



Validation of the Mathematics Teaching Model for Malaysian High School Teachers: A Structural Equation Modelling Analysis

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Abstract

Mathematics is a challenging yet essential subject that plays a vital role in professional success. Therefore, strengthening students' mathematical abilities requires effective teaching approaches. This study aims to validate a mathematical teaching model for high school teachers in Malaysia. Employing a quantitative cross-sectional survey design, data were collected from 374 high school teachers selected through simple random sampling, meeting the minimum requirements for factor analysis and SEM validation. Structural Equation Modelling (SEM) was applied using various fit indices, including RMSEA, GFI, CFI, TLI, and Chi-square, which confirmed the model's structural validity. Discriminant validity was established, as diagonal matrix values exceeded those of other cells, and each construct demonstrated adequate reliability and convergent validity with acceptable Composite Reliability (CR) and Average Variance Extracted (AVE) values. Path analysis, based on beta estimates, standard errors, critical ratios, and p-values, revealed that mathematical knowledge is the strongest and most significant predictor of mathematics teaching practice among Malaysian's high school teachers. Mathematical belief also showed a significant positive influence on teaching practice, while attitude toward mathematics exhibited a significant negative effect. In contrast, mathematical competence was not a statistically significant predictor of teaching practice. Overall, this study validates a mathematical teaching model comprising four constructs: mathematical knowledge, mathematical belief, attitude toward mathematics, and mathematics teaching practice. The findings contribute to the understanding of effective mathematics teaching in the Malaysian context and provide valuable insights for teachers, researchers, and education stakeholders to improve teaching practices and enhance student learning outcomes.

Keywords: high school teacher; mathematics teaching model; structural equation modelling.

1 Introduction

Mathematics is a subject that is particularly difficult and demanding, but highly relevant for professional job success [36]. However, Malaysian students performed poorly in the Trends in International mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA). Malaysia achieved an above-average score of 519 in their initial participation in TIMSS and PISA in 1999, ranking 16 out of 38 nations [54]. However, in the last TIMSS test, Malaysian eighth graders showed diminishing tendencies. According to Yang and Sianturi [83], Malaysia was frequently ranked last in the TIMSS test. Alhassora *et al.* [6] emphasized that Malaysian students TIMSS and PISA scores were less than sufficient. Malaysia, for example, was rated 26th out of 45 countries in 2011 with a mean score of 440 [54]. This score improved in 2015, reaching 465 [35]. This score, however, declined in 2018, with an overall score of 440 [50].

Malaysian students' lower scores in TIMSS and PISA might be related to teacher proficiency in mathematics teaching. In this case, there is a noticeable lack of a particular, well recognised model for teaching mathematics in Malaysian schools. While the curriculum emphasizes various pedagogical approaches, such as student-centered learning and project-based learning, the implementation of these strategies remains inconsistent across different schools and regions [21]. Research reveals that teachers often rely on traditional methods and textbooks, which do not effectively encourage the development of critical thinking and problem-solving abilities necessary for effective mathematics instruction [21, 67]. Furthermore, the integration of STEM education, while supported by the Ministry of Education, has not yet converted into a unified teaching style that is routinely applied in classrooms [78]. Disparities in student engagement and mathematical achievement are exacerbated by the absence of a clear teaching model, especially for diverse student populations, such as those from rural and indigenous backgrounds [58, 13]. Therefore, even though a number of programs and frameworks have been put out, Malaysia's lack of a standardised mathematics teaching model still makes it difficult to achieve educational equity and excellence.

In this case, a specific mathematics teaching model is needed to empower the Malaysian students' mathematics knowledge. Mathematics teaching models play a vital role in boosting student learning by generating engagement, promoting deeper comprehension, and developing essential skills. In higher mathematics classrooms, for example, the BOPPPS model (Bridge, Objectives, Pre-assessment, Participatory Learning, Post-assessment, and Summary) has been successfully implemented, promoting active engagement and enhancing the educational process [82]. Similarly, when compared to traditional teaching methods, structured cooperative learning models like the Learning Together model have shown notable improvements in students' mathematical achievement, underscoring the value of collaborative learning environments [41, 84]. Additionally, it has been demonstrated that emphasizing mathematical modelling in advanced mathematics instruction increases students' attention and fosters creative thinking, improving their overall learning experience [59, 20]. When taken as a whole, these models and trends highlight how crucial interactive and adaptable teaching methods are in mathematics education, as they help students get ready for the problems of a world that is changing quickly [42].

