-constructs showing satisfactory alignment: $\chi^2 = 106.841$, $\chi^2/df = 1.811$, RMSEA = 0.052, CFI = 0.973, TLI = 0.965. Additionally, the initial measurement model for modelling resilience showed that its three sub-constructs demonstrated a reasonable fit with the observed data: $\chi^2 = 480.210$, $\chi^2/df = 3.638$, RMSEA = 0.094, CFI = 0.871, TLI = 0.851. However, two items (S6, S7) of struggle and one item (G1) of growth had factor loadings below 0.70. These items were subsequently removed from further analysis. The revised measurement model demonstrated improved fit indices, indicating a good alignment with the observed data; $\chi^2 = 224.082$, $\chi^2/df = 2.576$, RMSEA = 0.072, CFI = 0.942, TLI = 0.930. The measurement model for teaching modelling practices which comprised five sub-constructs, demonstrated a satisfactory fit to the data: $\chi^2 = 1107.687$, $\chi^2/df = 2.143$, RMSEA = 0.062, CFI = 0.923, TLI = 0.916. However, two items (U3, U6) from the understanding sub-construct had factor loadings below 0.70 and were therefore excluded in the following analyses. The improved measurement model of teaching modelling practices exhibited a strong fit with the observed data, with all five sub-constructs exhibiting satisfactory alignment: $\chi^2 = 981.132$, $\chi^2/df = 2.161$, RMSEA = 0.062, CFI = 0.929, TLI = 0.923. The self-efficacy construct showed factor loadings ranging from 0.700 to 0.938, while those for modelling resilience varied from 0.714 to 0.875. The teaching

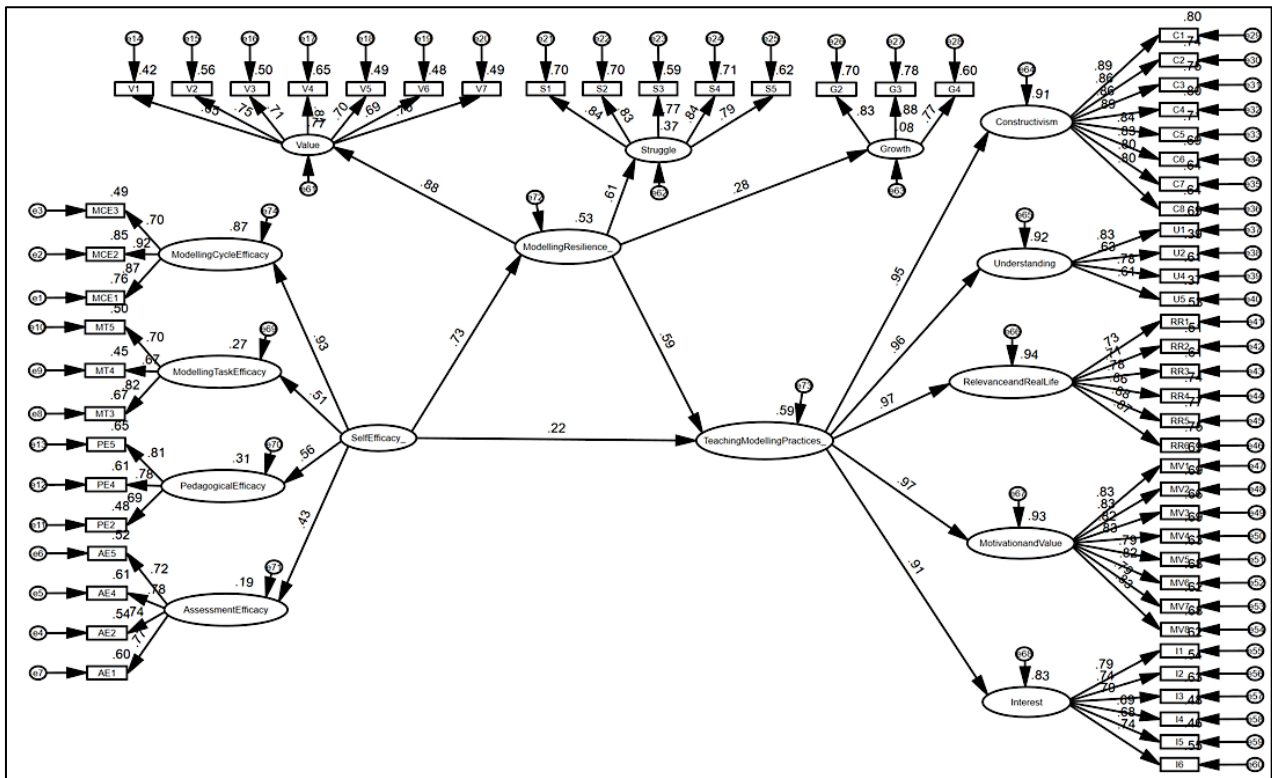


Figure 2. The hypothesized model (Source: Authors' own elaboration)

modelling practices construct exhibited factor loadings between 0.700 and 0.875. All factor loadings were statistically significant ($p < 0.001$), demonstrating meaningful relationships with their respective constructs.

