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Factors Affecting Mathematical Knowledge for Teaching among Pre-service Teachers

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ABSTRACT

The low level of mathematical knowledge for teaching (MKT) among pre-service teachers is an important issue that needs to be addressed wisely to ensure they can carry out more effective teaching activities in the future. This study was conducted to examine factors that affect MKT among pre-service teachers in Institute of Teacher Education (ITE). The influence of mathematical belief (MB), mathematics teaching efficacy belief (MTEB) and opportunities to learn (OTL) have been tested to explain the factors affecting MKT. The design of this study is correlational research. Using a structured questionnaire together with paper and pencil test adapted from the literature reviewed, data were collected from 187 pre-service teachers. The partial least squares-structural equation modeling (PLS-SEM) is used to analyze the collected data. The empirical results indicated that constructivist belief (β=0.21, $p<0.001$), mathematics teaching outcome expectancy belief (MTOEB) (β=0.353, $p<0.001$), OTL-Practicum (β=0.355, $p<0.001$) and OTL-Program (β=0.287, $p<0.001$) are significant predictors to explain the factors that affect MKT. Moreover, it was found that OTL-Practicum (β=0.29, $p<0.001$) and OTL-Program (β=0.149, $p<0.1$) are significant predictors of pre-service teachers MB. Overall, the model explained 60.9% of the variance in MKT. Hence, in the future, it is proposed that ITEs provide more opportunities for pre-service teachers to help them improve the mastery of MKT.

INTRODUCTION

Teacher is an individual who are responsible for implementing an effective teaching and learning processes to ensure that pupils master each skill contained in the mathematics curriculum (Shirvani, 2015). Besides that, they are also responsible for implementing an effective teaching and learning processes to enhance students' mathematical performance (Goos, 2013). The low level of mathematical knowledge for teaching among teachers will indirectly contribute to the implementation of less effective mathematics teaching and learning processes (Ball, Thames, & Phelps, 2008).

In addition, the low level of MKT also contributes to the low level of mathematics achievement among students (Segarra & Julià, 2022). This is because the teacher's level of mathematical knowledge has a direct relationship with student achievement (Celik et al., 2022).The mathematic teachers' knowledge framework can be divided into two parts, the content knowledge related framework and content knowledge for teaching mathematics framework (Holmes, 2012). According to Holmes (2012), the content knowledge related framework consists of the Bloom et al. (1956) instrumental and relationship understanding (Skemp, 1978), conceptual and procedural understanding (Hiebert & Carpenter, 1992) , knowledge depth (Webb, 1997) and cognitive difficulty (Porter, 2002). While the content knowledge for mathematics teaching framework consists of the pedagogical content knowledge framework (Shulman, 1986) and the mathematical knowledge for teaching framework (Ball & Bass, 2002).

The concept of pedagogical content knowledge (PCK) was introduced by Shulman (1986), which is called "a missing paradigm" in studies related to teacher teaching and education. Shulman has criticized the lack of attention given to the content of lessons related to teaching practice and assessment of pre-service teachers as well as studies

on the effectiveness of teaching practices. By introducing PCK concepts, Shulman intends to emphasize the content of lessons learned in teaching and teacher education, and to address the differences between content knowledge and pedagogy (Depaepe et al., 2013). While the MKT concept is a model of mathematical knowledge that a teacher needs to teach effectively. This includes evaluating student responses, answering questions posed by students, preparing assignments and making lesson plans (Ball et al., 2008).

The low level of MKT among pre-service teachers also affects the success of a teacher education program provided. According to Tatto, Rodriguez, and Lu (2015), knowledge of pre-service teachers at the end of the teaching course followed is a key indicator of the success of teacher education programs that have been enrolled. Ministry of Education (MOE) has allocated a large amount of money annually to the Institute of Teacher Education (ITE) to ensure the teacher education program offered are able to produce high quality teachers (Kementerian Kewangan Malaysia, 2017). If the MKT level among pre-service teachers at the end of the course is low, this illustrates that the teacher education program offered by ITE is less effective to produce competent teachers and consequently the return on investment made by the MOE is not worthy. To address the issue, there is a need to conduct a study to identify factors affecting MKT among pre-service teachers in ITE.

Based on the systematic literature review carried out, it was found that there are some recommendations from previous researchers on the variables that can be tested to explain the factors affecting MKT. Among them, Austin (2015) proposed to examine the construct of personal mathematics teaching efficacy belief (PMTEB). Furthermore, Mohd Tajudin, Chinnapan, and Saad (2017) suggested that the teachers' CK is also associated with opportunities to learn (OTL) and an innovative teaching strategy. Subsequently Simsek and Boz (2016) suggested factors such as gender, age and opportunity to learn through the teaching practice were also considered.

Ernest (1989) has stated that, the differences between mathematics teachers are not only because of their knowledge, but also related to their beliefs. This is because it is possible for two different teachers to have similar knowledge, but they might teach the students with different approach. Teacher's beliefs have become a popular field in education-related studies because of their relationship to knowledge to teach (Thompson, 1992). According to Cross (2009) beliefs are conscious or unconscious opinions and views of the individual about himself, about the world or about his place in the world. According to Ernest (1989), there are generally three categories of beliefs associated with mathematics teachers, namely beliefs about the nature of mathematics, belief in teaching and learning, and beliefs related to principles of education. For this research, we are focusing on the belief in teaching and learning, which is also known as mathematical belief (MB) (Beswick, 2012).