In the context of Malaysian education, there are several models of mathematics teaching model that have been developed by previous scholars [1]. The mathematical teaching practice model by Borhan [18] involves trust and attitude amongst beginner teachers, whereas Adnan *et al.* [1] associates the beliefs, conceptual knowledge, and experience of future teachers who are demanding under the mathematics education programme at the Faculty of Education at IPTA in Malaysia. By involving polytechnic professors as a sample study, Mahmud [53] presented a model that associates teaching practice with students' beliefs, knowledge, judgement, and achievements in mathe-

matics. Previously, Siti Mistima [77] used structural equation modelling and selected high school mathematics teachers as a sample study to identify the relationship between teaching practices and the beliefs of math and teachers' pedagogical knowledge content. Likewise, Mariani [57] also used high school mathematics as a sample of her research to develop a creative teaching model based on competence, personality, and stimulation of creativity. Recently, Mansor and Jamaludin [55] have also developed a model of mathematics teaching practice and its relationship with the basic knowledge of teaching and learning process among teachers, but the sample of their research are mathematics teacher in primary schools.

Although several models of mathematics teaching practice have been available, there is still no comprehensive study in the context of mathematics secondary school education in Malaysia to identify whether there is a structured relationship between mathematical knowledge, mathematical beliefs, attitudes towards math, mathematical competence, and mathematical teaching practices involving teachers in secondary schools. Simultaneously, the researchers took the initiative to carry out this study among high school mathematics teachers as an attempt to help further improve the quality of teaching practice among mathematics educators. The necessity of the current research is filling the gap of the mathematics teaching model that incorporate the teachers' mathematical knowledge, beliefs, attitudes, and teaching practices. Furthermore, high school mathematics is a sample of this research to develop a creative teaching model based on competence, personality, and stimulation of creativity. Recently, Mansor and Jamaludin [55] developed a model of mathematics teaching practice and its relationship to the basic knowledge of teaching and learning process among teachers, but the sample in the research was mathematics teacher in a primary school. Therefore, the new insight proposed by the current research is a mathematics teaching model encompassing teachers' mathematical knowledge, beliefs, attitudes, and teaching practices that is valid and reliable to be used among high school in Malaysia. Specifically, the current research aims to determine the mathematical teaching model for high school teachers in Malaysia.

2 Literature Review

There are some concepts focused on the current research which need to be addressed in order to emphasize its significant on students' mathematics knowledge. In terms of mathematics knowledge, the failure of teachers to apply their knowledge of mathematics in actual mathematics teaching practices resulted in the occurrence of some errors in the teaching process that led to difficulty in student acceptance, the consequence of which was a deterioration in student achievement [4]. The study of [12] confirmed that the weak achievements in mathematics currently in secondary school where the students obtained less satisfactory results in the mathematics and calculus foundation during the early stages of university studies is said to be due to the teachers themselves. Saenz *et al.* [70] emphasize that teachers having a solid foundation in mathematics, particularly those with advanced degrees in the field, considerably improve student performance. This is supported by findings from [30], which highlight that teachers' specialized content knowledge is crucial for fostering student success in mathematics. Furthermore, research has demonstrated that teachers' mathematical knowledge for teaching-including their ability to explain concepts clearly and evaluate students' understanding-significantly influences student learning outcomes [74]. For example, Beilock *et al.* [16] found that teachers' mathematical proficiency not only enhance their teaching effectiveness, but also reduces students' math anxiety, fostering a more supportive learning environment.

Similarly, teachers need to have a positive attitude towards mathematics, as it will produce a

more effective learning process when students successfully master mathematics, which will lead to improved problem-solving skills that affect their achievement [28]. Perera and John [64] in their research about teacher self-efficacy beliefs for teaching math, stated that teachers' beliefs impact how teachers perceive barriers and opportunities in the learning environment. This is related to the ontological aspect of the belief as suggested by [52], that beliefs are always attached to the object of the belief. The objective of belief covers the personal, social, and epistemological aspects of nature. As a result of this belief, the teacher can create an appropriate learning environment. It can further influence students in terms of choosing, investing effort, and persisting towards goals related to activities [52, 9]. As stated in [36], teachers' beliefs about math will likely shape the learning environment. This is because the teacher's belief is related to the integration of content and pedagogy into understanding of how specific topics, problems, or issues are organised, represented, tailored to the wide range of interests and learning styles of students, and presented for instruction [79, 3]. It means that teachers' mathematics beliefs are related to the learning environment in the classroom, according to [56] where this is one of the factors that should be given more attention, despite the current development of math teaching. Furthermore, Xie and Chai [81] stated that the importance of teachers' belief was that it could impact teachers' instructional decision-making and enhance students' achievement. Teachers' belief has a reciprocal relationship where it can impact the teachers' teaching practice [15].

