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An Exploration into Teachers' Technological Mathematics Knowledge: Changling Xiwang Elementary School as A Case Study

Shiwei Tan[1], Wenrong Jiang[2]

[1]Department Mathematics and Statistics, Guangxi Normal University, China
[2]Guilin city middle school nineteenth, Guilin, China
744134237@qq.com

Abstract

The role of teachers in educational institutions in this era must at least know the duties of teachers as professional educators, namely educating, teaching, guiding, directing, training, assessing, and evaluating students in early childhood education. The main purpose of this study is to find out how the teacher's ability to explore technological mathematical knowledge is in teaching mathematics in the classroom. The research paradigm adopted in this study is qualitative research. The main sample in this study were 24 teachers who teach at Changling Xiwang Elementary School. This research was carried out from March to May of the 2020/2021 academic year. The results showed that the teacher's perception of technological abilities in teaching technology-based mathematics, the ability of mathematics teachers to teach mathematics, and the ability of technology-assisted mathematics teachers to teach mathematics in class were categorized as good. These results indicate that most of the teacher's abilities are classified as good about using technology in teaching mathematics. The research suggests furthering researchers to be able to develop technology-based learning media, especially in the field of mathematics in teaching mathematics material in the classroom. Teachers in this century are advised to keep up with the times that are filled with facilities based on information and communication technology (ICT).
Keywords: mathematics, teacher's technological mathematics knowledge, exploration, teaching elementary school

Abstrak

Peran guru dalam lembaga pendidikan di era ini setidaknya harus mengetahui tugas guru sebagai pendidik profesional, yaitu mendidik, mengajar, membimbing, mengarahkan, melatih, menilai, dan mengevaluasi peserta didik pada pendidikan anak usia dini. Tujuan utama dari penelitian ini adalah untuk mengetahui bagaimana kemampuan guru dalam menggali pengetahuan teknologi matematika dalam pembelajaran matematika di kelas. Paradigma penelitian yang dianut dalam penelitian ini adalah penelitian kualitatif. Sampel utama dalam penelitian ini adalah 24 guru yang mengajar di SD Changling Xiwang. Penelitian ini dilaksanakan pada bulan Maret sampai dengan Mei tahun ajaran 2020/2021. Hasil penelitian menunjukkan bahwa persepsi guru terhadap kemampuan teknologi dalam mengajar matematika berbasis teknologi, kemampuan guru matematika dalam mengajar matematika, dan kemampuan guru matematika berbantuan teknologi dalam mengajar matematika di kelas termasuk dalam kategori baik. Hasil ini menunjukkan bahwa sebagian besar kemampuan guru tergolong baik dalam menggunakan teknologi dalam pembelajaran matematika. Dengan demikian penelitian ini menyarankan peneliti selanjutnya untuk dapat mengembangkan media pembelajaran berbasis teknologi khususnya bidang matematika dalam mengajarkan materi matematika di kelas. Guru di abad ini disarankan untuk mengikuti perkembangan zaman yang dipenuhi dengan fasilitas berbasis teknologi informasi dan komunikasi (TIK).
Kata kunci: TPACK, Guru sekolah dasar, teknologi

Corresponding author: Ria Kasanova
Email Address: 744134237@qq.com (Guangxi Normal University, Guilin, China)
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INTRODUCTION

Basic education facilities and infrastructure are important factors to ensure good quality education(Hanafi, Yasin, Toran, Mokhtar, & Bari, 2010a, 2010b), especially in the 21st century filled with technology facilities (Virtanen et al., 2021). Then the requires adjustment efforts along with an increased understanding of technology at the elementary school level because elementary school formal education institutions are one form of formal education unit that organizes general education at the most basic level, which is often called elementary school education which is the initial and basic stage for the next stages of education (Bernard, Akbar, Ansori, & Filiestianto, 2019; Fernandes, Rodrigues, & Ferreira, 2020; Hermita et al., 2018; Thao, Hoang, & Kato, 2016). We need good qualified, creative, and innovative educators from this basic stage to produce quality students for the nation's development (Ghizan, 2013; Thanh et al., 2020).