The exclusion of certain indicators was informed by conceptual reasoning alongside empirical evaluation. Although these items were originally intended to operationalize their respective constructs, further scrutiny indicated that they reflected peripheral, context-specific, or potentially ambiguous facets that were not integral to the constructs' theoretical foundations. Retention of such indicators could have compromised construct clarity and internal consistency. The observed low factor loadings provided empirical support for this conceptual judgment rather than constituting the sole rationale for item removal. While the elimination of indicators may raise concerns regarding potential construct underrepresentation, this concern is mitigated by the retention of a sufficient number of indicators capturing the core dimensions of each construct, all of which demonstrated strong and statistically significant associations with their latent variables. The measurement refinement represents a deliberate balance between theoretical coherence and content coverage, aimed at strengthening construct validity. Scholars generally advise that indicator deletion be limited to a modest proportion of the original scale, commonly suggested to be approximately 20%, to safeguard construct coverage, provided that theoretical coherence is preserved and an adequate number of indicators remains for each construct (DeVellis, 2017).

Examining the Hypothesized Model

The final structural equation model (SEM) demonstrated an acceptable fit to the data, with $\chi^2 = 3502.905$, $\chi^2/df = 2.063$, $RMSEA = 0.059$, $SRMR = 0.064$, $CFI = 0.900$, and $TLI = 0.900$. **Figure 2** illustrates finalized structural model, depicting the relationships among self-efficacy, modelling resilience, and teaching modelling practices. Importantly, all path coefficients within the proposed model showed statistical significance. Standardized factor loadings across the sub-constructs ranged from 0.700 to 0.923, reflecting strong explanatory power. Teaching modelling practices exhibited substantial R^2 of 0.588, suggesting that self-efficacy and modelling resilience together accounted for 58.8% of the variance in teaching modelling practices. Furthermore, self-efficacy explained 73% of the variance in modelling resilience, as indicated by an R^2 value of 0.730.

Direct, Indirect and Moderating Effect

Table 4 presents detailed statistics on the direct, mediating and moderating effect of self-efficacy \rightarrow modelling resilience, and self-efficacy \rightarrow teaching modelling practices. This analysis includes the upper and lower confidence intervals, and p -values.

Table 4. Path analysis

Construct	Direct Effect		CI 95%		Decision
	β	p	Lower	Upper	
Self-efficacy → Modelling resilience	0.730	0.005	0.634	0.871	Significant
Self-efficacy → Teaching modelling practices	0.220	0.006	0.122	0.299	Significant
Construct	Indirect Effect		CI 95%		Decision
	β	p	Lower	Upper	
Self-efficacy → Modelling resilience → Teaching modelling practices	0.429	0.001	0.314	0.565	Partial Mediation
Construct	Moderating Effect		CI 95%		Decision
	β	p	Lower	Upper	
Self-efficacy → Teaching modelling practices	0.220	0.006	0.122	0.299	Significant
Teaching experience → Teaching modelling practices	0.401	0.012	0.299	0.472	Significant
Self-efficacy*Teaching experience → Teaching modelling practices	-0.076	0.083	-0.163	0.003	Not Significant / No moderation

As detailed in **Table 4**, the direct path coefficients were statistically significant for the relationships of self-efficacy → modelling resilience [$\beta = .730, p < .05, 95\% \text{ CI } (.634 \sim .871)$] and self-efficacy → teaching modelling practices [$\beta = .220, p < .05, 95\% \text{ CI } (.122 \sim .299)$]. Consequently, the first research question was fully supported. The indirect positive effect of self-efficacy on teaching modelling practices via modelling resilience was statistically significant [$\beta = .429, p < .05, 95\% \text{ CI } (.314 \sim .565)$]. However, since the direct effect of self-efficacy on teaching modelling practices remained significant after accounting for modelling resilience, the mediation effect is therefore characterised as partial. Our hypothesis was fully supported, confirming the mediating role of modelling resilience between self-efficacy and teaching modelling practices.

Self-efficacy had a significant positive effect on teaching modelling practices [$\beta = .220, p < .05, 95\% \text{ CI } (.122 \sim .299)$]. Similarly, teaching experience also showed a significant positive effect on teaching modelling practices [$\beta = .401, p < .05, 95\% \text{ CI } (.299 \sim .472)$]. However, the interaction method analysis revealed that the interaction effect between self-efficacy and teaching experience was not statistically significant [$\beta = -0.076, p > .05, 95\% \text{ CI } (-.163 \sim .003)$], indicating that teaching experience does not significantly moderate the relationship between self-efficacy and teaching modelling practices. Therefore, the third research question was not supported.