In terms of teachers' attitude towards math, Russo *et al.* [68] reveal that attitude captures the personal thoughts, feelings, and actions when expressing a personal view that can be positive or negative. Mathematics teacher's attitude in teaching refers to teacher confidence and self-belief in their ability to effectively facilitate students learning mathematics [69]. When teaching math, their beliefs and attitudes play an important role in justifying an in-depth focus on the process [49]. Therefore, mathematics teacher's attitude is one of the most important aspects of math teaching. Furthermore, Gresham and Burleigh [32] stated that mathematics teacher's attitude can influence how math will be taught and how the students will view math. The negative attitude of teachers will likely set the stage for lifelong behaviour and attitudinal patterns such as mathematics anxiety and avoidance of math-related tasks [33]. Alsmadi [10] stated that the high integration of mathematics towards STEM emphasises the need to study teacher attitudes towards mathematics. To be able to integrate math learning, teachers, as the main facilitators in class, should have and promote a positive attitude towards math, which can increase the number of students interested in math [5].

3 Materials and Methods

3.1 Participant

The current research aims to determine the mathematical teaching model for high school teachers in Malaysia. Quantitative research utilizing cross sectional survey design was conducted to gain the objective of the current research. According to Connelly [22], cross sectional survey design is research conducted at one point in time to collect data in order to gain a snapshot of what being studied. The data collected through survey is valid to accurately reflect the construct being studied [39]. Through the survey, researcher can analyze various perspective in the education setting, thereby it can be used to validate a specific model in the educational setting [23]. Therefore, it is sufficient to use the survey research design in the current research. In this case, the stage of the current research are as follows:

1. Researcher mapping the participants and the sample.

2. Researcher distributed the survey to the research sample.
3. Researcher analyzed the data collected with structural equation modelling technique.

The participants in the current research were high school teachers in Malaysia, particularly in Negeri Sembilan. The population of high school mathematics teachers in Negeri Sembilan were 1204 who teach in 125 schools. The selection of the sample size in the current research were determined based on simple random sampling method considering the minimum sample size of factor analysis and SEM validation for survey research. For the survey research, Hogarty *et al.* [40] contend that a sample size of 300 offers a more solid basis for factor analysis and guarantees that the factor solutions are stables and indicative of the underlying constructs being evaluated. Furthermore, research have demonstrated that bigger samples of 200 improve the findings' robustness and generalizability, even though smaller sample sizes can still produce results in SEM that are acceptable. For instance, a study's sample size of 202 was considered appropriate; however, the authors pointed out that a bigger sample might increase the precision and generalizability of the findings [63]. Similarly, another study revealed that a sample size of 213 was sufficient, however a bigger sample would yield more trustworthy insights [62]. Therefore, the determination of the sample size in this research will consider the minimum of 300 teachers. The simple random sampling was conducted by distributing 430 questionnaires to all population, and only 392 teachers filled the questionnaires. Therefore, based on the given standard of the sample size for survey in this research, the minimum sample size was achieved. The characteristics of the sample size are as follows: most of the participants were female, with 68.1%, and male, with 31.9%. In terms of education background, 78.6% of the participants hold degree certificates, 20.9% hold master degree certificates, and 0.5% hold diploma certificates. 75.3% of the participants teach major math, 22.4% teach minor math, and 2.3% teach other subjects. Most of the participants have teaching experiences more than 15 years, with a percentage of 40.3%; 26% of the participants have teaching experience of 11 – 15 years; 21.9% have teaching experience of 5 to 10 years; and 11.7% have teaching experience less than 5 years. The detailed information about the participants can be seen in Table 1.

3.2 Instrument

In modelling the mathematics teaching in Malaysian high school, there are five constructs involved in this research, and each construct is measured with each instrument. The constructs were mathematical knowledge adopted from [53], mathematical beliefs adopted from [18], attitudes towards mathematics adopted from [18], the competence of mathematics adopted from [57], and the practice of teaching math adopted from [18]. Other than that, researchers also examine the demographics of the respondents. Therefore, there are six instruments used in this research, for a total of 160 items. In the current research, the instrument validity and reliability will be confirmed through the measurement model validation. In this case, construct validity through model fit indices, convergent validity through average variance extracted (AVE), discriminant validity through Heterotrait-Monotrait ratio of correlations (HTMT) used to confirm the validity. In term of the reliability, the composite reliability and Cronbach alpha will be examined.

3.3 Data analysis

The purpose of the current research was to examine the mathematical teaching model for teachers in high schools in Malaysia. The current researcher hypothesizes that there is consistency in

Table 1: Demographic distribution of respondents.