Thus the role of teachers in educational institutions in this era must at least know the duties of teachers as professional educators, namely educating, teaching, guiding, directing, training, assessing and evaluating students in early childhood education through formal education, basic education and secondary education(Yu, Niemi, & Mason, 2019). As the agent of change, teachers must continue to develop their teaching process by understanding Technological Pedagogical Content Knowledge (TPACK)(Listiawan, Purwanto, As'Ari, & Muksar, 2018; Voithofer, Nelson, Han, & Caines, 2019; T.T. Wijaya & Hermita, 2021).

There are research findings that teachers do not use supporting media to clarify the material and make it easier for students to understand the presented material (Chatmaneerungcharoen, 2019; T.T. Wijaya, 2021; T.T. Wijaya, Jianlan, & Purnama, 2020; L. Zhang, Zhou, & Wijaya, 2020). Less varied methods and the absence of media also cause children to have difficulty learning mathematics (T.T. Wijaya, Ying, et al., 2020; X. Zhang, Zhou, & Wijaya, 2020). The difficulties experienced by students have an impact on low mathematics learning outcomes (Tommy Tanu Wijaya, Ying, & Purnama, 2020), this is evidenced by the number of students who do not meet the minimum completeness criteria, this is due to one of the external factors, namely the use of learning media that has not been maximized in learning mathematics(Fried, 2007). This problem is supported by research conducted by Darjiani on the analysis of students' learning difficulties in mathematics, showing that students have difficulty in numeracy skills, conceptual aspects, and problem-solving aspects(Salinas et al., 2013).

Shulman first coined TPACK that PCK is related to teachers' understanding of educational technology. TPACK is the ability of teachers to facilitate student learning of certain content through pedagogical and technological approaches. Learning through TPACK can explore teachers in increasing teacher capacity for understanding technology in learning in general(Lainufar, Mailizar, & Johar, 2020). According to Arbiyanto et al (2018), TPACK is knowledge about various technologies that can be utilized in learning and using technology. With this in mind, Mishra and Koehler (T.T. Wijaya, Jianlan, et al., 2020)added a technological knowledge dimension to Shulman's conception of obtaining TPACK. They suspect that teachers can use seven types of knowledge to create technology-integrated learning strategies. In addition to the three basic knowledge sources of technological knowledge, pedagogical knowledge, and content knowledge, four other types of knowledge can emerge from their relationship. These are pedagogical content knowledge, technological pedagogical knowledge, technological content knowledge, and TPACK(Bakar, Maat, & Rosli, 2020; Habibi, Yusop, & Razak, 2020; T.T. Wijaya, Purnama, & Tanuwijaya, 2020).

By adjusting the visualization of Mishra and Kohler (2006) TPACK as three separate circles of knowledge, the construction used to describe the teacher's TPMK can be described as figure 1.

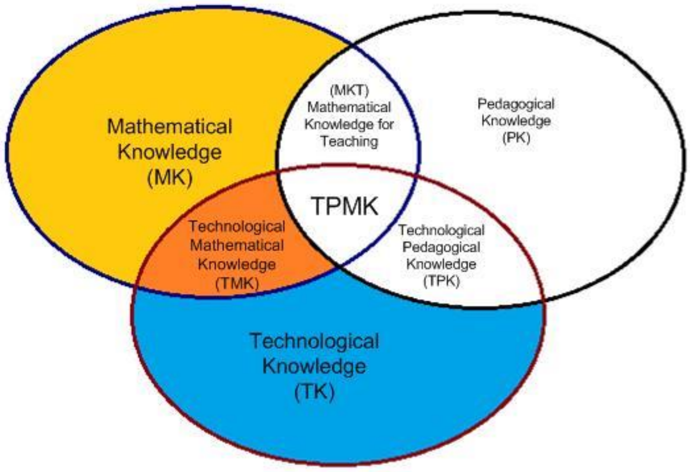

Figure 1. Constructs of teachers' TPMK(Chai, Lim, & Tan, 2016; Koh, 2019)

