

The Technological Pedagogical Content Knowledge (TPACK) among Mathematics Teachers In Primary Schools

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ABSTRACT

The purposes of this study are to identify the level of technological pedagogical content knowledge (TPACK) and identify the relationships among different components of technological pedagogical content knowledge (TPACK) of mathematics teachers in primary schools. The instrument used in this study is TPACK survey instrument (Pamuk et al., 2013) to measure teacher's technological pedagogical content knowledge. The participants of this study consist of 173 mathematics teachers from 24 primary schools of five areas in Banjarmasin, South Kalimantan, Indonesia. The finding of descriptive analysis was that the majority of the respondents reported moderate level of TPACK's components. The structural model test results show that the value of chi square is 4.843; P-value is 0.184; CMIN/DF is 1.614; RMSEA is 0.063; GFI is 0.993; AGFI is 0.911; TLI is 0.989; and CFI is 0.999. Structural equation modeling (SEM) was used to test all hypotheses. The finding of hypothesis test shows that there are significant relationships exist among TPACK components. The implication of this study is to increase primary schools mathematics teachers' ability about technological pedagogical content knowledge. In addition, primary schools mathematics teachers should constantly be balance with the ability of technological pedagogical content knowledge components so that learning in classroom could be meaningful.

KEYWORDS: TPACK, mathematics teachers

BACKGROUND OF STUDY

Information Communication Technology (ICT) has been developed rapidly and has been used in all areas of knowledge, including in the field of education. Realizing the importance of information technology in education, mathematic teachers should utilize the technology to assist the learners achieve their goals and to ease them in understanding and using the concepts of mathematics. ICT has been proven to be a means that develop individual intellectual skill in mathematics which is a prerequisite to not only the prosperity of each individual in this information explosion but also in shaping education policy in a country as a whole. Oldknow & Taylor (2000) noted there are at least three reasons for promoting the integration of ICT in education: i) public policy; ii) desirability and; iii) inevitability.

Many of researches result from mathematics education illustrate that the integrating of ICT may change the environment of teaching and learning mathematics (Chandra & Briskey, 2012; Tay, Lim, Lim, & Koh, 2012). ICT seems to provide a focal point that encourage interaction between learners and the technology itself. This implies that ICT used in instruction will support constructivist pedagogy, where learners use technology to explore and reach an understanding of mathematical concepts (Sang, Valcke, Braak, Tondeur, & Zhu, 2011; Crisan, 2004). British Educational Communications and Technology Agency (BECTA) (2003) describes that the benefits of ICT that are used in mathematics learning will increase motivation amongst pupils, fast and accurate feedback to pupils using ICT and greater collaboration between pupils. Thus, ICT can make students more active and not solely dependent on their teacher so they can study independently. Furthermore, for ICT to be used effectively in everyday teaching, radical changes are advocated in approaches to the teaching of mathematics. For this reason, it is important to promote research and practice that are able to provide teachers the opportunities to adequately utilize and integrate the technology into mathematics classrooms.

Beside that based on the results of primary school teacher competency test organized by the ministry of education and culture of Indonesia in 2012 indicates that the competency of elementary school teachers in Indonesia is below average, with an average value of 42.06 at the national level and in 2013 with an average

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value 42.5 (Ministry of Education and Culture of Indonesia 2012, 2013). According to Ministry of Education and Culture of Indonesia (2012), the material tested for teachers' competency test covers 30 percent on pedagogy competence and 70 percent on professional competence. Tested pedagogical competence is the integration of pedagogical concepts into the field of the study of learning processes in the classroom. While the professional aspect of the field of study is the basic competencies tested in accordance to the academic qualifications of teachers. These competences are the ability of the teacher in planning and implementing the learning process. The teacher competency test itself is implemented on line.

In addition, Bingimlas (2009); Keong, Horani& Daniel (2005); Jones (2004) found that the barriers preventing the integration and adoption of information and communication technology (ICT) in teaching mathematics are; lack of teachers' confidence, teachers' computer anxiety, lack of teachers competence and lack of access to resources. Furthermore, factors related to the nature of the teacher's personality are computer self-efficacy, self-concept, attitudes, motivation and needs, and these are considered crucial to the integration and development of modern technologies in education (Paraskeva, Bouta, and Papagianni, 2008; Benson, 2004; Hsioung, 2002; Roussos, 2002).