Demography	Total	Percentages (%)
Gender		
Male	125	31.9
Female	267	68.1
Ethnic		
Malays	307	78.3
Cina	51	13.0
India	34	8.7
Ages		
25–30 years	46	11.7
31–35 years	91	23.2
36–40 years	82	20.9
Older than 40 years	173	44.1
Education level		
Diploma	3	0.5
Degree	308	78.6
Master	42	20.9
Subject		
Major Mathematics	295	75.3
Minor Mathematics	88	22.4
Others	9	2.3
Teaching experiences		
Less than 5 years	46	11.7
5–10 years	86	21.9
11–15 years	102	26.0
More than 15 years	158	40.3

the structured model of the construct of mathematical knowledge, mathematical beliefs, attitudes towards mathematics, the competence of mathematics, and the practice of teaching mathematics with the study data obtained in Malaysia. To confirm the hypothesis model, the model was examined through structural equation modelling. According to [35], structured equation modelling (SEM) is a set of statistical techniques that enable a series of relationships between one or more free variables and one or several based variables to be examined. In other words, simultaneous analysis of data can be performed to determine the relationship between the latent variables present in the hypothesis model involving exogenous and endogenous variables. SEM can analyse the relationship between different structures in a structured model, as in this study involving five structures to be combined simultaneously [56]. The compatibility of the measurement model with the data is indicated by the reliability of the structured equation model (SEM) [65]. This means that if the measuring model does not match the study data, then the constructed structurally equated model is invalid. Therefore, several measurement indicators were considered in this research. Firstly, researchers checked the model fit indices through the goodness of fit indices. For the current research, the model fit indices standard based on [37] and [35] was followed. They proposed

that the threshold for model fit indices be as follows: in absolute fit indices, RMSEA (<0.08), GFI (>0.90); in incremental fit indices, AGFI, CFI, TLI, and NFI (>0.90); and for Chi square/df (<5.0).

Researchers also check the validity and reliability of the model. For current research, the validity of the model was tested through convergent validity (AVE). Validity is said to be achieved when the AVE value reaches a minimum value of 0.5 ($AVE \geq 0.5$). However, an AVE with a value of 0.45 can still be considered if the measurement model is complex [35]. Therefore, any item that has a low load factor is recommended to be removed as it may affect access to a minimum AVE value of 0.5, resulting in the convergence validity of the construct not being achieved. Other than that, researchers check the discriminant validity of the model. In this case, if all diagonal matrix values are greater than the other values in cell lines and columns, then said discriminatory effectiveness is achieved [2]. The reliability of the model was checked with composite reliability. CR refers to the extent to which the internal persistence of the items that measure something is constructed. Each construct must reach a minimum CR value of 0.60 ($CR \geq 0.6$) to show the achieved composite reliability. Other than that, reliability was checked with Average Variance Extracted (AVE). AVE is the percentage of the variance value extracted by the items that measure something constructed. A minimum AVE value of 0.5 ($AVE \geq 0.5$) must be achieved to demonstrate the reliability of something constructed after the measurement model has been attained [66].

To explain the intercorrelation between variables, several aspects will be checked namely beta estimate, standard error, critical ratio, and p-value. In SEM models, the beta estimate is used to evaluate the strength and direction of the link between variables, as well as the impact size [8]. The standard error quantifies the variability or precision of these beta values and is critical for determining the credibility of the findings [29]. The critical ratio is derived by dividing the beta estimate by its standard error; a critical ratio larger than 1.96, equal to a significance threshold of 0.05, usually indicates a statistically significant association [43]. Lastly, the p-value measures the likelihood that the observed data would occur under the null hypothesis. A p-value less than 0.05 contradicts the null hypothesis, bolstering the significance of the beta coefficient-identified association.

4 Results

4.1 Model validation

Before testing the hypothesis that the combination of teachers' mathematical knowledge, teachers' mathematics beliefs, teachers' mathematical attitude, teachers' mathematical competence and teachers' teaching practice is the actual model of mathematics teaching in Malaysian high school education, the model structure was confirmed. The confirmation considered several aspects such as the model fit indices, discriminant validity through Heterotrait-Monotrait ratio of correlations (HTMT), the construct reliability which was measured through composite reliability (CR), and convergent validity which was measured through Average variance extracted (AVE).

Firstly, researcher check the model fit indices to confirm the model structure. The result of model fit indices reported in Table 2. As reported in Table 2, several model fit indices considered in the current research achieve the minimum standard. For example, the RMSEA attain the value of 0.039, attaining the standard of below 0.080. The GFI value was 0.961, CFI value was 0.977 and TLI value was 0.969. All of these model fit indices attain the standard of 0.90. Therefore, the model structure is valid.

Table 2: Model fit indices and acceptance levels.