DISCUSSION

This study examines how modelling resilience mediates the relationship between self-efficacy and teaching modelling practices among mathematics teachers in Malaysia. By focusing on the specific context of mathematics, this study emphasises the relevance of mathematical modelling and the critical factors that shape teaching modelling practices. The findings offer valuable perspectives on the interconnected roles of self-efficacy, modelling resilience, and teaching modelling practices in the mathematics classroom. The findings indicated a positive association between teachers' self-efficacy and modelling resilience, consistent with prior studies (Li, 2023). The finding highlights the crucial importance of mathematics teachers' confidence in their abilities when navigating the complexities of mathematical modelling. It aligns with Bandura's (1997) social cognitive theory, which suggests that those with greater self-efficacy tend to persist through challenges, adapt to setbacks, and remain committed to achieving difficult goals—key attributes of resilience. Moreover, the significant positive association between self-efficacy and teaching modelling practices observed in this study reinforces prior research emphasising that crucial role of teacher self-efficacy is associated with higher instructional quality and corresponds with more innovative teaching approaches (Yahya & Maat, 2022). Teachers exhibiting strong self-belief in mathematics likely to employ pedagogical strategies proven effective in mathematics classrooms (Berg et al., 2025). Thus, enhancing teacher self-efficacy may function as a practical pathway to strengthen resilience, particularly within the demanding context of teaching mathematical modelling.

Consistent with prior research on resilience as a mediator in educational settings (Li, 2023; Simacon & Veloria, 2022), this research shows that modelling resilience plays a mediating role in the relationship between self-efficacy and teaching modelling practices among mathematics teachers in Malaysia. The significant indirect effect indicates that teachers exhibiting stronger self-efficacy are inclined to develop greater modelling resilience, which in turn enhances their engagement in modelling-based instruction. Although the mediation is partial—meaning self-efficacy also significantly associates with teaching practices—modelling resilience emerges as a key psychological factor mediating the relationship between teachers' confidence and effective pedagogical strategies. These findings support the theoretical framework presented in earlier literature and underscore the demand for professional development programs that build both self-efficacy and resilience. Strengthening these areas can empower teachers to adopt and sustain effective modelling instruction that addresses the varied needs of students. This also reinforces the idea that modelling resilience acts as a bridge—either fully or partially—between self-efficacy and various instructional outcomes, particularly in mathematical contexts. As Agtarap and Miranda (2022) and Li (2023) suggest, confidence in modelling skills associated with a greater likelihood of adopting and maintaining modelling-focused practices in the classroom, while resilience further linked to improved academic achievement. The partial mediation identified in this study points to the importance of modelling resilience in the relationship between teachers' self-efficacy and instructional effectiveness.

This study revealed that both self-efficacy and teaching experience independently and positively associated with teaching modelling practices, suggesting that teachers with greater self-efficacy and longer teaching experience are better at teaching modelling practices. However, the interaction effect between self-efficacy and teaching experience was not statistically