Currently, one of the most important ways of providing technological support is to use a framework for integrating complex problems of knowledge from pedagogy, content, technology and different forms of interactions among these elements in classroom (e.g., Koehler et al. 2007; Ferdig 2006; Mishra and Koehler 2006; Koehler and Mishra 2005; Niess 2005). Mishra and Koehler (2006) developed the technological pedagogical content knowledge (TPACK) model which was adapted from the Pedagogical Content Knowledge model (PCK) by Shulman (1986).

Technological Pedagogical Content Knowledge (TPACK) in any discipline is the perfect union of three knowledge domains (content, pedagogy, and technology) to develop a knowledge base from which a teacher can view a lesson and understand how technology can enhance the learning opportunities and experiences for students while also knowing the correct pedagogy to enhance the learning content. In mathematics education, a teacher with a TPACK perspective is a teacher that understand the correct pedagogy with this technology. By having a proper TPACK, he will be able to engage and motivate students as they explore the content of mathematics to a greater degree. The TPACK framework suggests that integrated knowledge of technology, pedagogy, and content is an essential condition to effective and innovative classroom teaching using technology (Abbitt, 2011).

In mathematics education, there have been several studies in using the TPACK framework (e.g. Meng and Sam, 2013; Stoilescu, 2011; Niess, 2009; Richardson, 2009). Guerrero (2010) stated that TPACK in mathematics goes beyond knowledge of learning a technology tool and its operation, per se, to the dimension of how to operate a piece of technology to improve mathematics teaching and learning. Although this knowledge includes learning the basic operational skills, it embodies the aspects of technology most relevant to its capacity for use in instruction to improve teaching and learning. Nowhere are these intricacies of technology's effect on content and instruction more varied and applicable than in the mathematics classroom, where technology has the potential to change not only what we teach but how we teach it.

It is important that educational reforms that a teacher's belief about their TPACK are pivotal in terms of using technology in the classroom. Besides, teacher's beliefs about their capability to use technology is a powerful predictor how effectively they will actually use technology (Lee & Tsai, 2010). For that reasons, the researcher is trying to focus her studies on Teachers' Technological Pedagogical Content Knowledge (TPACK) among primary schools mathematics teachers. Therefore, it is critical to investigate the relationships among the technological pedagogical content knowledge components in order to identify the factors that contribute to a teacher's use technology of mathematics teaching and learning process in primary school Banjarmasin, Indonesia.

Based on the background of study the research questions are:

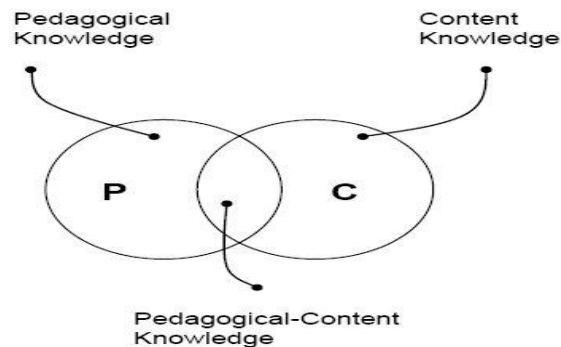
- i. What is the level of the components of technological pedagogical content knowledge (technological knowledge, content knowledge, pedagogical knowledge, pedagogical content knowledge, technological pedagogical knowledge and technological pedagogical content knowledge) among mathematics teachers in primary schools?
- ii. Are there any significant relationships exist between technological knowledge (TK) with technological content knowledge (TCK) and technological pedagogical knowledge (TPK); pedagogical knowledge (PK) with TPK and pedagogical content knowledge (PCK); content knowledge (CK) toward TCK and PCK; and

TK, CK, PK TCK, TPK, and PCK toward technological pedagogical content knowledge (TPACK) among mathematics teachers in primary schools?

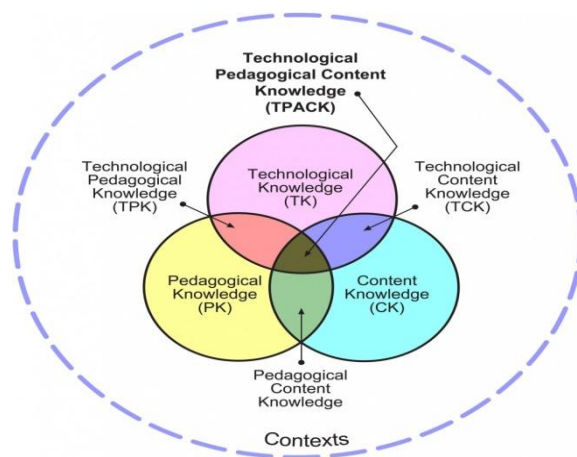
Theoretical Framework

Technological Pedagogical Content Knowledge (TPACK)