Categories	Level of acceptance of index	Index value	Comments
Absolutefit index	RMSEA<0.08	0.039	The required level is achieved
Incrementalfit index	GFI>0.90	0.961	The required level is not achieved
	CFI>0.90	0.977	The required level is not achieved
	TLI>0.90	0.969	The required level is not achieved
Parsimoniousfitindex	Chi-square/df<5.0	1.588	The required level is achieved

To emphasize the validity and reliability of the model, the researcher checked the model’s construct validity, convergent validity and the Cronbach alpha. The construct validity checked through CR and convergent validity was checked through AVE. The result can be seen in Table 3.

Table 3: Construct reliability and validity results.

Construct	CR (≥ 0.6)	AVE (≥ 0.5)	\sqrt{AVE}	Cronbach’s α
Mathematical knowledge	0.733	0.586	0.766	0.758
Mathematical beliefs	0.746	0.500	0.707	0.688
Attitudes toward mathematics	0.914	0.727	0.852	0.854
Mathematical competence	0.817	0.529	0.727	0.701

Based on the result, the CR and AVE values of each construct have been found to have exceeded the specified threshold values of 0.6 for CR and 0.5 for AVE. Based on the result, the mathematical knowledge CR was 0.733 with AVE was 0.586, the mathematical belief CR was 0.746 with AVE was 0.500, the attitude toward mathematics CR was 0.914 with AVE was 0.727, and mathematical competence CR was 0.817 with AVE was 0.529. Other than that, the Cronbach alpha attained the minimum value of 0.7. For example, Cronbach alpha for mathematics competence was 0.758, mathematical belief was 0.688, attitude towards mathematics was 0.854, and mathematics competence was 0.701. Even the Cronbach alpha value for mathematics belief was 0.688 but the reliability still acceptable as the composite reliability attained the minimum standard. This proves that the reliability and validity of the model have been achieved [35]. Furthermore, the model discriminant validity was checked through Heterotrait-Monotrait ratio of correlations (HTMT). The result can be seen in Table 4.

Table 4: Intercorrelation between constructs.

Construct	Knowledge	Belief	Attitude	Competence	Practice	AVE
Knowledge	0.766					0.586
Belief	0.499	0.707				0.500
Attitude	0.158	0.418	0.852			0.727
Competence	0.283	0.518	0.462	0.727		0.529
Practice	0.102	0.490	0.324	0.348	0.709	0.503

Table 4 shows the AVE value of each structure on the diagonal matrix is greater than the other values, i.e., the value on the row and the value in the column. This situation proves that the validity of model discrimination has been achieved [35]. The AVE value obtained for each construct is as follows: mathematical knowledge equals 0.766, mathematical belief equals 0.707, attitude against mathematics equals 0.852, mathematical competence equals 0.727 and mathematical teaching practice equals 0.709. It also shows that all AVE values for each construct have values below 0.90, which proves the existence of good discriminatory validity. Therefore, based on the model fit indices, convergent validity, construct validity and discriminant validity, the model was stated to be valid and reliable, and the hypothesis result can be reported.

Furthermore, researchers checked the multicollinearity of the model by examining the correlation between the constructs. Based on Table 5, almost all constructs showed a correlation knowledge with mathematical teaching practice (0.89), and mathematical belief with mathematical teaching practice (0.89). These values indicate the moderate level of multicollinearity. However, since the measurement model gain the acceptable model fit indices, the model is still acceptable and can be retained for further analysis [35]. The strong correlations among a few constructs may reflect theoretical closeness or shared variance, but they do not necessarily compromise the overall validity of the measurement model. The detailed information about the correlation between constructs is shown in Table 5.

Table 5: Correlation between constructs.

Construct 1		Construct 2	Value
Mathematical knowledge	↔	Mathematical belief	0.90
Mathematical belief	↔	Attitude toward mathematics	0.35
Attitude toward mathematics	↔	Mathematical competence	0.47
Mathematical competence	↔	Mathematical teaching practice	0.44
Mathematical knowledge	↔	Attitude toward mathematics	0.41
Mathematical knowledge	↔	Mathematical competence	0.31
Mathematical knowledge	↔	Mathematical teaching practice	0.89
Mathematical belief	↔	Mathematical competence	0.27
Mathematical belief	↔	Mathematical teaching practice	0.89
Attitude toward mathematics	↔	Mathematical teaching practice	0.41

4.2 Hypothesis testing

After confirming the model structure, researcher report the result of the mathematics teaching model in Malaysian’s high school. In this case, researcher hypothesize that the combination of teachers’ mathematical knowledge, teachers’ mathematics belief, teachers’ mathematical attitude, teachers’ mathematical competence and teachers’ teaching practice is the appropriate model of mathematics teaching in Malaysian high school. This hypothesis testing intend to report whether each variable is the variable that significant to support the mathematics teaching practice in Malaysian’s high school. To confirm the model, several aspect were reported namely beta estimate, standard error, critical ratio, and p-value. The result can be seen in Table 6.