Based on the recommendations given by earlier researchers, this study will examine the effect of the mathematical belief, mathematics teaching efficacy belief (MTEB) and opportunities to learn (OTL) on pre-service teachers MKT. Thus, based on the MKT model by Ball et al. (2008), this study will develop and test the conceptual model of the study by integrating the MKT model by Ball et al. (2008), mathematical belief model by Ernest (1989), Social Cognitive Theory (SCT) by Bandura (1989) and the concept of OTL from Carroll (1963) to examine the factors that affect mathematical knowledge for teaching among pre-service teachers in ITE. Specifically, the objective of this study is to test the model that explained the factors affecting mathematical knowledge for teaching (MKT) among pre-service teachers.

Significance of the Study

Significance of this study is seen in terms of its contribution to theory and practice. The findings have contributed significantly to the body of knowledge by producing a comprehensive model to explain the factors affecting MKT among pre-service teachers. This model has combined both factors from the context of teachers' belief and OTL they have acquired during teacher education programs.

This study was also one of the studies on the factors affecting MKT among pre-service teachers by using Structural Equation Modelling (SEM) method. Therefore, the result of this study can be used by various stakeholders such as the Ministry of Education (MOE), especially the Institute of Teacher Education (ITE) who is responsible for the training of future mathematics teachers. The ITE can use the findings from this study as a guideline in developing a teacher education program which capable of producing competent mathematics teachers. In addition, the findings of this study can also be used as references to other higher education institutions who are responsible for training potential mathematics teachers to ensure that future teachers will master the MKT before they are placed in school.

Findings from this study can also be utilized by pre-service teachers who are studying in ITE and in any other higher education institutions to understand the factors that affect their MKT. Through that understanding, it will be able to create awareness for them to appreciate every opportunity they earned during the teacher education program.

Furthermore, the findings of this study can also be used as a reference to future researchers who study the factors affecting pre-service teachers' knowledge. The findings of this study are also expected not only relevant in the context of factors affecting pre-service teacher knowledge in mathematics, but also includes teachers' knowledge in other disciplines. Hence this study is very significant to be carried out to contribute towards theory and practical.

THEORETICAL BACKGROUND AND RESEARCH MODEL

The model underpinning this study is the model of MKT by Ball et al. (2008). This model was chosen based on its relevance to measure the mastery of mathematical content knowledge (CK) and pedagogical content knowledge (PCK) among pre-service teachers. The MKT model is also used by previous researchers to measure the level of mathematics teacher knowledge. Buchholtz (2017) examined the perceptions of pre-service teacher regarding OTL and PCK. Norton (2017) also used the MKT model to examine the relationship between confidence level with CK and PCK among pre-service teachers. Other researchers who used the MKT model in their studies were Shahbari (2017), Qian and Youngs, (2016), Pape et al. (2015), Kleickmann et al. (2015), Venkat and Spaull (2015), Hine (2015), Leong, Chew and Abdul Rahim (2015, Mosvold and Fauskanger (2015), Thanheiser et al. (2013), Kleickmann et al. (2013) and Tatto et al. (2012).

MKT covers three categories of knowledge related to the content knowledge of teachers (1) common content knowledge (CCK), that is, knowledge and skills of mathematics that are not only devoted to teaching mathematics, (2) specialized content knowledge (SCK), the mathematical knowledge and skills that are unique to teaching mathematics, and (3) horizontal content knowledge (HCK), which is the awareness of the relevance of each topic in mathematics (Ball et al., 2008). In addition, MKT also consists of three categories of knowledge related to PCK: (4) knowledge related to content and students (KCS), namely knowledge related to student's mathematical thinking, which requires interaction between specific mathematical understanding and understanding of student's mathematical thinking, (5) knowledge related to content and teaching (KCT), which is knowledge related to teaching design, which requires interaction between mathematical understanding and understanding of pedagogical issues affecting student learning, and (6) knowledge related to content and curriculum (KCC) of teaching and learning materials (Ball et al., 2008).

Besides that, teachers' beliefs have become a popular field in education-related studies because of their relationship to knowledge to teach (Thompson, 1992). Although the term "belief" is very popular among educational researchers, there is no definite definition (Pajares, 1992). For example, according to Cross (2009) "beliefs are conscious or unconscious opinions and views of the individual about himself, about the world or about his place in the world. These opinions develop during the individual's joining in different social groups and also they are considered as correct by the individual". Whereas Philipp et al. (2007) defined belief as "psychologically held understandings, premises, or propositions about the world that are thought to be true". Besides that, Richardson (1996) has defined belief as "understandings, premises or propositions about the world that are felt to be true".

Based on the views of most researchers, belief is a structure that is accepted as true and can influence behaviour (Kul & Celik, 2017). In addition, beliefs also influence the kind of knowledge that teachers will use to teach in the classroom (Leinhardt & Greeno, 1986). According to Ernest (1989), there are generally three categories of beliefs associated with mathematics teachers, namely belief about the nature of mathematics, belief in teaching and learning, and beliefs related to education principles. Teacher's belief in teaching and learning mathematics refers to their views on the preferred method of teaching and learning. Examples are their mental picture of the appropriate teaching activity implemented in the implementation of mathematics learning activities (Ernest, 1989). In addition to the term beliefs related to teaching and learning, there are also researchers using the term mathematical beliefs, bearing the same meaning (Beswick, 2012). There is an agreement among earlier researchers that teachers' beliefs regarding mathematics teaching and learning play an important role in determining the teaching objectives of teachers and directly affect their professionalism (Cross, 2009; Philipp et al., 2007).