The teacher TPMK above is divided into 7 main development points as Mathematical Knowledge (MK), which means knowledge of mathematics teacher content. Technological Knowledge (TK) means the teacher's knowledge of various technologies; Pedagogical knowledge (PK) means the teacher's knowledge about the teaching process or method; technological mathematical knowledge (TMK) – the teacher's knowledge of technological tools that can be used to represent mathematical knowledge or the teacher's use of technology to represent mathematical knowledge(Chai et al., 2016). In the framework of Mishra and Koehler (2006), this construct is represented by content knowledge technology (TCK); Technological Pedagogical Knowledge (TPK) means Teacher knowledge about using technology to apply different teaching methods; Technological Mathematical Knowledge (TMK), As defined by Silverman and Thompson (2008), it represents teachers' pedagogical content knowledge (PCK) for teaching mathematics; TPMK – teacher's knowledge of using technology to apply teaching methods to mathematics(Koh, 2019).

Of the seven developments above, in this study, researchers only discussed TMK itself. Thus, Technological Mathematical Knowledge (TMK) itself means that the teacher's knowledge regarding the application of technology in learning mathematics. The concept of TMK thinking provides an understanding that to teach mathematics it is not enough just to understand the knowledge of mathematics (knowing mathematics science) but also to know of how to teach mathematics with the help of technology(Chai et al., 2016; Koh, Chai, & Lee, 2015).

From this opinion, we as mathematics educators, especially in the technological era, demand that we strive to know and understand technology in mathematics lessons for teachers who teach in elementary schools in China in general and at Changling Xiwang Elementary School in particular. So, the researcher wants to examine how far the teacher's knowledge and understanding of technological mathematical knowledge in teaching mathematics material is. Because of the importance of mathematics teachers' knowledge in using technology, the researchers wanted to know how the teacher's ability to explore technological mathematical knowledge was in teaching mathematics in the classroom at Changling Xiwang Elementary School.

METHOD

Research Paradigm

The research paradigm adopted in this study is qualitative research. Qualitative research methods emphasize collecting data about naturally occurring phenomena (Alshenqeeti, 2014; Aspers & Corte, 2019). This research tradition is considered suitable for current research because the researcher observes the teacher's Technological Mathematical Knowledge in the natural classroom environment. The main sample in this study were 24 teachers who teach at Changling Xiwang Elementary School. This research was carried out from March to May of the 2020/2021 academic year. The type of data collected from the research sample is primary data. Agung (2014: 90) says primary data is obtained from the first source or obtained directly from the first source.

Therefore, the data collection methods in this study were observation and questionnaires. The observation in question, the researcher has his observation sheet to carry out, checks the list of things that support indicators regarding TMK described in the questionnaire, it seems that it is said that direct observation with this method is aimed at obtaining valid evidence as supporting material for information in a study. (W. Gulo) while giving the questioner to the object of research in this case, the researcher himself met face-to-face with every class teacher in each classroom where the teacher taught him. With this method, researchers observe and collect qualitative information about the elaboration of indicators regarding how teachers understand technology in teaching mathematics in the classroom. Struwig and Stead (2001) consider that the qualitative research paradigm allows researchers to understand the issue under study from the perspectives of the research participants. This explains the epistemological view of qualitative research, which shows that researchers gain knowledge through personal encounters with teachers who teach in elementary schools.

The following are some of the main indicators regarding TMK described in the questionnaire for the development of elementary school teachers, as shown in table 1 below.