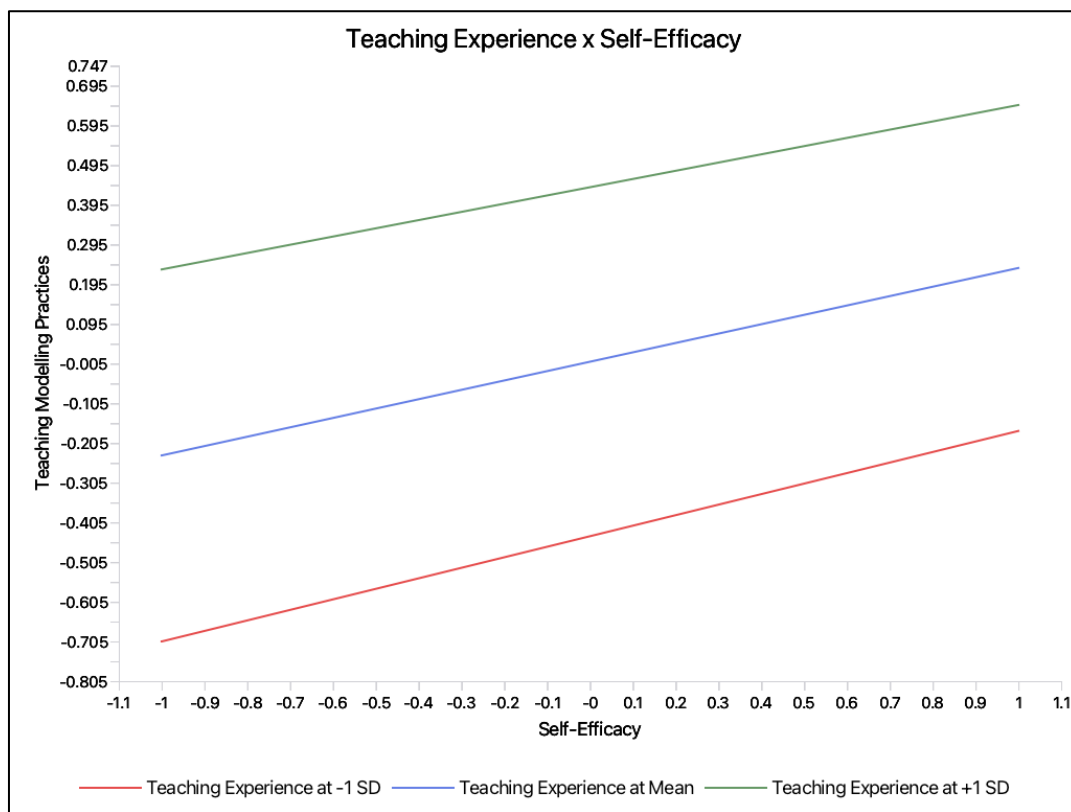


Figure 3. The simple slope test (Source: Authors' own elaboration)

significant, suggesting that teaching experience fails to significantly moderate the association between self-efficacy and teaching modelling practices. This indicates that the association of self-efficacy on teaching practices remains stable, irrespective of a teacher's years of teaching experience. These findings stand in contrast to previous literature, which often emphasises the association of teaching experience with instructional quality and students' academic performance (Ene et al., 2022). Both practically and theoretically, experienced teachers tend to possess stronger pedagogical content knowledge, better classroom management skills, and greater adaptability—factors that are expected to complement and strengthen the association between self-efficacy and teaching practices. As such, teachers should be better positioned to align their self-beliefs with effective classroom strategies, including modelling-based instruction. This discrepancy in results might be attributed to mathematical modelling being relatively new in Malaysia's curriculum, having been introduced only in 2021. Although many teachers possess extensive teaching experience, they may have had limited opportunities to engage with modelling tasks or to receive formal training to develop expertise in modelling instruction specifically. Consequently, their teaching experience may not significantly strengthen the relationship between self-efficacy and modelling practices, as modelling remains an evolving teaching approach. In this context, teaching experience may not yet be a strong factor in shaping modelling competency, particularly given the limited availability of professional development in this area. Moreover, teaching mathematical modelling often demands a set of specialised competencies that go beyond general teaching experience. For instance, the ability to design authentic real-world tasks, support open-ended problem-solving, and guide students through the iterative stages of the modelling process may not be emphasised in traditional teaching practice. Finally, a basic slope analysis was performed to gain a more comprehensive understanding of the moderating influence of teaching experience on self-efficacy and teaching modelling practices. As seen in **Figure 3**, the relationship between self-efficacy and teaching modelling practices is not significantly moderated by teaching experience. Compared to participants with average or below-average levels of teaching experience, those who reported higher-than-average levels of teaching experience did not show a stronger relationship between self-efficacy and teaching modelling practices.

CONCLUSION AND IMPLICATION

To conclude, this study highlights key factors associated with how teachers approach the practice of teaching mathematical modelling in the classroom. It underscores the crucial roles of self-efficacy and modelling resilience, offering new insights that build upon and extend existing research into effective teaching practices. Although the integration of mathematical modelling into classroom instruction remains a global educational priority, it is often hindered by cognitive, pedagogical, and motivational barriers—particularly among teachers with low modelling self-efficacy. This research advances the field by providing empirical evidence that validates the mediating role of modelling resilience, a factor that has been largely overlooked in the mathematical modelling literature. The findings indicate a positive association between self-efficacy and modelling-related teaching practices, emphasising the importance of teachers' confidence in effectively incorporating modelling into their instruction. Furthermore,

the identification of modelling resilience as a partial mediator suggests that resilience partially explains the relationship between self-efficacy and teaching practices. The study also examined the role of teaching experience in this relationship. While both self-efficacy and experience were found to independently associated with effective modelling practices, teaching experience was not found to moderate the association between self-efficacy and instructional implementation. This suggests that even experienced teachers may struggle to translate their expertise into effective modelling instruction without targeted training and support, particularly as mathematical modelling remains a relatively new and evolving area within the Malaysian education context. Considering these findings, the study affirms the significance of sustained professional development and capacity-building initiatives specifically tailored to modelling instruction. While teaching experience is undeniably valuable, its role on teaching practices may be limited unless supported by modern pedagogical strategies and content knowledge aligned with ongoing curriculum reforms.