The research conducted by Ekmekci et al., 2019 on teachers teaching elementary mathematics has proven that the beliefs in teaching and learning had influenced the teacher's knowledge. Besides that, the result from studies conducted by Ren and Smith (2017) and Swars et al. (2007) also found that mathematical belief can affect the teacher's knowledge. Therefore, this study will also examine the influence of mathematical beliefs on the MKT among pre-service teachers in ITE.

Furthermore, the beliefs associated with the mathematics teaching efficacy were also found to influence the practice of teaching among mathematics teacher (Austin, 2015). According to Vieluf, Kunter, and Van de Vijver

(2013) self-efficacy beliefs are influenced by two well-known psychological theories of the 20th century, namely the theory of Locus of Control (Rotter, 1966) and Social Cognitive Theory (Bandura, 1977, 1989). Bandura (1977) defines self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments". Meanwhile, teaching efficacy belief is defined as the teacher's response to their ability to influence student learning, including those who are adversely affected or unmotivated (Guskey & Passaro, 1994). As is well known, MTEB is commonly described by two sub-constructs, namely PMTEB and MTEOB (Enochs et al., 2000). However, for this study the researchers have chosen to test only the influence of MTEOB on MKT as based on previous studies it has been found that MTEOB factors influence MKT more than PMTEB. In addition, findings from studies conducted by Shi (2016) also found that PMTEB factors did not have a significant direct effect on MKT.

Apart from the MKT model, MTEB and mathematical belief, researchers will also test the effect of OTL in this study. Previous studies have shown that OTL variables influence the teacher's knowledge and teacher's belief (Ayieko, 2014; Konig et al. 2017). In addition, the study conducted by Akkoç and Yesildere (2010) also found that OTL teaching practice (practicum) have influenced teachers' PCK significantly. A part from that, the study conducted by Kleickmann et al. (2013) and Tatto et al. (2012) on pre-service teachers also found the opportunity to follow the coherent teacher education program (OTL-Program) also influenced the mastery of CK and PCK of the teacher. This clearly shows that OTL is an important factor affecting the mastery of knowledge and academic achievement of future teachers. Hence, this study will also examine the influence of OTL on the MKT among pre-service teachers at ITE.

The variable for efficacy belief is represented by the MTOEB construct and the variable for mathematical belief are represented by constructivist belief. OTL constructs consist of both OTL-Practicum and OTL-Program. Based on the model as shown in Figure 1, the MKT variables serve as an endogenous variable to the constructivist beliefs, MTOEB, OTL-Practicum and OTL-Program variables. While the constructivist belief and MTOEB variables act as an endogenous variable to the OTL-Practicum and OTL-Program variables and at the same time both variables also serve as exogenous variables to MKT variables. This study was conducted to address the following research question:

RQ: Is the model developed are able to explain the factors affecting mathematical knowledge for teaching (MKT) among pre-service teachers?

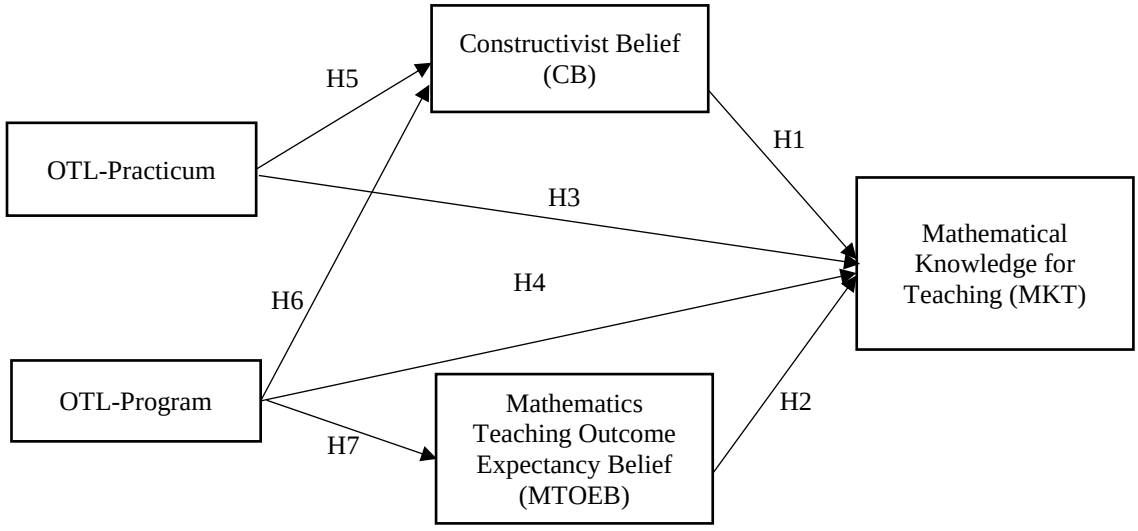


Figure 1. The research model

Based on the research model illustrated in Figure 1, the research hypotheses tested in this study are as follows:

H1: Constructivist belief has a significant direct effect on MKT

H2: MTOEB has a significant direct effect on MKT

H3: OTL-Practicum has a significant direct effect on MKT.

H4: OTL-Program has a significant direct effect on MKT.

H5: OTL-Practicum has a significant direct effect on constructivist belief.

H6: OTL-Program has a significant direct effect on constructivist belief.

H7: OTL-Program has a significant direct effect on MTOEB.