Table 1. Indicators for TMK development

TMK Components	**indicators**
Technological Knowledge	Technological Knowledge teacher's : a) Basic and technical component problems on the computer b) Ease of using technology.

	c) Able to use presentation program, d) Able to use printer, scanner, projector, etc e) Using the internet as a medium of communication.
Mathematics Knowledge	Mathematics Knowledge Teacher's a) Understand concepts, propositions, etc. b) Knowledge of material history c) Use of sources of books, journals, etc. d) Participate in mathematics seminars
Technological Mathematical Knowledge	The ability of mathematics teachers in understanding technology: a) The use of Ms. Office in learning mathematics b) selection and adjustment of technological approach c) technology-based facilities

Some of the indicators above will be developed into statement items and measured using a Likert scale. Licket scale starting from; very less = 0; less = 1; enough = 2; good = 3 and very good = 4 .

The survey with a needs assessment questionnaire was processed by calculating the frequency of the alternative answers that had been chosen for each of the questions given for later analysis. Hartati (2010:66) explains that to measure the questionnaire data the following formula is used: P = fn *100% Description: P = percentage number, f = frequency of answers, n = number of respondents. after being analyzed, an interpretation is then carried out using the following percentage categories.

Table 2. Indicators for TMK development

Answers percentage	**criteria**
$P = 0$	nobody
$0<P<25$	Small pars
$25<P<50$	Almost a half
$50\leq P<75$	half
$75\leq P<100$	mostly
$P=100$	totally

Research Stage

This research was conducted in three (3) stages: the preparation, implementation, and data collection stages. 1) Researchers at the preparation stage made preparations related to observation sheets and questionnaire sheets. 2) the implementation stage, this research was carried out on each class teacher in each different classroom at one of the Yanki elementary schools, Changling Xiwang Elementary School. 3) the stages of data collection, data collection is carried out with a closed questionnaire filled out by the teacher when the researcher conducts a direct meeting with the teacher in his class. After getting the data, the researchers conducted a study of the results obtained and concluded.

RESULT AND DISCUSSION

The following are the results of the research: the teacher's perception of knowledge about technology, knowledge of the material being taught, and knowledge of technology-based mathematics taught in class. Thus, for a clearer understanding of the teacher's understanding of Technological Mathematical Knowledge, it can be seen in graphs 1, 2 and 3 below.

Teacher's response about Technological Knowledge

Figure 2 The shows the responses or responses about technology knowledge from all teachers who teach mathematics at Changling Xiwang Elementary School.

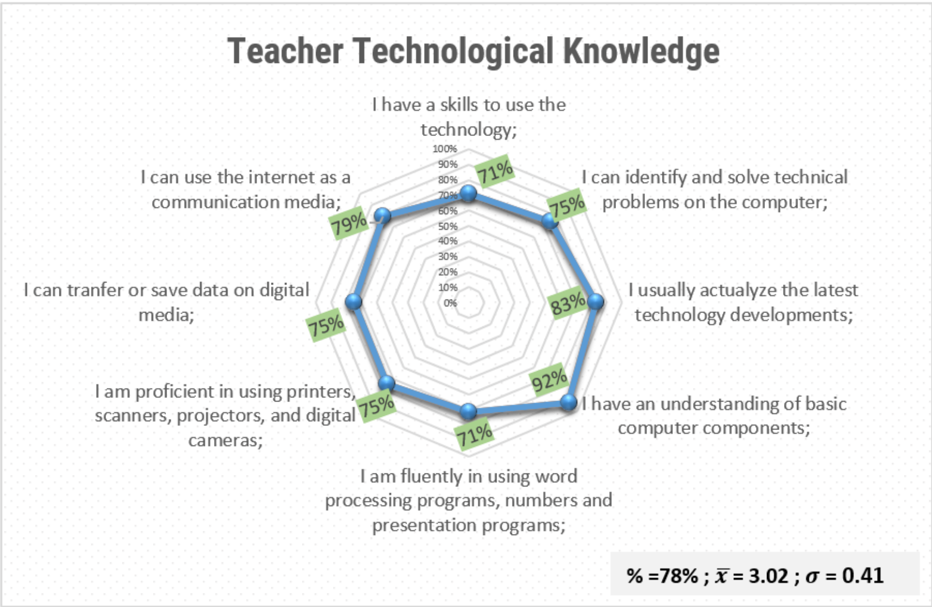

Figure 2. Perception result of teacher technological knowledge

In Figure 2 shows the results of teachers' perceptions of the ability of teachers' technological knowledge related to mathematics, seen from the average percentage for all indicators of 78% with good categories. The results of this perception show that most of the teachers are classified as good at technology in teaching mathematics.