Table 6: Regression weights of structural model.

Endogenous		Exogenous	Estimate (β)	S.E.	C.R.	p-value	Decision
TP	←	MK	0.458	0.050	9.186	0.000	Significant
TP	←	MB	0.068	0.026	2.597	0.009	Significant
TP	←	MA	-0.056	0.027	-2.040	0.041	Significant
TP	←	Comp	0.018	0.019	0.905	0.366	Not Significant

The beta estimate is a standardized path coefficient that show the strength and direction of the effect. Based on the result, only the correlation of attitude toward mathematics was weak with negative impact. Other factor impact to mathematics teaching practice was positive even showed with weak impact. For example, 0.458 on the relation of mathematical knowledge to teaching practice, 0.068 on the relation of mathematical belief to teaching practice, and 0.018 on the relation of mathematical competence to teaching practice. The standard error (S.E) showed the precise and reliable estimate of the strength of relationship between factors. In this case, the highest S.E was found in the relation of mathematical knowledge to teaching practice with S.E of 0.050. The S.E on the relation of mathematical belief to teaching practice was 0.068, S.E on the relation of mathematical attitude to teaching practice was 0.027, and S.E on the relation of mathematical competence to teaching practice was 0.019.

In term of the critical ratio, only the correlation of teaching competency did not achieved the standard of ± 1.96 indicating the path is not statistically significant. Other correlation achieved the standard, for example, 9.186 in the relation of mathematical knowledge to teaching practice, 2.597 in the relation of mathematical belief to teaching practice, and -2.040 in the relation of attitude toward mathematics to teaching practice. It was supported with the p-value, where only the relation of mathematical competences did not statistically significant.

Based on the results, the conclusion of the mathematical teaching model in Malaysian’s high school can be stated as follow; the mathematical knowledge is the strongest and most significant predictor of mathematics teaching practice in Malaysian high school. The mathematical belief is significant in predicting mathematical teaching practice in Malaysian’s high school. The attitude toward mathematics has significant negative influence toward teaching practice, and mathematics competences does not have a statistically significant influence on teaching practice.

5 Discussion

This research aims to examine the model of mathematics teaching for mathematics teachers in Malaysian’s high schools. Several aspects included in the model were teachers’ mathematics knowledge, teachers’ mathematics beliefs, teachers’ attitude towards mathematics, teachers’ competency, and mathematics teaching practice. The result showed that the model was attained to the model fit indices standard, such as absolute fit indices (RMSEA) incremental fit indices (GFI, CFI, and TLI) and parsimonious fit indices (Chi-Square). RMSEA and CFI were significant in measuring the model fit indices in SEM since RMSEA measures the discrepancy based on the approximation per degree of freedom and CFI measures the improvement of the model fit in relation to the baseline model [75]. It is because the model in the current research attains a cut-off for the standard of RMSEA CFI [71]. Other than that, the model was tested for multicollinearity. Multicollinearity refers to the condition that the variables tend to measure the same things,

and too strong multicollinearity indicates an unreliable and inaccurate result. Therefore, in the current research, the cut-off for multicollinearity was achieved [11]. In the current research, two constructs have greater multicollinearity. However, it can still be considered acceptable since the model meets the standard of model fit indices. The model was also tested for validity and reliability through composite reliability (CR) and average variance extracted (AVE), which indicate acceptable values. Convergent validity is known as the degree to which the construct converges to explain the variance of the items, and the AVE is a metric for comparing the variance captured by a construct to the variance resulting from measurement error [34]. Therefore, the result of the current research confirms the model of mathematics teaching among high school teachers in Malaysia. The model proposed in the current research consists of several aspects, namely mathematics knowledge, teachers' mathematics belief, teachers' attitude towards mathematics, and mathematics teaching practice. When compared to existing models, such as those proposed by [76] and [38], the emphasis on teacher mathematical expertise is consistent, as both models emphasise the importance of a strong understanding of mathematical material for effective education. Additionally, the current model's emphasis on teachers' beliefs and attitudes is consistent with the findings of Martino and Zan [27], who claim that these psychological elements have a major impact on teaching practices and student involvement. The inclusion of teacher competency in the Malaysian model is consistent with Darling-Hammond [24] who emphasis on the value of teacher qualifications and ongoing professional development in improving educational outcomes.