METHODOLOGY

Research Design

This study was conducted using a quantitative approach. A quantitative approach was chosen because the study involved hypothesis testing based on a specific theory that contained variables that were measured by number and analyzed using statistical procedures to determine whether the generalization of the predictions of the theory was correct. Therefore, based on the recommendations made by Cohen, Manion, & Morrison, (2011), the quantitative study approach is most appropriate. The design of this study is correlational study, which is to study the important factors that explain the variation in dependent variables, namely mathematical knowledge for teaching (MKT).

Data Collection

Data was collected from 187 pre-service teachers using a structured questionnaire and paper and pencil test. Both measures were adapted from previous research done by other researchers (Enochs, Smith, & Huinker, 2000; Hill, Schilling, & Ball, 2004; Tatto, Senk, & Rowley, 2008; Zakaria et al., 2009). We have divided the questionnaire into four sections, the first section collected the demographic data, the second section collected information about mathematical belief, the third section collected information about mathematics teaching efficacy belief and the last section measured opportunities to learn. The test consists of multiple-choice questions examining MKT among pre-service teachers.

In the context of this study, the population comprises all pre-service teachers of semester 6 to 8 who are currently pursuing a Bachelor of Teaching (Hons) (Mathematics for Primary Education) program at ITE. To ensure they are eligible to be appointed as a teacher in the future, they need to complete the teacher education program with a high Cumulative Grade Point Average (CGPA). A total of 306 pre-service teachers are currently pursuing this program nationwide. Justification for the selection of all Bachelor of Teaching (Hons) (Mathematics for Primary Education) in semester 6 to 8 because these students have followed most courses offered and are currently undergoing phase 1 practicum. Additionally, their selection as a population coincides with research issues that have a direct connection with them. This study uses a simple random sampling method. This method was selected to ensure that each sample had the same opportunity to be selected as a sample of the study (Acharya et al., 2013). Overall, the population for this study was 306 pre-service teachers (N = 306). However, some of them have been used for pilot studies, which are 105 people. The remainder of the remaining population is about 201 people and the total sample size determination is obtained by computation based on Krejcie and Morgan (1970) tables. Based on the Krejcie and Morgan charts, with a population of 201 pre-service teachers, the total sample size required is about 132 people (n = 132). After completing the data collection process, 191 respondents had answered the questionnaire and MKT test. Out of that, only 187 respondents had answered the questionnaire and MKT test completely.

Measures

Mathematical belief measures were adapted from Zakaria et al. (2009). The instrument has been developed to measure mathematical beliefs among teachers. It contains 8 items that measure constructivist beliefs. Findings from Confirmatory Factor Analysis conducted by Adnan, Abdullah, and Che Ahmad (2014) on the instrument indicate that the items are suitable for measuring mathematical beliefs. They reported the comparative fit index (CFI) value for the mathematical belief construct was 0.983.

The measure for MTEB was adapted from Enochs et al. (2000). It contains 8 items that measure MTOEB. Permission to adapt the instrument has been applied and granted approval. They reported the reliability for the instrument was $\alpha = 0.75$. This illustrates that items are suitable for measuring the constructs. This is because the Cronbach alpha value for the constructs exceeds 0.70 (Nunnally & Bernstein, 1994). The measure for OTL-Practicum and OTL-Program was adapted from Tatto et al. (2008). It consisted of 14 Likert type items (OTL-Practicum = 8 items and OTL-Program = 6 items).

Whereas MKT test was adapted from Hill et al. (2004). It consisted of 32 multiple choice items. They reported the level of reliability of items that measure CK of primary school mathematics teacher for number and operation topics $\alpha = 0.784$, while for PCK was $\alpha = 0.888$ (Hill et al., 2004). This illustrates the level of reliability of both constructs is good. The validity of the items used in the MKT test has been determined by items analysis. Item analysis has been carried out to distinguish good items with poor items. Item analysis is intended to produce a high-quality test (Considine et al., 2005). Item analysis will be able to provide information regarding the response to each item whether they are able to answer or not that item. It also provides information on how each item works, whether the item is easy or difficult. In addition, an item analysis can discriminate between higher performance groups and lower performance groups (Si-Mui Sim & Raja Isaiah Rasiah, 2006). ANATES 4.0.9 by Karno and Wibisono (2004) software was used to analyse the MKT test items.

Demographic Profile

The study sample was of 187 pre-service teachers from ITE (65.7% were female). Majority of the pre-service teachers involved in this study are Chinese (42.8%), whereas Malays about 21.9%, Indian 18.7% and others 16.6%. The CGPA obtained was quite high, which was almost 99% of them got the CGPA above 3.00. This showed that their academic achievements were good. All the samples involved were the outstanding students who were selected. The minimum requirement for admission to a bachelor's degree course at ITE is to earn at least 5A's during their Malaysian Certificate of Education (MCE) examination. Table 1 shows the descriptive statistics results of participants.

Table 1. *Descriptive statistics results of participants*

	Frequency	Percent
Gender		
Male	64	34.2
Female	123	65.8
Ethnicity		
Malay	41	21.9
Chinese	80	42.8
Indian	35	18.7
Others	31	16.6
Cumulative Grade Point Average (CGPA)		
3.75 – 4.00	26	13.9
3.00 – 3.74	159	85.0
2.00 – 2.99	2	1.1
0 – 1.99	0	0

DATA ANALYSIS

For this study, the researcher has used the SmartPLS 3.0 (Ringle et al., 2015) software to analyse the data. SmartPLS 3.0 was used to analyse the data for this study because it was suitable to answer the research question. According to Hair, Ringle, and Sarstedt (2011) if the research goals were exploratory, so we should use PLS-SEM. When analysing the data we have followed the analysis procedure as suggested by Hair, Hult, Ringle, and Sarstedt (2017). Firstly, we analysed the measurement model and then followed by analysing the structural model. This is to make sure the measures used in the study are reliable and valid to answer the research questions.

