A study on the subject Teaching knowledge Level of middle school Mathematics Teachers integrating technology

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Abstract. Teachers with good content knowledge, effective teaching strategies and integrated technology play a crucial role in the learning effect of students. Based on the modified Questionnaire of Pre-service Teachers' Teaching and Technical Knowledge, the data results were processed by Matlab and Excel software to analyze the subject teaching knowledge level of 53 in-service mathematics teachers with integrated technology. It is found that in-service mathematics teachers have good subject and teaching knowledge, but weak technical knowledge, good subject teaching knowledge and teaching knowledge of integrated technology, and need to improve the subject knowledge of integrated technology, teachers have a good level of subject teaching knowledge of integrated technology, but there is room for improvement.

Keywords: Mathematics teacher; TPACK; Information Technology

1 Introduction

The rapid development of information technology has brought the development power to education and also become one of the characteristics of modern educational technology [1]. Due to the close relationship between technology and teaching, the use of information resources has become an important part of classroom teaching and has gradually become an indispensable knowledge for teachers to use technology in teaching [2]. Mathematics education is an important part of basic education, and how to effectively apply technology in mathematics classroom teaching is an issue that mathematics educators should consider for a long time [3].

Learning in the 21st century integrates all kinds of technological equipment, and uses learning resources in the learning environment to carry out a series of complete interactive processes between students and teachers [4]. Teaching is a complex activity involving different types of knowledge. Content knowledge, teaching knowledge and technical knowledge are all related and can support each other [5]. Therefore, students and teachers in the 21st century must have sufficient technological literacy [6].

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Ingkavara and Thanyaluck pointed out that the use of educational technologies such as computers and mobile applications can promote learners with learning disabilities to represent abstract concepts [7]. D. Borissova uses advanced teaching tools for verifying the required tool components for calculating the corresponding areas or girth of various two-dimensional shapes [8]. Kartal and Cinar note that important digital tools such as dynamic math software make learning easier and can help teachers avoid rote memorization [9]. It can be seen that teachers' ability to adapt to information teaching greatly affects students' learning results.

Subject teaching knowledge of integrated technology was proposed by Mishara and Koehler [10]. It is a knowledge framework about how to use technology to carry out effective teaching in specific situations. It includes seven factors: Subject content knowledge, teaching method knowledge, technology knowledge, subject teaching knowledge, teaching method knowledge of integrated technology, subject content knowledge of integrated technology and subject teaching knowledge of integrated technology (Figure 1). Based on the above analysis, the seven elements of TPACK are explained in more detail.

- Teaching knowledge (PK): The knowledge of general mathematics teaching activities, such as student learning and teaching evaluation, which is independent of the content of a mathematics topic.
- Subject knowledge (CK): Independent of teaching activities, refers to a comprehensive understanding of mathematical structures, problems, and processes.
- Technical knowledge (TK): Knowledge of using emerging technologies, specifically hard technologies (tools, equipment, hardware, etc.).
- Subject Pedagogical Knowledge (PCK): Representational knowledge and pedagogical knowledge to promote students' mathematics learning.
- Content Knowledge of Integrated Technologies (TCK): Knowledge of mathematical thematic characterization using emerging technologies.
- Teaching Knowledge with Integrated Technology (TPK): The knowledge of applying technology to teaching, using technology to influence teacher teaching strategies and student learning.
- Subject Pedagogy Knowledge Integrated with Technology (TPACK): The use of emerging technologies for teaching strategies and representations of specific mathematical topics to promote student learning. When the technology is ubiquitous, TPACK is transformed into PCK.

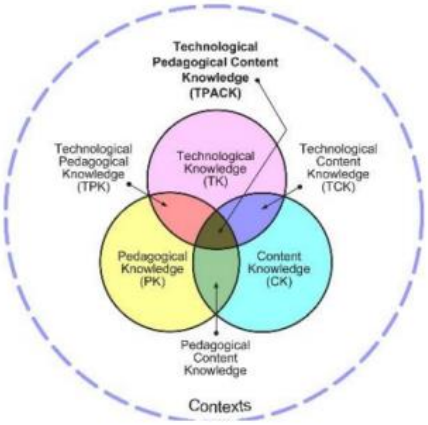

Fig. 1. TPACK model

Meanwhile, Schmidt et al. [11] compiled a TPACK questionnaire covering 7 structural models -- "A questionnaire on teachers' teaching and technical knowledge", and found that questionnaire is an effective and reliable way to assess the development of TPACK for pre-service and in-service teachers. How well have middle school mathematics teachers mastered information technology since China entered the information age? What is the knowledge of integrated information technology pedagogy? These questions are critical. Therefore, the focus of this study is to analyze the development of in-service mathematics teachers' TPACK level in China, and put forward suggestions for mathematics teachers to better master the information teaching technology, in order to achieve the necessary professional ability of teachers in the information society.

2 Methods

Quantitative analysis method and literature analysis method are adopted in this study. The questionnaire consists of two parts, which is mainly adapted according to the questionnaire prepared by Schmidt et al., combining with localization and subject characteristics. It consists of 7 dimensions, and is composed of 20 questions. The questions themselves are closely related to the research topic. A 5-point scale is adopted, with 1 point = strongly disagree, 2 points = disagree, 3 points = uncertain, 4 points = agree, and 5 points = strongly agree. Matlab and Excel were used for statistical analysis to understand the TPACK level of mathematics teachers. The higher the average score, the better the teacher's knowledge level.

In order to ensure the validity of the questionnaire measurement, the reliability test of the questionnaire was carried out. The Alpha coefficient is mainly used as the reliability index (see Table 1). It can be seen that except for the α value of TK, the α value of other dimensions exceeds 0.7, and the α value of TK is 0.647, which is also close to 0.7. The specific α value of the questionnaire was 0.929, indicating high internal consistency and statistical analysis could be conducted.