Furthermore, the present model emphasis on teaching techniques aligns with the frameworks developed by the National Council of Teachers of Mathematics [31], which promotes student-centered teaching methods. Finally, the current model's scientific rigour, particularly through structural equation modelling (SEM) and fit indices assessment, supports best practices in educational research, as noted by [47]. Overall, the Malaysian model has many similarities with previous literature, highlighting the importance of these variables in defining successful mathematics education and enhancing student learning results. According to [46], mathematics teachers' knowledge currently addressed as the central issue in the success of mathematics teaching. The knowledge can be the one that poses by the teacher individually (knowledge for teaching) and knowledge that used in the classroom (knowledge in teaching) [72]. It is related to the current research which poses two aspect of teachers' knowledge namely knowledge about teaching practice and the knowledge about the context and organization of the mathematics teaching. It is important since it could influence the students achievement. Maasz and Schlöglmann [52] found in their research that in Malaysia, the mathematics teachers' knowledge influence students' achievement in school. Therefore, they suggest to enhance and improve the teachers' content and pedagogical knowledge related mathematics teaching.

In terms of mathematics belief, Maass *et al.* [51] reveals that teachers' mathematics belief is the key factor influencing the teachers' mental scheme in carrying out the learning process. It could influence the performance of the teachers. Wang *et al.* [80] found in their research that teachers' mathematics beliefs could impact several aspects of mathematics teaching, such as teachers' development, teachers' content, pedagogical and technological knowledge, and the philosophical and psychological aspects of the teachers. It is rational since the aspect of a teachers' mathematics belief is related to how the teacher's belief in their characteristic or self-capability in carrying out the learning and teaching process. It is also related to the concept of the teacher's mathematical attitude discussed in the current research. It is related to how the teacher responded to and practiced aspects of math teaching and learning that could maintain their belief or self-confidence. For example, the teachers' attitude toward math indecision, the teachers' attitude toward how to provide fun learning, the teachers' attitude toward math value, and the teachers' attitude toward their self-efficacy. Both aspects are significant in maintaining the teacher's performance, so the students can experience a quality learning process. According to Jusoh *et al.* [45], a math teacher should have a positive attitude, whereas a negative attitude leads to less teaching practice, bored

students, and not interactive teaching.

Blömeke *et al.* [17] categorized several aspects of mathematics teaching practice according to the teachers' ability to manage the classroom, to support students, to activate students' cognition in a generic and subject-specific way, as well as to implement mathematics teaching with high quality. The teaching practice heavily relies on other aspects such as the teacher's knowledge and beliefs. For example, Aljaberi and Gheith [7] stated that teaching practice and teachers' belief have interconnected with each other, where teachers' belief drives teacher performance or practice and teachers' practice drives teacher belief. Maass *et al.* [51] stated that the teacher's pedagogical and content knowledge and practice of teaching lead students to the ability to design the learning process and comprehend solutions to problems. However, teachers should be concerned about the current development of teaching practice. Hill *et al.* [38] stated that teacher teaching practice in the classroom should go beyond the traditional method of providing knowledge and memorization to a modern method where the teacher only acts as the facilitator in the classroom and let the students grasp and comprehend their understanding. In this case, the current framework is beneficial in guiding teachers to understand the type of teaching method. The framework proposes three aspects of mathematics teaching practice, namely the teacher-centered method, the student-centered method, and creative teaching.

On the framework validated in the current research, it fills the gap in providing a sufficient mathematical teaching model for high schools in Malaysia. This is significant since, according to [58], teachers' beliefs about math and overall math teaching play a significant role in determining how teachers help their students improve their math skills. Bakar *et al.* [14] stated that a teacher's positive attitude could help the teacher successfully integrate the mathematical teaching, learning, and desired outcome. Teachers' knowledge about math as well as their beliefs and understanding can guide the organisation of the math teaching process in the classroom [60]. Moreover, in Malaysia, the secondary school's science curriculum has been created to give students the knowledge and skills in science and help them develop thinking skills and strategies, so they can solve problems and make decisions in daily life. However, according to Ismail *et al.* [44] who conducted research in Malaysia, math teaching in the classroom did not have a clear direction for the enhancement of students critical, creative, and innovative thinking skills. Therefore, the current research result is hoped to be a reference in conceptualising mathematics education in Malaysia.

In regard to the mathematics teaching model, previous research has been conducted. For example, a study by [26] explores the mathematical teaching model, emphasizing teacher knowledge. Based on the research, several aspects of teachers' knowledge were considered in the mathematical teaching model, such as providing and evaluating explanations; selecting and using representations; analyzing student errors, misconceptions, and non-conventional solutions; and selecting tasks. Setyaningsih *et al.* [73] developed a realistic and child-friendly mathematical learning model. They suggest six aspects, namely explaining the learning objective, providing contextual problems, conveying abstract processes, devising strategies, communicating the results, and drawing conclusions. Ismail *et al.* [44] also explored early mathematical modeling, but in the context of the students. The current research provides a more comprehensive framework in the context of the mathematical teaching model to be used by teachers. The current model consists of teachers' mathematics knowledge, mathematics belief, attitude towards mathematics, competency, and teaching practice. The current model focuses more on the teachers. The prerequisites in several aspects for the teachers to be able to promote a better learning process were emphasized. The current model emphasized not only knowledge and the pedagogical aspect, but also attitude, belief, and practice. Therefore, the current research contributes to providing a comprehensive framework or model for teaching mathematics. It can be a significant reference for a recommended framework for teachers, researchers, and educational stakeholders. Other than that, the current math teaching practice can reflect on the current model in order to enhance the quality of the teaching

and learning process.