Measurement Model

When using multiple measures for an individual construct, the researcher should take into consideration the extent to which the measures demonstrate convergent validity (Hulland, 2002). Hair et al. (2017) has stated that a composite reliability (CR) of 0.70 or above and an average variance extracted (AVE) of more than 0.50 are considered acceptable. The result of Confirmatory Factor Analysis (CFA) stated in Table 2 shows that all the composite reliability values are above 0.70 and the AVE is all above 0.50. Therefore, based on the CFA result obtained, we can conclude that convergent validity for this measurement model has been fulfilled.

Table 2. *Result of CFA for measurement model*

Construct	Item	Internal Reliability (Cronbach Alpha)	Convergent Validity		
			Factor Loading	Composite Reliability	AVE
Constructivist Belief	CB1	0.857	0.708	0.890	0.507
	CB2		0.750		
	CB3		0.730		
	CB4		0.744		
	CB5		0.789		
	CB6		0.725		
	CB7		0.750		
	CB8		0.441		
Mathematics Teaching Outcome Expectancy Belief (MTOEB)	MTOEB1	0.828	0.555	0.876	0.544
	MTOEB2		0.709		
	MTOEB4		0.811		
	MTOEB5		0.717		
	MTOEB6		0.838		
	MTOEB8		0.762		
OTL-Practicum	OTL_Prac1	0.898	0.797	0.919	0.586
	OTL_Prac2		0.816		
	OTL_Prac3		0.833		
	OTL_Prac4		0.679		
	OTL_Prac5		0.709		
	OTL_Prac6		0.779		
	OTL_Prac7		0.730		
	OTL_Prac8		0.769		
OTL-Program	OTL_Prog1	0.866	0.789	0.900	0.603
	OTL_Prog2		0.733		
	OTL_Prog3		0.857		
	OTL_Prog4		0.820		
	OTL_Prog5		0.810		
	OTL_Prog6		0.630		
Mathematical Knowledge for Teaching		N/A[a]		N/A[a]	N/A[a]

Note:

[a] Single item measures

Besides convergent validity, the researcher also needs to take into consideration about discriminant validity in order to make sure the items used to measure a certain construct are different with another construct in the model. According to Fornell and Larcker (1981) discriminant validity can be established by calculating the square root of the AVE. Besides that, Hair et al. (2017) also stated that discriminant validity also can be establish by assessing the cross loading and heterotrait-monotrait ratio of correlations (HTMT) value. For this study we are only used square root of the AVE to assess the discriminant validity. If the square root of the AVE for each construct is higher than its correlations with the other constructs, then the discriminant validity is established (Fornell & Larcker, 1981). As shown in Table 3, all of the square roots of AVE for each construct were higher than the correlations. Diagonal elements are the square roots of the AVE for the corresponding construct.

Table 3. *Correlation between construct*

Constructs	(1)	(2)	(3)	(4)	(5)
(1) MTOEB	**0.738**				
(2) Constructivist Belief	0.005	**0.712**			
(3) OTL-Practicum	0.088	0.358	**0.766**		
(4) OTL-Program	0.142	0.281	0.454	**0.777**	
(5) MKT	0.427	0.419	0.592	0.558	**N/A**[a]

Note:
[a] Single item measures

Structural Model and Hypothesis Testing

The results demonstrated that, (1) constructivist belief had a positive effect on MKT (β=0.21, p<0.001) (2) MTOEB had a positive effect on MKT (β=0.353, p<0.001) (3) OTL-Practicum had a positive effect on MKT (β=0.355, p<0.001); (4) OTL-Program had a positive effect on MKT (β=0.287, p<0.001); (5) OTL-Practicum had a positive effect on constructivist belief (β=0.29, p<0.001); (6) OTL-Program had a positive effect on constructivist belief (β=0.149, p<0.1) and (7) OTL-Program had a positive effect on MTOEB (β=-0.142, p<0.1). The results of the structural model analysis are illustrated in *Figure 2*.

Based on the analysis, it was found that the two OTL factors namely OTL-Practicum and OTL-Program contributed 14.6% to CB. This means that both OTL factors have little predictive power over CB. In addition, it is found that the OTL-Program factor contributes only 2% to MTEOB and this means that the OTL-Program factor has very little predictive power over MTEOB. Overall, the model explained 60.9% of the variance in MKT (**Error! Reference source not found.**). This means, overall this model has a modest forecasting power.