TPACK Model was built based on a model developed by Shulman (1986) explaining how teachers' understanding of Knowledge & Technology by relationship with each other in the creation of effective teaching practices. PCK generally is defined as the knowledge developed through the knowledge base that is the synthesis of three content knowledge, pedagogy knowledge and context knowledge. Shulman's model emanating through Venn diagram at Figure 1.1



This idea was later developed by Mishra and Koehler (2006) by adding a third set of Technology and Knowledge and develop into & TPACK. They are teaching and learning process based on the content and must make use of advances in technology. This Model can be illustrated through the TPACK diagram Venn in Figure 1.2



Based on figure 1.2, it is illustrated that the TPACK not only constructed of three primary knowledge i.e. content knowledge, pedagogical knowledge and technology knowledge, but there are three more sets of their combined knowledge that are also considered to be important in the TPACK namely: pedagogical content knowledge (PCK), technological content knowledge (TCK) and technological pedagogical knowledge (TPK).

In addition, technological aspects are systematically considered in the following ways:

Content Knowledge (CK)

Content knowledge is the knowledge about the actual subject matter that is to be learned or taught. Knowledge of content is of critical importance for teachers. As Shulman (1986) noted, this would include: knowledge of concepts, theories, ideas, organizational frameworks, knowledge of evidence and proof, as well as established practices and approaches towards developing such knowledge.

Pedagogical Knowledge (PK)

Pedagogical Knowledge is deep knowledge about the processes and practices or methods of teaching and learning and encompasses (among other things) overall educational purposes, values, and aims (Koehler & Mishra, 2008).

Technology Knowledge (TK)

Technology knowledge (TK) is the knowledge about standard technologies, such as books, chalk and blackboard, and more advanced technologies, such as the Internet and digital video. This involves the skills required to operate particular technologies.

Pedagogical Content Knowledge (PCK)

Pedagogical content knowledge is consistent with, and similar to Shulman's idea of knowledge of pedagogy that is applicable to the teaching of specific content. PCK covers the core business of teaching, learning, curriculum, assessment, and reporting such as the conditions that promote learning and the links among curriculum, assessment, and pedagogy. An awareness of common misconceptions and ways of looking at them, the importance of forging links and connections between different content ideas, students' prior knowledge, alternative teaching strategies, and the flexibility that comes from exploring alternative ways to looking at the same idea or problem are all essential for effective teaching (Koehler & Mishra, 2008).

Technological Content Knowledge (TCK)

Technological pedagogical knowledge (TPK) is the knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning setting and conversely, knowing how teaching and learning setting, and conversely, knowing how teaching might change as the result of using particular technologies (Koehler & Mishra, 2008).

Technological Pedagogical Knowledge (TPK)

TPK is knowledge about enhancing pedagogical practices, components (i.e., teaching, assessment, motivation etc.) with the implementation of technology into teaching and learning activities. In this knowledge base, teachers need to seek ways to enrich or support his or her teaching by use of specific technology (Koehler & Mishra, 2008).

Technological Pedagogical Content Knowledge (TPACK)

TPACK is an emergent for the knowledge that goes beyond all these components (content, pedagogy, and technology). Technological pedagogical content knowledge is an understanding that emerges from an interaction of content, pedagogy, and technology knowledge (Koehler & Mishra, 2008).

TPACK aims to support skill development of teacher for acquiring and explaining how technology-related subject-specific knowledge is applied during teaching and learning activities (Koehler & Mishra, 2009).

METHODOLOGY**Study Participants**

The study participants comprised of 173 mathematics teachers from 24 primary schools of five areas in Banjarmasin. The participants in this study are primary teachers of grades 1st to 6th. The writer delivered the instrument to the primary teachers from five areas in Banjarmasin (West Banjarmasin, South Banjarmasin, East Banjarmasin, Middle Banjarmasin, and North Banjarmasin), South Kalimantan, Indonesia. A total of 166 teachers responded to the survey, constituting a response rate of 95.95%.