These results are not much different from the observations made that the facilities related to technology owned by Changling Xiwang Elementary School are quite good. Therefore, the guarantee of facilities based on communication and information technology positively impacts teacher knowledge about the use of technology itself. In his research, Jhoe said that ICT-based facilities are quite good and greatly affect teachers' understanding of the use of technology and student achievement(Ozturk & Bayrak, 2015; Swanson, 2020; Vasquez, 2015).

The technological knowledge of teachers is measured using an instrument consisting of 8 statements. As shown in Figure 2, from 24 respondents, the actual average (mean) for all respondents is 3.03. The standard deviation shows the size of the data variation to the mean (the distance between the data and the mean). The standard deviation for mathematical knowledge is 0.41. This means that the data variance is relatively sufficient so that the standard deviation is smaller than the mean.

Teacher's response about Mathematical Knowledge

Figure 3 shows the responses or responses about the knowledge of mathematics material from all teachers who teach mathematics at Changling Xiwang Elementary School.

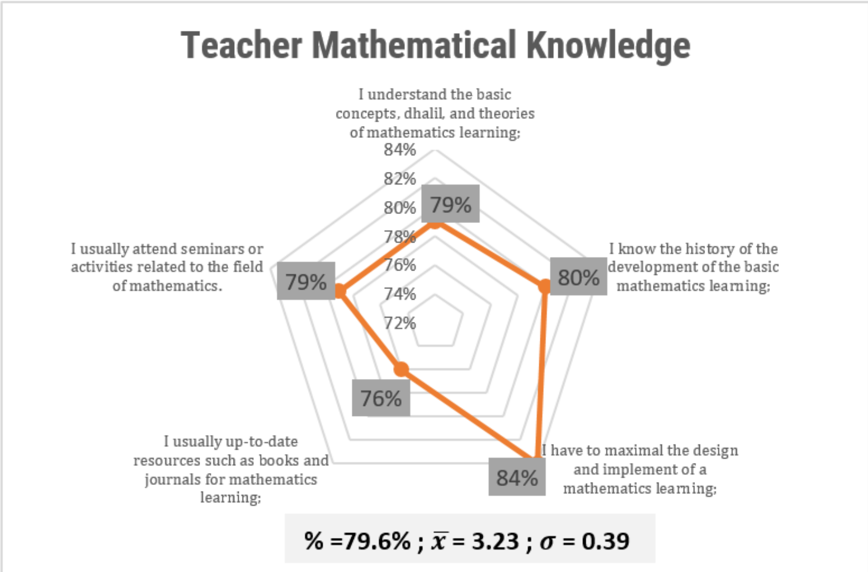

Figure 3. Perception result of teacher mathematical knowledge

In Figure 3 shows the results of teachers' perceptions of teachers' mathematical abilities in teaching mathematics material in elementary schools by looking at the average percentage for the overall indicator of 79.6%, which belongs to the good category. The results of the average percentage show that most of the overall teachers are already classified as capable enough to understand mathematics material. Associated with the results of research conducted by Mazur that, the average ability of teachers are already classified into the category of quite good, it has a very positive impact on the ability of the students themselves(Fox-Turnbull, 2019; Nurlaela, Samani, Asto, & Wibawa, 2018).

As shown in figure 3, teacher's mathematics knowledge is measured using 5 statement instruments, from 24 respondents the actual average (mean) for all respondents is 3.23. The standard deviation shows the size of the variation of the data to the mean (the distance between the data and the mean). The standard deviation for mathematical knowledge is 0.39. This means that the data variance is relatively sufficient so that the standard deviation value is smaller than the mean.