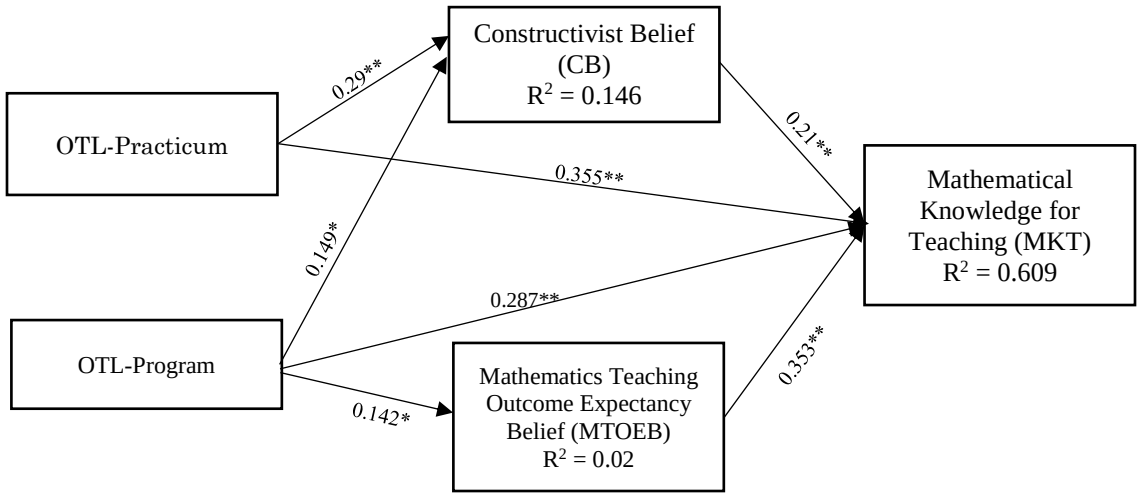


Figure 2. Structural model

Table 4. *Summary of hypothesis tests*.

Hypothesis	Standardized path coefficients (β)	t-value	Supported
H1. CB → MKT	0.21**	3.887	Yes
H2. MTOEB → MKT	0.353**	6.426	Yes
H3. OTL-Practicum → MKT	0.355**	6.301	Yes
H4. OTL-Program → MKT	0.287**	5.122	Yes
H5. OTL-Practicum → CB	0.29**	3.897	Yes
H6. OTL-Program → CB	0.149*	1.814	Yes
H7. OTL-Program → MTOEB	0.142*	1.718	Yes

Note: *p-value < 0.1, **p-value < 0.001

DISCUSSION

The purpose of this study was to examine the factors affecting mathematical knowledge for teaching among pre-service teachers in Malaysia. Due to that, this study examined the relationship between mathematical belief (in term of constructivist belief), mathematics teaching efficacy belief (in term of MTOEB) and MKT. Besides that, the influence of OTL on MKT, MTOEB and mathematical belief was also examined.

Based on the findings from the analysis, all factors studied have significant direct effect with the MKT. The findings from the first hypothesis testing showed that constructivist beliefs factor has a positive direct effect to the pre-service teachers MKT. This finding confirms that pre-service teachers with high positive constructivist belief will also master the MKT learned during the teacher education program in ITE. This is likely because a pre-service teacher with high constructivist belief is more likely to work independently to improve the level of mathematical knowledge for teaching without expecting help from lecturers. Additionally, it also implies that pre-service teachers have the perception that student-centered learning approaches are more effective than traditional teacher-centered learning methods.

The results of the multiple regression analysis for this study are parallel with those found in previous studies. Among them, the findings from Ren et al. (2017) found that mathematical beliefs are one of the factors that affect a teacher's MKT. In addition, the findings from the study conducted by Swars et al. (2007) also supported the findings of this study. The findings from the study conducted on 103 pre-service primary school teachers in the United States found that the mathematical beliefs had a positive relationship with the teacher's knowledge. Recent studies conducted by Ekmekci et al. (2019) and Meschede et al. (2017) found both the domain of teacher beliefs, namely traditional beliefs and constructivist beliefs, had significant relationships with teacher knowledge. Hence it is important for responsible parties, especially MITE to take the necessary steps to improve the level of mathematical belief of pre-service teachers, especially the aspects of constructivist belief. In addition to improving the level of MKT, mathematical beliefs are also able to influence the student's mathematics achievement. The findings from the study conducted by Suthar, Tarmizi, Midi and Adam (2010) on 473 university students in Malaysia found that mathematical beliefs factor has influenced their mathematics achievement.

Furthermore, it was found that the MTOEB had a positive direct effect on the MKT of a pre-service teacher. This finding confirms that pre-service teachers who have high positive MTOEB will also dominate the MKT learned during the teacher education program. There are several possibilities that cause MTOEB factors to play a role in influencing the level of pre-service teacher MKT. Among them are their belief that effective teaching methods can influence the mathematics achievement of a student (Blazar, 2015). The belief of a pre-service teacher about the importance of an effective teaching may have slightly affected their MKT. This is because according to Celik et al. (2022) and Blazar (2015) effective teaching activity can influence the student's mathematics achievement. For example, if a teacher believes that teaching effectively contributes to the mathematics achievement of a student then it will encourage them to deepen their MKT to ensure that they can teach more effectively in the future.

As a responsible institution to train pre-service teachers who will serve as primary school mathematics teachers, MITE should take some necessary steps to ensure that MTEB levels can be improved. MTEB level improvement is important as it is one of the factors that contributes to the increase in the level of MKT among pre-service teachers in ITE. In addition, according to Lotter et al. (2016) and Pape et al. (2015) the level of teacher's efficacy can be improved through a professional development program. Throughout the teacher education program at ITE, the trainee teachers have been exposed to various courses to ensure that they can become competent teachers in

the future. Hence, the MITE is recommended to double efforts to provide more professional development courses and programs to ensure that the level of pre-service teacher's efficacy can be improved and indirectly contributes to the improvement in the mastery of MKT.

