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Measuring and Factors Influencing Mathematics Teachers' Technological Pedagogical and Content Knowledge (TPACK) in Three Southernmost Provinces, Thailand

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Abstract. Technology becomes an important role in teaching and learning mathematics nowadays. Integrating technology in the classroom helps students have better understanding in many of mathematics concepts. One of the major framework for assessing the knowledge of integrating technology with the pedagogy and content in the classroom is Technological Pedagogical and Content Knowledge (TPACK) framework. This study aimed to measure mathematics teachers' TPACK in three southernmost provinces, Thailand and to study on factors influencing their TPACK. A quantitative study was carried out with 210 secondary level mathematics teachers in the three southernmost provinces, Thailand which were random by two stage sampling technique. Data were collected by using a questionnaire to identify the level of mathematics teachers' TPACK and the factors influencing their TPACK. Descriptive statistics, Pearson product moment correlation and multiple regression analysis were used for analysing data. Findings reveal that the mean score of mathematics teachers' TPACK is 3.33 which is in the medium level and the three factors which have positive correlation at .05 level of significant with the level of TPACK are teaching experience factor, individual specialization factor and personal & organization factor. However, there are only two factors influencing mathematics teachers' TPACK. The two factors are individual specialization factor and personal & organization factors. These give better understanding on mathematics teachers' knowledge in integrating technology with the pedagogy and content which will be the important information for improving mathematics teachers' TPACK.

INTRODUCTION

Despite the fact that many scholars in Thailand are trying to find their ways to improve students' learning, teaching and learning of mathematics in Thailand has not been very effective. The examination results evaluated and reported by the National Institute of Education Testing Service [1] which is the updated report in the Ordinary National Educational Test of middle school students in Thailand shows that the average mathematics scores of secondary school students from 2011-2013 are less than 50%. Additionally, the results from The Programme for International Student Assessment (PISA) of 2015 found that the mathematics average score of Thai students is 415 which is statistically significant below the average of The Organization for Economic Co-operation and Development (490) and Thailand was ranked in 54th out of 70 participating countries [2]. Moreover, if we focus in mathematics achievement of the fourth grade students from the Trends in International Mathematics and Science Study (TIMSS) 2011, the average score of mathematics achievement of Thai students are 458 which is significantly lower than the international average (500) and Thailand was ranked 38th in mathematics achievement out of 50 participating countries [3]. These suggest that the teaching and learning of mathematics in Thailand can benefit from further innovations and improvement.

Kay [4] Mentioned that teaching and learning in 21st century must have well ordering process which allows students to participate in the teaching and learning for example, creating situations based on students' interest, creating group activities. These will lead students be able to analyse and integrate their knowledge with other subjects. For effective teaching, teacher must be the instructor, have the characteristics of learning coaching and can lead students

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to the world of learning. The role of the teacher in the past must be changed when the world is going forword to the 21st century. Teacher in the modern age need to be more knowledgeable for enhancing students' learning, strengthen the skills needed for careers, and ICT has taken an educational role and being a part of the everyday life of people around the world. Therefore, teacher must have some knowledge in integrating ICT into the teaching and learning as well.

In order to go along with the teaching and learning in 21st century, integrating ICT in teaching and learning makes the concept in the particular content become more concrete and easily to understand especially in mathematics because mathematics is one of the abstract subject which is difficult for students and ICT will lead students to have better understanding in the concept. Hence, the integration of technology, pedagogy with the teaching content is important in developing students' understanding of a particular mathematical content. In this context, it is essential that teachers should improve their knowledge of integrating technology with the pedagogy and teaching content in their teaching.

Technological Pedagogical and Content Knowledge (TPACK) is defined as a notion which emerges from the interaction among content, pedagogy and technology knowledge. TPACK is a term that has been described to be the basis of successful teaching in relation with the use of technology which provides the teachers with the understanding as the representation of the concepts of using technologies and pedagogical techniques which technology is used in such constructive ways to deliver the teaching content, knowledge of what leads the concepts to be difficult or easy to learn together with how technology can do to redress some of the problems that students deal with; knowledge of the students before knowledge and theories of epistemology; and knowledge of how technology can be applied to extend the existing knowledge to develop new epistemologies or strengthen old ones [5].

However, despite the availability of hardware and software in the technology-rich secondary school, a study by Norton et al. [6] found that teachers rarely use computers in their teaching because they believe in their existing pedagogy; they are concerned about time constraint and their preference towards some particular text resources. Moreover, some teachers had restricted images of the potential of computer in mathematics teaching and learning because they have absorbed images of teacher-centered and content-focus pedagogy [6].