The result of the current research is hoped to enhance the performance of the teacher's teaching practice. It is because the quality of education offered relies heavily on teachers' effectiveness in the classroom [25]. Kuennen and Beam [48] emphasises that mathematics teachers need to plan the lesson, select and decide what content to teach now and what to teach later, as well as choose the best teaching strategy that suits the students' level of understanding. All those duties will be able to be filled by Malaysian's teachers with a deep understanding of math knowledge. The role of teacher in the classroom can be seen in certain categories, namely controller, prompter, participant, resource, or tutor [61]. This is in accordance with the competences and practice of mathematics teaching of the teacher in classroom activities. Other than that, Brandmiller et al. [19] stated that how teachers perceive their students may have a substantial influence on these students' future educational outcomes and trajectories. For example, the teacher views their students in positive and negative ways. In this case, the teacher hoped to have a positive attitude and give a positive view of the students, as suggested in this research. Therefore, based on the current research, the model of mathematics teaching practice that suits Malaysian's high school teachers should consider mathematics knowledge, teachers' mathematics belief, teachers' attitude towards mathematics, teachers' competency, and mathematics teaching practice.

Based on the mathematical teaching model validated in the current research, further research utilizing the model can be carried out. For example, further researchers can use the model to teach math and explore the students' math knowledge before and after the model is implemented. In this case, causal comparative research comparing the students pre-test results and their post-test results can be done. Further research can explore the teacher's practice in using the model. The researcher can explore the teacher's knowledge, belief, attitude, and competency based on the items suggested in the current research. Further research can also explore the teacher's perception of the model. It is important since the teacher's perception and opinion can adjust and enhance the quality of the model. Other than that, further research can also consider the model in different subjects, for example, biology, physics, chemistry, and others. It can be done since the model covers many aspects of teaching and is not specific to a mathematical subject. It can strengthen the validity of the model.

6 Conclusions

The aim of the current research is to determine the mathematical teaching model for high school teachers in Malaysia. This research formulated the mathematics teaching in Malaysia with five constructs: mathematics understanding, mathematics belief, attitude towards mathematics, mathematics competences, and mathematics teaching practice. The model was tested with structural equation modelling. The model obtained model fit indices such as RMSEA, GFI, CFI, TLI, and Chi square attaining the acceptable threshold. Almost all constructs have a sufficient correlation estimate, with a value of less than 0.85 confirming the multicollinearity of the model. Furthermore, each construct has been found to have exceeded the specified threshold values, namely CR exceeding 0.6 and AVE exceeding 0.5, proving the reliability and validity of the model. As a conclusion, this research contributes to providing a mathematics teaching model fit for the Malaysian's high school teachers. Based on the validity of the model, teacher can use the model in their teaching practice. Other than, ministry of education and other stakeholder can consider this model to be referenced in conducting mathematics teaching.

The current research on the paradigm of mathematics education for Malaysian's high school

teachers has various limitations that should be considered. To begin, the model primarily focuses on specific constructs such as teachers' mathematical knowledge, beliefs, attitudes, competency, and teaching practices, potentially overlooking other influential factors such as school's environment, students' characteristics, and socio-cultural contexts, which could also impact teaching effectiveness. Furthermore, while the model was validated using structural equation modelling (SEM), the dependence on quantitative methods may limit the investigation of qualitative aspects of teaching and learning, such as teacher-student interactions and classroom dynamics. Furthermore, the model's applicability may be limited by its context-specificity to Malaysian's high schools, which may not translate to other educational environments or cultures. To improve the robustness of future research, prospective studies should use a mixed-methods approach to capture a more comprehensive picture of the teaching-learning process. Furthermore, updating the model to include external elements and undertaking longitudinal research may provide more insight into the changing character of mathematics teaching practices over time. Finally, resolving these constraints and recommendations may lead to a more nuanced understanding of effective mathematics teaching strategies in various educational environments.

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Ethical Considerations The study was conducted in accordance with the ethical standards and was approved by the Human Research Ethics Committee, Universiti Pendidikan Sultan Idris (UPSI) (Approval Number: UPSI/2024/ETHICS/35). All procedures performed in studies involving human participants complied with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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