Based on the findings, both OTL factors have a significant direct effect on the pre-service teachers MKT. The dominant factor affecting the level of MKT among pre-service teachers is the OTL-Practicum. This is likely because they feel that opportunities they have earned during the teacher education program at ITE are in line with their needs as a teacher in the future. According to Gerasimova et al. (2017) the balance between theory and practice is important to produce future quality teachers. Each pre-service teacher at ITE was given the opportunity to pursue knowledge both in terms of theory and practice. The curriculum framed by the MITE covers all aspects to ensure the potential teachers will be able to educate students successfully.

Additionally, the opportunity to undergo two-phase teaching practice (practicum), which is about three months in each phase guided by experienced lecturers and mentors might also contributed to the pre-service teacher's perception about OTL they have acquired during the teacher education program at ITE. This is because according to Toh, Berinderjeet, and Koay (2009) the duration of adequate training in teaching can influence the level of a pre-service teacher MKT. This finding confirms that pre-service teachers who gain high positive learning opportunities will also master the MKT while pursuing a teacher education program at ITE.

Based on the analysis conducted, it is also found that the OTL among pre-service teachers was explained by the OTL-Practicum more dominant than the OTL-Program. This is likely because pre-service teachers feel that practicum experience is more important than the coherent teacher education program. This is because the opportunity to undergo practicum allows them to feel the real condition of being a teacher in the future. Meanwhile the OTL-Program was too general and includes many aspects. Therefore, the pre-service teacher believes it was less important than the opportunity to undergo the practicum.

A similar study conducted by Ayieko (2014) found that both dimensions of OTL were positively related to mathematical belief. Besides that, the findings are also consistent with Konig et al. (2017) and Akkoç & Yesildere (2010) findings which stated that there is a significant relationship between pre-service teachers' OTL-Practicum and their PCK. Furthermore, earlier findings by Toh, Berinderjeet, and Koay (2009) have established that OTL-Practicum affected Singapore pre-service secondary mathematics teachers' CK. In addition, a similar study by Tatto et al. (2015) and Kleickmann et al. (2013) also found that OTL-Program influenced the mastery of CK and PCK of the teacher.

The findings from the fifth and sixth hypothesis tests show that OTL have a positive relationship with constructivist beliefs. This finding confirms that pre-service teachers who gain more learning opportunities will also influence their mathematical beliefs. This is likely because the OTL acquired by pre-service teachers from school and throughout the teacher education program has influenced their mathematical beliefs. For example, the experience they gained during the teaching practice (practicum) has led them to believe that a student-centered teaching strategy is more effective than a traditional teacher-centered teaching strategy. In addition, a clear link between courses in the teacher education program is also likely to have influenced their mathematical beliefs. For example, before they learn about numbers, fraction, decimal and percentages they were given an exposure on basic number courses at the initial stage of study at ITE. Continuity in the courses studied has slightly affected their beliefs regarding teaching and learning of mathematics.

Besides that, it was found that the OTL factors has a significant positive relationship with the mathematics teaching efficacy beliefs. This finding confirms that pre-service teachers who gain high positive learning opportunities will also influence their MTOEB. This situation may be due to the experience gained by pre-service teachers during the teacher's education program has influenced their self-efficacy beliefs. For example, experiences of school-based experience, micro teaching and practical training have led them to believe that pupils' learning is influenced by effective teaching (MTOEB). This findings were supported by some findings from previous studies. Among them are studies by Swars, Smith, Smith, and Hart (2009) and Swars et al. (2007) found that the OTL is one of the factors that influence the mathematics teaching efficacy of pre-service teachers. The findings from other studies also support the findings of this study, including studies by Philippou and Christou (2002) who also found that the OTL-Program factor affects teacher's mathematics teaching efficacy belief. Recent studies conducted by Berger, Girardet, Vaudroz, and Crahay (2018) on 154 vocational teachers also found that teaching experience (OTL-Practicum) influences the teacher's efficacy.

Although all four factors were found to have significant direct effects on mathematical knowledge for teaching, this does not mean that the level of pre-service teacher content knowledge and pedagogical content

knowledge is due to these factors. The findings of this study only confirm that there is a relationship between these factors and MKT, and they have directly affected pre-service teacher MKT.

The model tested in this study shows that OTL-Practicum and OTL-Program can account for 14.6% of the variance in constructivist belief while about 60.9% of the variance in mathematical knowledge for teaching. The contribution of this study towards Institute of Teachers Education (ITE) and implementers is there is a need for both of them to provide necessary opportunities to learn, mathematical belief and MTEB to the pre-service teachers in order to ensure they can increase their MKT. If pre-service teachers' MKT is low because of lack of OTL, mathematical belief and MTEB it will affect the teacher education program implementation. Enough and adequate opportunities to learn, mathematical belief and MTEB provided by the ITE seem to bring a greater teacher education program to the pre-service teachers.

CONCLUSION

This study was conducted to identify the factors that affect mathematical knowledge for teaching among pre-service teachers at the Institute of Teachers Education. The finding of this study reveals that the main factor affecting the MKT of a pre-service teacher is the opportunity to learn and MTOEB. Opportunities to follow a coherent teacher education programs as well as the opportunity to undergo teaching practices have influenced their MKT positively. Hence, in the future, it is proposed that ITEs provide more opportunities for pre-service teachers to help them improve the mastery of MKT. According to Barnard-Brak, Lan and Yang (2018) and Irvin, Byun, Smiley and Hutchins (2017) apart from being able to increase MKT, the OTL factors can also improve the mathematical achievement of a pre-service teacher. Besides OTL, other two factors (MTOEB and mathematical beliefs) also influenced the MKT of pre-service teachers. The findings are parallel to previous studies by Meschede et al. (2017); Ren and Smith (2017); Qian et al. (2016) and many more. Hence, both teachers' beliefs in the future must be emphasized in the effort to empower teachers' education.