Teacher's response about Technological Mathematical Knowledge

Figure 4. The following shows responses or responses about Technological Mathematical Knowledge from all teachers who teach mathematics at Changling Xiwang Elementary School.

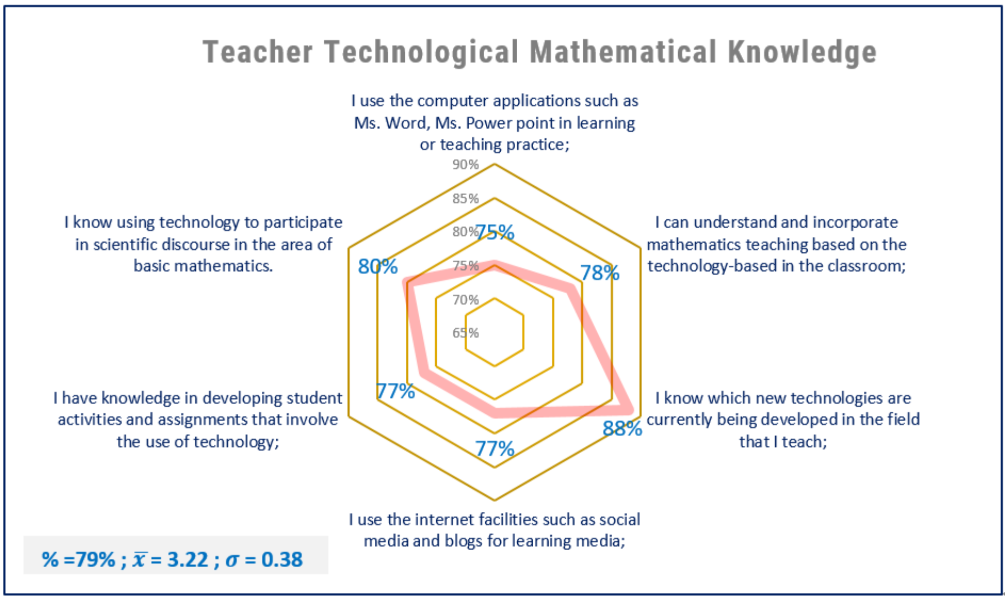

Figure 4. Perception result of teacher technological mathematical knowledge

Figure 4 shows the results of teachers' perceptions about the ability of mathematics teachers with the help of technology in teaching mathematics material in the classroom by looking at the average percentage for the overall indicator of 79% which is classified as Good. Overall the teachers are quite good at having the ability about technological mathematical knowledge.

From the teacher's technological mathematical knowledge, it is measured by 6 statement instruments. As shown in figure 4, from 24 respondents, the actual average (mean) for all respondents is 3.22 The standard deviation shows the size of the variation of the data to the mean (distance from the average data to the mean). The standard deviation for mathematical knowledge is 0.38. This means that the variance of the data is relatively sufficient so that the standard deviation is smaller than the mean.

The results of teachers' perceptions of technological mathematical knowledge are closely related to the results of teachers' perceptions of understanding technology and understanding the material being taught, it is proven that the teacher's lack of ability to use technology makes it difficult for a teacher to teach technology-based material in the classroom.

From the three results above, it is not much different from the observations made by the researchers and not much different from the observations directly observed by the researchers themselves.

CONCLUSION

Based on the results of the research above, it is concluded that the teacher's perception of technological abilities in teaching technology-based mathematics is classified as good category. Perceptions about the ability of mathematics teachers in teaching mathematics material in elementary schools are categorized as a good, while the perception of the ability of mathematics teachers to be assisted by technology in teaching mathematics in class is also in the good category, from these three results indicate that most of the teachers' abilities are quite good. About the use of technology. Therefore, teaching technology-assisted mathematics material is excellent.

In general, the use of technology is quite good, so that the teacher's knowledge of technology knowledge and its use is good. Thus, the research suggests that further researchers can develop technology-based learning media, especially in mathematics, in teaching mathematics material in class. Teachers in this century are advised to keep up with the times that are filled with facilities based on information and communication technology (ICT).

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