Research Instruments

The instrument was the TPACK survey instrument (Pamuk et al., 2013) to measure teacher's TPACK. TPACK survey developed by Pamuk et al. (2013) is a 32 – item survey of TPACK with seven subscales: technology knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), technological pedagogy knowledge (TPK), technological content knowledge (TCK), pedagogical content knowledge (PCK), and technological pedagogical and content knowledge (TPACK). The survey items are of five level Likert's scale (from 1—strongly disagree to 5—strongly agree). The measure of TPACK domains were used in this study to represent participants' self-assessment of their knowledge. Pamuk et al. (2013) described the development and validation of this instrument and reported Cronbach's alpha coefficients for subscales ranging from 0.759 to 0.916 and the whole instrument is 0.950.

Data Analysis

Internal reliability of the seven construct was first established through high Cronbach alphas for all constructs: TK ($\alpha = .821$), PK ($\alpha = .758$), CK ($\alpha = .883$), PCK ($\alpha = .801$), TPK ($\alpha = .762$), TCK ($\alpha = .765$), and TPACK ($\alpha = .920$). The analyses in this study were conducted using the Statistical Package for the Social Science software (SPSS) 19.0 and Analysis of Moment Structure (AMOS) 16.0. Descriptive statistics were used to describe the research data. The descriptive analyses involved were the mean, percentage, frequency, and standard deviation. The descriptive analysis was conducted using SPSS 19.0. The inferential statistical analysis was used for statistical hypothesis testing including the Structural Equation Modeling. The Inferential statistical analyses were conducted using AMOS 16.0.

RESULT AND DISCUSSION

The Level of The Components of TPACK

Data from observations was recorded and processed with the program Statistical Packages for Social Sciences (SPSS) Version 19.0 for the mean, the distribution, frequency and standard deviation (Nazir, 2003). The result of Descriptive analysis was conducted to answers first research question as show in table 1.

Table 1
Mean, Standard Deviation and categorization of Technological Pedagogical Content Knowledge

Dimension	Mean	Std. Deviation	Categorization
Technology Knowledge	3.4241	.65369	Moderate
Content Knowledge	3.9016	.47232	Moderate
Pedagogical Knowledge	3.9937	.41847	Moderate
Pedagogical Content Knowledge	3.7835	.43183	Moderate
Technology Pedagogical Knowledge	3.9351	.53921	Moderate
Technological Content Knowledge	3.9385	.47165	Moderate
Technological Pedagogical Content Knowledge	3.9167	.43293	Moderate
Technological Pedagogical Content Knowledge (Whole)	3.8377	.40963	Moderate

Table 1 shows the highest score that is Pedagogical knowledge with $M = 3.9937$ ($SD = .41847$); technological content knowledge with $M = 3.9385$ ($SD = .47165$); technological pedagogical knowledge with $M = 3.9351$ ($SD = .53921$); technological pedagogical content knowledge with $M = 3.9167$ ($SD = .43293$); content knowledge with $M = 3.9016$ ($SD = .47232$); pedagogical content knowledge with $M = 3.7835$ ($SD = .43183$); and the lowest is the technology knowledge with $M = 3.4241$ ($SD = .65369$). *Mean of whole of Technological Pedagogical Content Knowledge* with $M = 3.8377$ ($SD = .40963$). However all subscales of mathematics teachers' technological pedagogical content knowledge in primary schools in Banjarmasin is at a moderate level.

It means that teachers are very knowledgeable about the technology knowledge, content knowledge, pedagogical knowledge, pedagogical content knowledge, technological pedagogical knowledge, technological content knowledge and technological pedagogical content knowledge of their fields but not able to deliver their knowledge about seven components of technological pedagogical content knowledge in a way that can give a better understanding of the students.

In additions, Niess (2009) states that mathematics teacher' development of TPACK relies on many factors, including experiences that use appropriate technologies as they learn mathematics at the collegiate level. Their content learning environments must go beyond simply expecting them to mimic experiences modeled as they learned mathematics. From social and psychological perspectives, these teachers need to participate in more experiences than simply learning the mathematics; they need to participate analyzing (i) the affordances/constraints of using a certain technology to teach specific mathematics content; (ii) teaching the content are changing as a result of using technology; (iii) creating suitable assessments that include the use of technology; (iv) posing questions that raise and prolong students' learning of mathematics while using technology; and (v) developing their knowledge about technologies that exist for teaching and learning specific mathematics concepts. Based on the statement before, this study stated that the improvement of pre-serviced and inservice teachers' TPACK components scores depends on the learning environment for technology integration competency (Angeli&Valanides, 2009; Agyei&Voogt, 2012, Gao et al., 2011).