This study offers significant contributions to mathematics education by highlighting the critical interplay between self-efficacy, modelling resilience, and teaching practices in mathematical modelling. While previous research has explored factors such as metacognition, attitude, and self-efficacy, the role of resilience as a mediating variable remains underexplored, particularly in the context of teaching. By empirically validating modelling resilience as a partial mediator, this study fills an important gap in the existing literature and deepens understanding of the psychological and pedagogical factors that relate to effective modelling instruction. The findings have practical implications for multiple stakeholders. For lecturers and teachers, the study encourages reflection on their own practices and supports the integration of resilience-building strategies in teacher training programs, thereby equipping future teachers to navigate the challenges of modelling instruction. Lecturers can incorporate these insights into curriculum design, aligning theory with practice to develop more competent and adaptable pre-service teachers. For in-service teachers, the findings emphasise the importance of cultivating both self-efficacy and modelling resilience, given their positive association with instructional quality and teachers' positive approach despite classroom challenges. The study also informs policymakers and curriculum developers, offering valuable data to support reforms that embed mathematical modelling into the school curriculum. It advocates for the inclusion of resilience-focused training within teacher preparation programs and encourages education ministries to prioritise modelling competency from early stages. By affirming the relevance and importance of incorporating mathematical modelling, this study highlights how mathematics can be meaningfully connected to real-life situations. Ultimately, the research offers valuable insights that can enhance teacher development, inform curriculum design, and guide policy decisions, thereby fostering more capable and resilient mathematics educators in today's evolving educational environment.

RESEARCH LIMITATIONS AND FUTURE SUGGESTIONS

As is common in research, this study is subject to certain limitations that warrant acknowledged. Firstly, while some of our hypotheses were fully supported, others were only partially validated. This suggests that factors such as teachers' self-efficacy, modelling resilience, and modelling competency may interact in more complex ways than initially assumed. Future studies could investigate these interactions more thoroughly and determine effective approaches to enhance modelling-focused teaching practices. Secondly, the use of a cross-sectional design, which collects data at one specific time, constrains the ability to examine how self-efficacy, modelling resilience, and teaching practices develop throughout a teacher's professional journey. This design also restricts the ability to infer causal relationships or track developmental shifts. Future studies should consider using experimental or longitudinal approaches, which are better suited for capturing changes over time and establishing cause-and-effect patterns. Thirdly, while correlation and mediation analyses help explore relationships between variables, they have limitations in determining directionality and rely on assumptions that may not always hold, such as accurate measurement of mediators and the absence of confounding variables. Advanced analytical methods could offer more robust insights into causal pathways. Fourthly, although the use of clustered sampling within five districts in Selangor supports internal validity, it limits the generalisability of findings to other regions and pre-service teacher populations. Expanding the sampling frame to include a broader geographic and institutional range—and involving both in-service and pre-service teachers—would offer a more representative understanding of teaching practices.

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Ethical statement: The authors stated that the research was approved by The Ethics Committee of Universiti Putra Malaysia (JKEUPM) granted approval for the data collecting process, and a letter of authorization to collect data was obtained, on 01/10/2025 with reference JKEUPM-2025-459. The authors supplied a written consent letter outlining the project's intent and the study's purpose. Participants indicated their agreement by ticking a box to confirm their full participation in the study.

AI statement: The authors stated that the article uses Artificial Intelligence (AI) to check for coherency, grammar, and overall readability, ensuring the content is clear and well-structured.

Declaration of interest: No conflict of interest is declared by the authors.