There are numerous barriers that can block the implementation of technology in teaching. Peggy [7] stated "these barriers range from personal fears (What will I do if the technology fails and my lesson can't proceed? How will I gain the confidence I need?) to technical and logistical issues (How does this software package work? Where or when should I use computers?) to organizational and pedagogical concerns (How can I ensure that students obtain adequate computer time without missing other important content? How do I weave computers into current curricular demands?)". Kastberg and Leatham [8] said that, it will not encourage teachers to integrate technology in their teaching if accessing to technology does not have knowledge of related curriculum material. This indicated that teacher lack knowledge of integration technology in their pedagogical and teaching content.

Therefore, this research aimed to measure mathematics teachers' TPACK based on each element of TPACK framework and to study on factors influencing the mathematics teachers' TPACK in the three southernmost provinces, Thailand in order to be the important information for improving their TPACK in the future.

METHODOLOGY

Samples

The samples in this study were 210 of secondary level mathematics teachers in the three southernmost provinces, Thailand which were random by 2 stages sampling technique. The first stage, the resecher selected 8-10 schools in Patani, Yala, and Narathiwat province (based on the number of school in each province) by purposive sampling technique. In the second stage, samples were selected for 2-15 mathematics teachers from each school refered from stage one, then the researcher got 70 mathematics teachers in each province. Therefore, there are 210 mathematics teachers in the three southernmost provinces, Thailand as the samples in this study.

Instrument

The instrument using in this study is the questionnaire for assessing mathematics teachers' Technological Pedagogical and Content Knowledge (TPACK) and for studying on factors influencing the mathematics teachers' TPACK in the three southernmost provinces, Thailand which devided into 2 part as follow;

Part 1: This part was adapted form the questionnaire of Sahin [9] and used for assessing TPACK of mathematics teachers based on seven elements under TPACK framework. The seven elements are Technological

Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical and Content Knowledge (TPACK).

Part 2: This part is for studying on four factors which are considered to be the expected factors influencing mathematics teachers' TPACK. The four factors are gender factor, teaching experience factor, individual specialization factor, and personal & organization factor.

The questionnaire was validated by two experts of Yala Rajabhat University, Thailand and was tried out to find the reliability. Cronbach's alpha coefficient was used to find the reliability and the reliability of this questionnaire is 0.93.

Data Collection

The questionnaire was given to 210 mathematics teachers in the three southernmost provinces, Thailand who is the sample in this study.

Data Analysis

The data were analysed by descriptive statistics to find the mean and standard deviation of mathematics teachers' TPACK in the three southernmost provinces, Thailand in each elements under TPACK framework, then the Pearson product moment correlation coefficient was used to find the correlation among each elements under TPACK framework and the correlation of four factors (gender factor, teaching experience factor, individual specialization factor, and personal & organization factor) which are considered to be the expected factors influencing mathematics teachers' TPACK with the mathematics teachers' TPACK. Next, the multiple regression analysis was used to find factors influencing mathematics teachers' TPACK in the three southernmost provinces, Thailand.

RESULTS AND DISCUSSION

This paper present results in two parts. The first part is on mathematics teachers' TPACK. The authors discuss on the mean score, the level of mathematics teachers' TPACK which is referring from the mean score of TPACK, the relationship among each elements under the TPACK framework and the relationship of four factors which are considered to be the expected factors influencing mathematics teachers' TPACK with the mathematics teachers' TPACK. The second part is on four factors which influencing the mathematics teachers' TPACK referring from part one. The four factors in this study are gender factor, teaching experience factor, individual specialization factor, and personal & organization factor. Last, the authors found the predicting equation of mathematics teachers' TPACK. The two parts were discussed as follow.

Mathematics Teachers' TPACK

TABLE 1. Mean, Standard deviation, and the level of mathematics teachers' TPACK in each element

TPACK Element	Mean	S.D.	Level
1) Technological Knowledge (TK)	3.60	0.67	High
2) Pedagogical Knowledge (PK)	3.57	0.67	High
3) Content Knowledge (CK)	3.46	0.61	Medium
4(Technological Pedagogical Knowledge (TPK)	3.53	0.73	High
5) Technological Content Knowledge (TCK)	3.39	0.69	Medium
6) Pedagogical Content Knowledge (PCK)	3.62	0.75	High
7) Technological Pedagogical and Content Knowledge (TPACK)	**3.33**	**0.67**	**Medium**

This table shows that mathematics teachers in the three southernmost provinces, Thailand have the maximum mean score in Pedagogical Content Knowledge (PCK))Mean =3.62), Technological Knowledge (TK))Mean =3.60), and Pedagogical Knowledge (PK))Mean =3.57) repectively. The scores of these three elements are in the high level referring from the mean score. The minimum mean score is in Technological Content Knowledge (TCK))Mean =3.39) which is in the medium level. However, the mean score of Technological Pedagogical and Content Knowledge

(TPACK) is 3.33 which is also in the medium level. This suggest that the knowledge in each element alone doest not make mathematics teachers have high level of TPACK.