The Relationship among TPACK Components

Statistical analyses used for this study were SEM to test all hypotheses. The structural model test results show that the value of chi square is 4.843; P-value is 0.184; CMIN/DF is 1.614; RMSEA is 0.063; GFI is 0.993; AGFI is 0.911; TLI is 0.989; and CFI is 0.999. According to the result of a structural model as mention above, the result of analysis of SEM to the relationship between the constructs can be seen in Table 2 as follows.

Table 2
SEM analysis of Model Structure Studies

The relationships between	Variable	Estimate	C.R.	P	Explanation
PCK	<--- CK	.644	13.183	***	Significance
TCK	<--- CK	.497	7.321	***	Significance
PCK	<--- PK	.314	6.394	***	Significance
TPK	<--- PK	.202	3.755	***	Significance
TPK	<--- TK	.545	8.524	***	Significance
TCK	<--- TK	.301	4.423	***	Significance
TPACK	<--- TCK	.178	13.093	***	Significance
TPACK	<--- TPK	.237	17.979	***	Significance
TPACK	<--- PCK	.175	12.218	***	Significance
TPACK	<--- CK	.291	23.030	***	Significance
TPACK	<--- PK	.121	13.144	***	Significance
TPACK	<--- TK	.212	20.340	***	Significance

Table 2 shows that: (i) There is significant relationship between the technological knowledge and the technological content knowledge among mathematics teachers in primary schools.; (ii) There is significant relationship between the technological knowledge and the technological pedagogical knowledge among mathematics teachers in primary schools; (iii) There is significant relationship between the technological knowledge and the technological pedagogical content knowledge among mathematics teachers in primary schools; (iv) There is significant relationship between the content knowledge and the technological content knowledge among mathematics teachers in primary schools; (v) There is a significant relationship between the content knowledge and the pedagogical content knowledge among mathematics teachers in primary schools; (vi) There is significant relationship between the content knowledge and the technological pedagogical content knowledge among mathematics teachers in primary schools; (vii) There is significant relationship between the pedagogical knowledge and the technological pedagogical knowledge among mathematics teachers in primary schools; (viii) There is significant relationship between the pedagogical knowledge and the pedagogical content knowledge among mathematics teachers in primary schools; (ix) There is significant relationship between the pedagogical knowledge and the technological pedagogical content knowledge among mathematics teachers in primary schools; (x) There is significant relationship between the pedagogical content knowledge to the technological pedagogical content knowledge among mathematics teachers in primary schools; (xi) There is a significant relationship between of the technological content knowledge and technological pedagogical content knowledge among mathematics teachers in primary schools; (xii) There is a significant relationships between of the technological pedagogical knowledge and the technological pedagogical content knowledge among mathematics teachers in primary schools

The results of this study is similar to the findings by Pamuk et al (2013) that there are positive correlation between the technological knowledge (TK) and technological content knowledge (TCK) and technological pedagogical knowledge (TPK); pedagogical knowledge (PK) with TPK and pedagogical content knowledge (PCK); content knowledge (CK) toward TCK and PCK; and TK, CK, PK TCK, TPK, and PCK toward technological pedagogical content knowledge (TPACK). The results of findings also similar to Chai et al. (2010) who found that technological knowledge, pedagogical knowledge and content knowledge were all significant predictors of TPACK.

TPACK studies such as Koehler et al (2007) and Angeli and Valanides (2009) showed that teachers increase new kinds of knowledge when they are able to make connections between technological knowledge, pedagogical knowledge, and content knowledge. These studies support the transformative view of TPACK

which states that the outcome of integrating multiple knowledge sources results in knowledge that is unique and different from a simple addition of its sources (Angeli and Valanides,2009).

In addition, Grandgenett (2008) stated that mathematics teachers with strong TPACK have six main characteristics: i) opening to experimentation with technological tools and willingness to experiment with new lessons using technology; ii) staying on task and not being sidetracked when teaching mathematics topics with technology; iii) providing clear pedagogical strategies by knowing where students are academically, what students need to know, and how the lesson should be taught; iv) helping students understand why technology is essential; v) using technology for teaching, assessment, and classroom management; and vi) being comfortable and optimistic about changes in technology.

CONCLUSION

The findings of this study are: the majority of the respondents is reported that TPACK components of respondents as having moderate level and there are significant relationships exist among TPACK components. Based on the findings that primary schools mathematics teachers are expected to increase their ability on technological pedagogical content knowledge. In addition, primary schools mathematics teachers must constantly balance the ability of technological pedagogical content knowledge's components so that learning in classroom being meaningful.

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