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REFERENCES

- Abu-Tineh, A. M., Khasawneh, S. A., & Khalailah, H. A. (2011). Teacher self-efficacy and classroom management styles in Jordanian schools. *Management in Education*, 25(4), 175-181. <https://doi.org/10.1177/0892020611416214>
- Agtarap, R., & Miranda, A. T. (2022). The mediating effect of students' resiliency on the relationship of self-concept and mathematics performance. *Asian Journal of Education and Social Studies*, 36(2), 1-10. <https://doi.org/10.9734/ajess/2022/v36i2772>
- AlAli, R. M., & Al-Barakat, A. A. (2024). Utilizing pre-service mathematics teachers to implement effective teaching and learning practices during their field experience. *Edelweiss Applied Science and Technology*, 8(6), 1228-1239. <https://doi.org/10.55214/25768484.v9i1.2203>
- Araújo, J. D. L., & Lima, F. H. D. (2020). The mathematization process as object-oriented actions of a modelling activity system. *Bolema: Boletim de Educação Matemática*, 34(68), 847-868. <https://doi.org/10.1590/1980-4415v34n68a01>
- Arseven, A. (2015). Mathematical modelling approach in mathematics education. *Universal Journal of Educational Research*, 3(12), 973-980. <https://doi.org/10.13189/ujer.2015.031204>
- Asempapa, R. S., & Brooks, G. P. (2020). Factor analysis and psychometric evaluation of the mathematical modeling attitude scale for teachers of mathematics. *Journal of Mathematics Teacher Education*, 25(2), 131-161. <https://doi.org/10.1007/s10857-020-09482-0>
- Berg, D. A. G., Ingram, N., Asil, M., Ward, J., & Smith, J. K. (2025). Self-efficacy in teaching mathematics and the use of effective pedagogical practices in New Zealand primary schools. *Journal of Mathematics Teacher Education*, 28(1), 129-149. <https://doi.org/10.1007/s10857-024-09623-9>
- Blum, W., & Borromeo Ferri, R. (2009). Mathematical modelling: Can it be taught and learnt? *Journal of Mathematical Modelling and Application*, 1(1), 45-58. https://eclass.uoa.gr/modules/document/file.php/MATH601/3rd%20%26%204rth%20unit/3rd%20unit_Modelling%20cycle.pdf
- Bukari, H. I., & Govender, R. (2024). Developing modelling competencies in pre-service mathematics teachers through reflective thinking skills. *African Journal of Teacher Education and Development*, 3(1), Article a54. <https://doi.org/10.4102/ajoted.v3i1.54>
- Cevikbas, M., Kaiser, G., & Schukajlow, S. (2022). A systematic literature review of the current discussion on mathematical modelling competencies: State-of-the-art developments in conceptualizing, measuring, and fostering. *Educational Studies in Mathematics*, 109, 205-236. <https://doi.org/10.1007/s10649-021-10104-6>
- Chirkina, T., Khavenson, T., Pinskaya, M., & Zvyagintsev, R. (2020). Factors of student resilience obtained from TIMSS and PISA longitudinal studies. *Issues in Educational Research*, 30(4), 1245-1263.
- Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge. <https://doi.org/10.4324/9781315456539>
- DeVellis, R. F. (2017). *Scale development: Theory and applications* (4th ed.). Sage.
- Durksen, T. L., Klassen, R. M., & Daniels, L. M. (2017). Motivation and collaboration: The keys to a developmental framework for teachers' professional learning. *Teaching and Teacher Education*, 67, 53-66. <https://doi.org/10.1016/j.tate.2017.05.011>
- Ene, C. U., Anyiam, L. I., & Onoja, A. E. (2022). Influence of teachers' years of teaching experience on students' academic achievement in Basic Education Certificate Examination in basic science. *African Journal of Science, Technology & Mathematics Education*, 8(1), 488-494.
- Ergene, B. C., & Ergene, Ö. (2024). Mathematical modeling self-efficacy of middle school and high school students. *Participatory Educational Research*, 11(4), 99-114. <https://doi.org/10.17275/per.24.51.11.4>
- Geiger, V., Galbraith, P., Niss, M., & Delzoppo, C. (2021). Developing a task design and implementation framework for fostering mathematical modelling competencies. *Educational Studies in Mathematics*, 109, 313-336. <https://doi.org/10.1007/s10649-021-10039-y>
- Gerber, S., Quarder, J., Greefrath, G., & Siller, H.-S. (2023). Promoting adaptive intervention competence for teaching simulations and mathematical modelling with digital tools: Theoretical background and empirical analysis of a university course in teacher education. *Frontiers in Education*, 8, Article 1141063. <https://doi.org/10.3389/feduc.2023.1141063>
- Greefrath, G., Siller, H., Klock, H., & Wess, R. (2022). Pre-service secondary teachers' pedagogical content knowledge for the teaching of mathematical modelling. *Educational Studies in Mathematics*, 109(2), 383-407. <https://doi.org/10.1007/s10649-021-10038-z>
- Guo, Y., Connor, C. M., Yang, Y., Roehrig, A. D., & Morrison, F. J. (2012). The effects of teacher qualification, teacher self-efficacy, and classroom practices on fifth graders' literacy outcomes. *The Elementary School Journal*, 113(1), 3-24. <https://doi.org/10.1086/665816>
- Haddad, S. M., Sousa, M. H., Cecatti, J. G., Parpinelli, M. A., Costa, M. L., & Souza, J. P. (2012). Intra-class correlation coefficients in the Brazilian network for surveillance of severe maternal morbidity study. *BMC Pregnancy and Childbirth*, 12(1), 1-10. <https://doi.org/10.1186/1471-2393-12-101>
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis* (7th ed.). Prentice Hall.