TABLE 2. The correlation among each element under TPACK framework of mathemetics teachers

Pearson Correlation	TK	PK	CK	TPK	TCK	PCK	TPACK
TK	1	.720**	.715**	.694**	.737**	.687**	.737**
PK	.720**	1	.706**	.685**	.667**	.795**	.703**
CK	.715**	.706**	1	.783**	.782**	.788**	.840**
TPK	.694**	.685**	.783**	1	.863**	.898**	.846**
TCK	.737**	.667**	.782**	.863**	1	.774**	.925**
PCK	.687**	.795**	.788**	.898**	.774**	1	.769**
TPACK	.737**	.703**	.840**	.846**	.925**	.769**	1

** Correlation is significant at the 0.01 level (2-tailed)

This table shows that the six sub elements under TPACK framework which are Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK) have the positive correlation with the Technological Pedagogical and Content Knowledge (TPACK) of mathematics teachers in the three southernmost provinces, Thailand at .01 level of significant. This suggests that all six sub elements under TPACK framework support mathematics teachers to have better knowledge in integrating the three main components of TPACK (TK, PK, and CK). The element which has the most positive correlation with TPACK is TCK and the element which has the least relationship with TPACK is PK. These also suggest that the knowledge of integrating technology in the content lead mathematics teacher to have high level of TPACK. However, teacher who has only knowledge in pedagogy alone not extremely help them to have high level of TPACK though this element has positive correlation with TPACK.

According to the results from table 1 and table 2, mathematics teachers in the three southernmost provinces, Thailand have the most knowledge in integrating Pedagogical and Content (PCK). Subordinating knowledge is the Technological Knowledge (TK) and Pedagogical Knowledge (PK) respectively. These indicated that each element alone is not enough to make mathematics teachers' TPACK being in the high level. Therefore, it is important to measure teachers' TPACK in each element under TPACK framework to indicate which element should be improve as many studies have measured teachers' TPACK [10,11,12] in order to enhance the level of teachers' TPACK. Moreover, there are other factors which help in enhancing mathematics teachers' TPACK as the study of Stewart, Antonenko, Robinson, and Mwavita [13] and Chua, and Jamil [14] which measured teaches' TPACK and found many factors which influence the teachers' TPACK. Hence, Teacher do need to have more knowledge in how to integrate these three main elements together in order to make students have better understanding in the teaching and learning mathematics concepts. Additionally, the results form table 2 which show the six sub elements under TPACK framework (TK, PK, CK, TPK, TCK, PCK) that have the positive correlation with mathematics teachers' TPACK indicated that if teacher lacks any knowledge of a particular element, it also affects the TPACK level of the teacher.

Factors Influencing Mathematics Teachers' TPACK

TABLE 3. The mean, standard diviation and level of expected factors influencing mathematics teacher's TPACK

Expected factor influencing mathematics teacher's TPACK	Mean	S.D.	Level
1) Gender factor	3.03	0.91	**Medium**
2) Teaching experience factor	3.87	0.51	**High**
3) Individual specialization factor	3.79	0.61	**High**
4(Personal & organization factor	3.85	0.53	**High**

This table shows that from the four factors which are considered to be the expected factors influencing mathematics teachers' TPACK, teaching experience factor has the maximum mean score)Mean =3.87) which is the the high level. Subordinating factors are personal & organization factor)Mean =3.85), and individual specialization factor)Mean =3.79) which also being in the high level. However, gender factor has the minimum mean score)Mean =3.03) which is in the medium level.

TABLE 4. The correlation among four factors with the level of mathematics teachers' TPACK

Pearson Correlation	Gender factor	Teaching experience factor	Individual specialization factor	Personal & organization factor	Level of mathematics teachers' TPACK
Gender factor	1	-.083 .330	-.285 .063	-.147 .219	.278 .069
Teaching experience factor	-.083 .330	1	.451 .006	.444 .007	**.320*** **.042**
Individual specialization factor	-.285 .063	.451 .006	1	.670 .000	**.450*** **.006**
Personal & organization factor	-.147 .219	.444 .007	.670 .000	1	**.338*** **.034**
Level of mathematics teachers' TPACK	.278 .069	**.320*** **.042**	**.450*** **.006**	**.338*** **.034**	1

* Correlation is significant at the 0.05 level (2-tailed)

This table shows that teaching experience factor, individual specialization factor, and personal & organization factor have the positive correlation with the level of mathematics teachers' TPACK at .05 level of significant. The factor which has the most positive correlation with the mathematics teacher's TPACK is the individual specialization factor, subordinating factor is personal & organization factor, and teaching experience factor respectively. However, the gender factor does not has any relationship with the level of mathematics teachers in the three southernmost provinces, Thailand.