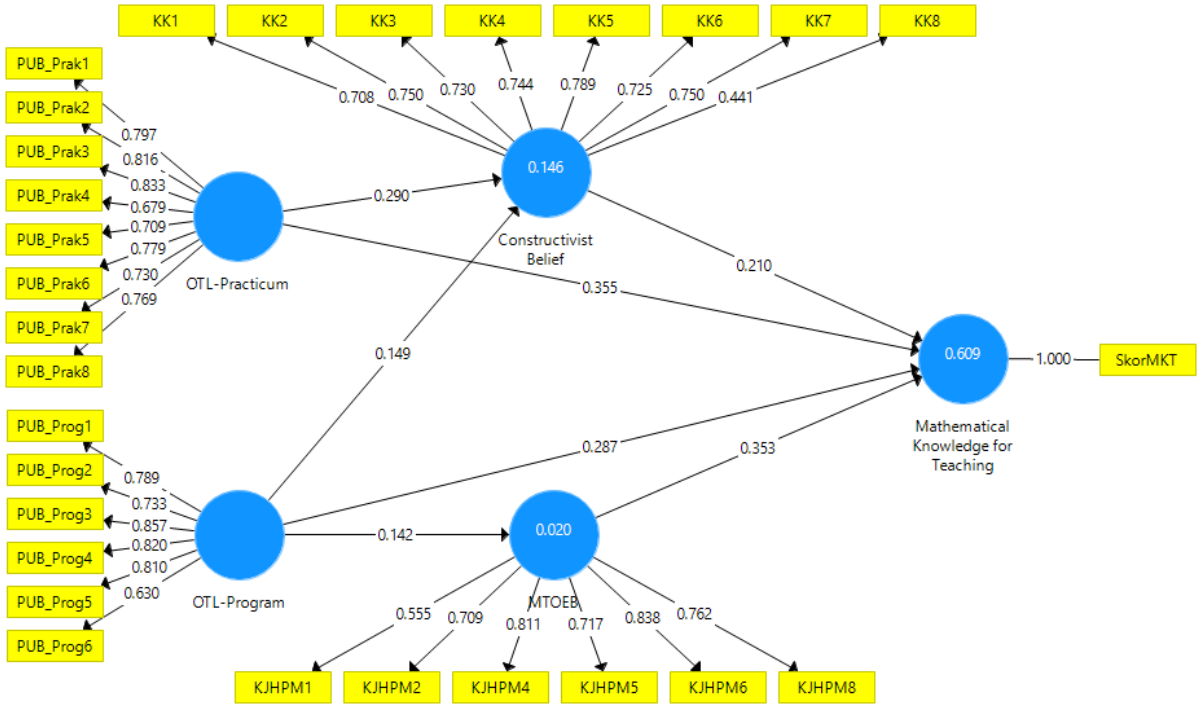
Overall, the model of factors that affect MKT among pre-service teacher is valid. This is because it was developed using extensive critical analysis and statistically tested (PLS-SEM) using SmartPLS 3.0 software to ensure that it is valid and reliable. Based on the analysis of measurement model, it was found that the items used in this study are valid. Besides that, the structural model shows there were four factors, namely OTL-Practicum, OTL-Program, constructivist belief and MTOEB contributing 60.9% to MKT. This means, overall this model has a moderate forecasting power. Hence there is a need to carry out further research in the future by considering the factors that have been proposed to increase the forecasting power of this model.

LIMITATIONS AND FURTHER RESEARCH

The study of teacher's knowledge was a continuous and growing research. Based on the critical analysis carried out, it was found that throughout the years 2019 until June 2022, there have been nearly 30 studies on teacher's knowledge published in selected journals. This clearly demonstrates that studies related to teacher's knowledge are important and are the focus of researchers around the world. According to Ren et al. (2017) more studies are needed in the future to explain how mathematical knowledge and teacher's belief are interconnected with each other. In order to ensure that the study about MKT and teacher beliefs factors have a greater impact in the future, it is recommended that the testing of mediator and moderator variables be implemented. It is suggested that in the future the role of mathematical belief and mathematics teaching efficacy belief factors will be tested as mediator between OTL and MKT. It is also proposed that the role of gender factors be tested as moderator between teacher's beliefs and MKT. This is because according to Leong et al. (2015) and Blomeke and Deleney (2012) it was found that gender factors also influenced the level of pre-service teachers MKT.

This study focuses on factors affecting MKT among pre-service teachers only. Hence, it is proposed that the scope of the study be extended to in-service mathematics teachers and lecturers at ITE and public universities. In addition, it is also suggested that future research be extended to pre-service teachers in early childhood education and special education. This is because both fields are also requiring the mastery of MKT in their teaching process. In addition, it is proposed that future studies should take into consideration other factors such as socio-economic status and involvement in teaching and research activities as variables that affect MKT. This is because according to Tatto et al. (2015) socio-economic status factor also affects the mastery of CK and PCK of pre-service teachers. Meanwhile, the study by Mu, Liang, Lu, and Huang (2018), stated that involvement in teaching and research activities also can affect the knowledge of a teacher. Hence, in the future it is proposed that both factors be included and tested in the model of factors affecting MKT among pre-service teachers.

APPENDICES



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