- Hendriyanto, A., Priatna, N., Juandi, D., Dahlan, J. A., Hidayat, R., Sahara, S., & Muhaimin, L. H. (2023). Learning mathematics using an ethnomathematics approach: a systematic literature review. *Journal of Higher Education Theory and Practice*, 23(7). <https://doi.org/10.33423/jhetp.v23i7.6012>
- Hidayat, R., Hermandra, & Ying, S. T. D. (2023). The sub-dimensions of metacognition and their influence on modeling competency. *Humanities and Social Sciences Communications*, 10, Article 763. <https://doi.org/10.1057/s41599-023-02290-w>
- Hidayat, R., Mohd Ayub, A. F., Abd Hamid, H. S., & Nasir, N. (2025). Difficulties in instructing mathematical modeling: Case study in Malaysia. *International Electronic Journal of Mathematics Education*, 20(2), Article em0811. <https://doi.org/10.29333/iejme/15815>
- Hidayat, R., Syed Zamri, S. N. A., Zulnaidi, H., Abdullah, M. F. N. L., & Mazlini Adnan. (2021). The interrelationships between metacognition and modeling competency: The moderating role of the academic year. *European Journal of Educational Research*, 10(3), 1853-1866. <https://doi.org/10.12973/eu-jer.10.4.1853>
- Holzberger, D., Philipp, A., & Kunter, M. (2013). How teachers' self-efficacy is related to instructional quality: A longitudinal analysis. *Journal of Educational Psychology*, 105(3), 774-786. <https://doi.org/10.1037/a0032198>
- Hutauruk, A. J. B., & Priatna, N. (2017). Mathematical resilience of mathematics education students. *IOP Conference Series: Journal of Physics: Conference Series*, 895, 012067. <https://doi.org/10.1088/1742-6596/895/1/012067>
- Idris, W. I. W., Hermawati, D., Hidayat, R., & Nasir, N. (2023). The role of job satisfaction in preschool teachers' well-being: a structural equation modeling analysis. *International Journal of Educational Methodology*, 9(4), 657-669. <https://doi.org/10.12973/ijem.9.4.657>
- Jabar, J. M., Hidayat, R., Samat, N. A., Rohizan, M. F. H., Rosdin, N. A., Salim, N., & Norazhar, S. A. (2022). Augmented reality learning in mathematics education: A systematic literature review. *Journal of Higher Education Theory and Practice*, 22(15), 183-202. <https://doi.org/10.33423/jhetp.v22i15.5570>
- Kaiser, G. (2007). Modelling and modelling competencies in school. In C. Haines, P. Galbraith, W. Blum, & S. Khan (Eds.), *Mathematical modelling: Teaching and assessment in a technology-rich world* (pp. 110-119). Woodhead Publishing. <https://doi.org/10.1533/9780857099419.3.110>
- Kannadass, P., Hidayat, R., Siregar, P. S., & Husain, A. P. (2023). Relationship between computational and critical thinking towards modeling competency among pre-service mathematics teachers. *TEM Journal*, 12(3), 1370-1382. <https://doi.org/10.18421/TEM123-17>
- Kline, R. B. (2023). *Principles and practice of structural equation modeling* (5th ed.). Guilford Press.
- Kooken, J., Welsh, M. E., McCoach, D. B., Johnston-Wilder, S., & Lee, C. (2013). *Measuring mathematical resilience: An application of the construct of resilience to the study of mathematics* [Paper presentation]. American Educational Research Association Annual Meeting, San Francisco, CA, United States.
- Lehmann, T. H. (2024). Mathematical modelling as a vehicle for eliciting algorithmic thinking. *Educational Studies in Mathematics*, 115, 151-176. <https://doi.org/10.1007/s10649-023-10275-4>
- Leong, K. E. (2014). Mathematical modelling in the Malaysian secondary curriculum. *Learning Science and Mathematics Online Journal*, 8, 66-74. http://www.recsam.edu.my/sub_lsmjournal/images/docs/2013/66-74_Leong%20Kwan%20Eu.pdf
- Leong, K. E., & Tan, J. Y. (2020). Exploring secondary students' modeling competencies. *The Math Enthusiast*, 17(1), 85-107. <https://doi.org/10.54870/1551-3440.1481>
- Leung, A. (2019). Exploring STEM pedagogy in the mathematics classroom: A tool-based experiment lesson on estimation. *International Journal of Science and Mathematics Education*, 17(7), 1339-1358. <https://doi.org/10.1007/s10763-018-9924-9>
- Li, S. (2023). The effect of teacher self-efficacy, teacher resilience, and emotion regulation on teacher burnout: A mediation model. *Frontiers in Psychology*, 14, Article 1185079. <https://doi.org/10.3389/fpsyg.2023.1185079>
- Maaß, K., Doorman, M., Jonker, V., & Wijers, M. (2019). Promoting active citizenship in mathematics teaching. *ZDM—mathematics Education*, 51, 991-1003. <https://doi.org/10.1007/s11858-019-01048-6>
- Mohd Saad, M. R., Mamat, S., Hidayat, R., & Othman, A. J. (2023). Integrating technology-based instruction and mathematical modelling for STEAM-based language learning: A sociocultural and self-determination theory perspective. *International Journal of Interactive Mobile Technologies*, 17(14), 55-80. <https://doi.org/10.3991/ijim.v17i14.39477>
- Moke, K. K. F., Chang, C. K. W., Prihadi, K., & Goh, C. L. (2018). Mediation effect of resilience on the relationship between self-efficacy and competitiveness among university students. *International Journal of Evaluation and Research in Education*, 7(4), 279-284. <https://doi.org/10.11591/ijere.v7i4.15725>
- Mota, A. I., Oliveira, H., & Henriques, A. (2016). Developing mathematical resilience: Students' voice about the use of ICT in the classroom. *Electronic Journal of Research in Education Psychology*, 14(38), 67-88. <https://doi.org/10.25115/ejrep.38.15041>
- Murphy, S., & Ingram, N. (2023). A scoping review of research into mathematics classroom practices and affect. *Teaching and Teacher Education*, 132, Article 104235. <https://doi.org/10.1016/j.tate.2023.104235>
- Oktay, A., Dogan, H., Özcan, Z. Ç., Dönmez, Ö., & Özdemir, H. (2021). Investigation of academic achievement, self-efficacy, and psychological resilience of sixth-grade students starting primary school at different ages. *Pegem Journal of Education and Instruction*, 11(1), 187-216.