TABLE 5. The factors influencing mathemetics teachers' TPACK

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	constant	-.398	1.046		-.381	.707
	Gender factor	.001	.269	.001	.005	.996
	Teaching experience factor	.161	.234	.123	.685	.499
	Individual specialization factor	.565	.243	.518	2.324	**.029**
	Personal & organization factor	.319	.119	.436	2.674	**.013**

Dependent Variable: Mathematics teachers' TPACK

This table shows that there are two factors influencing mathematics teachers' TPACK in the three sounthernmost provinces, Thailand at .05 level of significant. The two factors are individual specialization factor, and personal & organization factor.

Therefore, the predicting equation of mathematics teachers' TPACK in the three southernmost provinces, Thailand at R^2=0.872 is $y' = -0.398 + 0.565C + 0.319D$, when C is the level of individual specialization factor and D is the level of personal & organization factor which referred from the mean score of each factor.

Acording to the table 4 and table 5, the finding shows the positive correlation of teaching experience factor, individual specialization factor, and personal & organization factor with the Technological Pedagogical and Content Knowledge (TPACK) of mathematics teachers in the three southernmost provinces, Thailand while gender have no correlation with TPACK of mathematics teachers. These might because of nowadays both man and woman have an equal opportunity to learn and women also have the potential to learn how to integrate technology in the teaching and learning as well as the man. Therefore, gender does not affect level of teacher's TPACK.

In addition, finding also shows that the factors influencing Technological Pedagogical and Content Knowledge (TPACK) of mathematics teachers in the three southernmost provinces, Thailand are individual specialization factor, and personal & organization factor. The first factor, Individual specialization factor, which influence mathematics teachers' TPACK might because of there are a lot of modern technology have been invented to address mathematics

instruction such as mathematical softwares. Some softwares are not easily to understand and implement in the classroom. This makes teachers need to learn and build their own expertise through training, adoption, implementation and extension. Once teachers are being at a specialized level, it will be possible to integrate the technology into the teaching methods and contents in the teaching mathematics. The other factors, personal & organization factor, also influence mathematics teachers' TPACK as well. This finding consistent with the study of Chua and Jamil [14] which found that personal & organizational factors is one factor that affected teachers' TPACK level. It might because of some teachers are not interesting in integrating technology in their teaching, some teacher have negative attitude toward using technology, or have more confident in their traditional teaching methods than integrating technology in the classroom. Moreover, teachers sometimes have to response to the school which does not support in integrating technology in the classroom or not supporting teachers to go for training in terms of integrating technology with their teaching methods with the contents they teach. In some school, the amount of time to teach in each period is too short to provide lesson or class activities which are integrated with the technology. Other studies also found many factors influencing teachers' level of TAPCK [13,15,16]. These affect the level of mathematics teacher's TPACK which also affects students' learning. Therefore, in Thailand, Thai educational system should support teachers to learn how to apply and integrate technology with mathematics contents through training on technology integration in particular mathematics content continuously from the begin to advance stage. School should pay attention in using technology in the classroom and motivate teachers to use the technology in their classroom by providing sufficient technology facilities both for teachers and students. These allow teachers to improve their TPACK in teaching mathematics which will lead students to have better understanding in the particular mathematics concept.

CONCLUSION

According to the results, mathematics teachers in the three southernmost provinces, Thailand have the most knowledge in Pedagogical Content Knowledge (PCK) and have the least knowledge in Technological Content Knowledge (TCK) which effect Technological Pedagogical and Content Knowledge (TPACK) of the teacher. Additionally, the six sub elements under TPACK framework (TK, PK, CK, TPK, TCK, PCK) have the positive correlation with mathematics teachers' TPACK. Moreover, the factors influencing Technological Pedagogical Content Knowledge (TPACK) of mathematics teachers in the three southernmost provinces, Thailand are individual specialization factor, and personal & organization factor. The findings in this study are beneficial for mathematics teachers. The school administrators, educators, specialists, and those who involve in the education system should take into consideration for enhancing mathematics teachers' TPACK.

Since the personal & organization factor is one of the factors affecting level of mathematics teachers' TPACK, the school administracters should take this information for creating school environment, arranging technological facilities, and supporting them to gain more knowledge in the use of appropriate technology for teaching and learning in mathematics content by providing training courses or supporting teachers to enhance their level of TPACK which will leads to the effective teaching and learning in the technological world nowadays. Moreover, there should be participatory action research among stakeholders such as school administrators, educators, specialists, and also teachers in order to find the way for enhancing mathematics teachers' TPACK.

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