- Özbek, A., & Köse, H. (2022). Determination of psychometric characteristics of mathematical modeling competencies scale: Gifted and talented youth. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Özel Eğitim Dergisi*, 23(4), 1-19. <https://doi.org/10.21565/ozelegitimdergisi.874247>
- Perera, H. N., & John, J. E. (2020). Teachers' self-efficacy beliefs for teaching math: Relations with teacher and student outcomes. *Contemporary Educational Psychology*, 61, Article 101842. <https://doi.org/10.1016/j.cedpsych.2020.101842>
- Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, 88(5), 879-903. <https://doi.org/10.1037/0021-9010.88.5.879>
- Razmjoo, S. A., & Ayoobiyan, H. (2019). On the relationship between teacher resilience and self-efficacy: The case of Iranian EFL teachers. *Journal of English Language Teaching and Learning*, 11(23), 277-292.
- Schunk, D. H. (1991). Self-efficacy and academic motivation. *Educational Psychologist*, 26, 207-231.
- Scrine, E. (2021). The limits of resilience and the need for resistance: Articulating the role of music therapy with young people within a shifting trauma paradigm. *Frontiers in Psychology*, 12, Article 600245. <https://doi.org/10.3389/fpsyg.2021.600245>
- Shanmugam, P., & Hidayat, R. (2022). Assessing grit and well-being of Malaysian ESL teachers: Application of the PERMA model. *Malaysian Journal of Learning and Instruction*, 19(2), 153-181. <https://doi.org/10.32890/mjli2022.19.2.6>
- Silverman, D. (2021). *Doing qualitative research*. SAGE Publications.
- Simacon, P. D. P., & Veloria, E. V. (2022). Reflective thinking skills and attitude towards problem-solving as mediated by mathematical resilience of the students. *Asian Journal of Education and Social Studies*, 35(4), 39-51. <https://doi.org/10.9734/ajess/2022/v35i4765>
- Tekin Dede, A., & Bukova Güzel, E. (2023). Developing a framework to support teachers' implementation of mathematical modelling. *International Journal of Mathematical Education in Science and Technology*, 56(2), 181-207. <https://doi.org/10.1080/0020739X.2023.2204098>
- Wang, T., Zhang, L., Xie, Z., & Liu, J. (2023). How does mathematical modeling competency affect the creativity of middle school students? The roles of curiosity and guided inquiry teaching. *Frontiers in Psychology*, 13, Article 1044580. <https://doi.org/10.3389/fpsyg.2022.1044580>
- Wess, R., Klock, H., Siller, H.-S., & Greefrath, G. (2021). Measuring professional competence for the teaching of mathematical modelling. In F. K. S. Leung, G. A. Stillman, G. Kaiser, & K. L. Wong (Eds.), *Mathematical modelling education in East and West* (pp. 249-260). Springer International Publishing. https://doi.org/10.1007/978-3-030-66996-6_21
- Wickstrom, M. H., & Arnold, E. G. (2023). Investigating secondary pre-service teachers as teachers and learners of mathematical modeling. *Teaching Mathematics and Its Applications: An International Journal of the IMA*, 42(1), 86-107. <https://doi.org/10.1093/teamat/hrab031>
- Xenofontos, C., & Mouroutsou, S. (2023). Resilience in mathematics education research: A systematic review of empirical studies. *Scandinavian Journal of Educational Research*, 67(7), 1041-1055. <https://doi.org/10.1080/00313831.2022.2115132>
- Yahya, N. F., & Maat, S. M. (2022). Mathematical modelling competencies mastery among secondary school teachers. *International Journal of Academic Research in Business and Social Sciences*, 12(5), 578-597. <http://dx.doi.org/10.6007/IJARBS/v12-i5/13154>
- Zee, M., & Koomen, H. M. Y. (2016). Teacher self-efficacy and its effects on classroom processes, student academic adjustment, and teacher well-being: A synthesis of 40 years of research. *Review of Educational Research*, 86(4), 981-1015. <https://doi.org/10.3102/0034654315626801>
- Zeytun, A. S., Cetinkaya, B., & Erbas, A. K. (2024). Why do prospective teachers have difficulties in mathematical modelling? Insights from their perspectives. *International Journal of Mathematical Education in Science and Technology*, 55(1), 94-117. <https://doi.org/10.1080/0020739X.2023.2171922>