Table 1. Reliability analysis of in-service mathematics teacher TPACK questionnaire

category	TK	PK	CK	PCK	TCK	TPK	TPACK
Alpha	0.647	0.710	0.708	0.820	0.903	0.867	0.757

Table 2 shows that female teachers are more than male teachers, accounting for 77.36%, and high school teachers account for a relatively high proportion. Teachers with teaching experience of less than 5 years account for 94.34% of the respondents, those with 6-10 years account for 1.89%, and those with more than 10 years account for 3.77%, indicating that young teachers are the main force of middle school math teachers. Among them, 71.7% of teachers work in urban schools and 28.3% in rural schools.

Table 2. Basic information of samples

	Gender		school level		teaching experience			school	
	girl	boy	Junior high school	High school	1-5 years	6-10 years	more than 10 years	urban	rural
sum	41	12	15	38	50	1	2	38	15
Percentage (%)	77.36	22.64	28.3	71.7	94.34	1.89	3.77	71.7	28.3

3 Results and discussion

The questionnaire starts from the basic knowledge of TK, PK and CK of mathematics teachers. As can be seen from Table 3, the average score of TK is 3.742. Teachers still have a large room for improvement in their understanding of technical knowledge. If the problem of computer screen cannot be projected, teachers are not sure whether they can solve it smoothly. The reason is that some young teachers lack of experience in teaching practice and lack of efficacy in technical knowledge. Or some mathematics teachers do not realize the auxiliary advantages of information technology, subjectively believe that the use of information technology is a waste of time and energy, and will have some resistance to the integration of technology teaching, thus reluctant to really learn technical knowledge.

Whether teachers can properly choose teaching methods has certain influence on students' attitude. For some Chinese students, math is boring, especially when they understand conceptual theorems and formulas. However, the PK level of math teachers is good, with an average score of 3.893. Teachers have high-level teaching knowledge, which has a significant impact on the development of students' intelligence and personality, as well as their attitude towards math learning.

Table 3.Observation results of TK, PK and CK

	statement	m	sd	α
TK-1	I was able to solve some hardware technical problems I encountered	3.510	0.912	
TK-2	I was able to solve some software problems	3.790	0.817	
TK-3	I often use information technology in my study and work	3.920	0.756	

Sub TK		3.742	0.690	0.647
PK-1	I can use different teaching strategies according to different teaching contents	3.890	0.670	
PK-2	I can plan some learning activities for students	3.770	0.824	
PK-3	I can adjust my teaching methods according to students' performance or feedback	4.020	0.500	
Sub PK		3.893	0.459	0.71
CK-1	My mathematics knowledge is solid, can meet the requirements of middle school mathematics teaching	3.770	0.669	
CK-2	I will use a variety of methods and strategies to understand mathematical knowledge	3.770	0.697	
Sub CK		3.774	0.467	0.708

The radar chart in Figure 2 is drawn by Matlab programming. It is obvious that the average value of PCK and TPK is higher than that of TCK, indicating that teachers have a relatively good grasp of technology-related knowledge, which is related to the rapid development of current information technology. Mathematics teachers have a higher level of TPK, has a certain teaching experience, for animation, video and other common in the classroom of the basic use of information technology are more familiar, therefore, need to train teachers to use a variety of different information technology teaching ability, teachers use information technology to carry out various forms of teaching ability.

However, the research on the application of technology in disciplines found that the average score of TCK was low (Table 4), indicating that the mathematics teachers surveyed lacked the successful integration of technology and subject knowledge [12]. One reason is that they are busy with teaching and do not systematically learn relevant theories of information technology and curriculum integration, so they lack systematic learning. Another reason is that nowadays middle school mathematics teachers generally have the ability to search and acquire information, but there is an incomplete phenomenon. When researchers asked a middle school math teacher if she used her school's library for material collection, she said she rarely borrowed books from libraries even though they had computers that could search for them.

Table 4. Observation results of PCK, TCK and TPK

	statement	m	sd	α
PCK-1	I can make appropriate mathematics teaching plans or schemes	3.890	0.640	
PCK-2	I know the basic knowledge that students should have before learning a certain math knowledge	3.980	0.571	
PCK-3	Without the use of information technology, I can also choose appropriate teaching methods to guide students to learn and think	3.790	0.661	
SubPCK		3.887	0.391	0.820
TCK-1	I can choose appropriate information technology to present mathematical knowledge	3.960	0.706	
TCK-2	I am able to use appropriate information technology to collect information and conduct more in-depth research on mathematical subject knowledge	3.790	0.743	
TCK-3	I am proficient in using at least one mathematical special software to help understand mathematical knowledge	3.870	0.761	

SubTCK		3.874	0.543	0.903
TPK-1	I can use information technology to help me better present the teaching message I want to convey	4.020	0.635	
TPK-2	I can use information technology to help me evaluate students better	3.830	0.672	
TPK-3	I can use information technology to help me create better teaching situations	3.920	0.756	
SubTPK		3.925	0.475	0.867

In addition, for students, it is the post-00s generation, and information products such as computer, tablet computer and mobile phone have penetrated into every aspect of students' daily life and entertainment. Therefore, compared with the previous students, great changes have taken place in the way of learning and thinking. Traditional teaching mode cannot be adopted in class and after class. At present, most mathematics teachers are only familiar with common software, but know little about some newly launched software and resources, and are unable to use complex functions. All these limit the promotion of teaching informatization, especially for older teachers, who are seriously lacking in information technology. For them, if they have a comprehensive and rich information technology resource library, they can directly meet different needs.

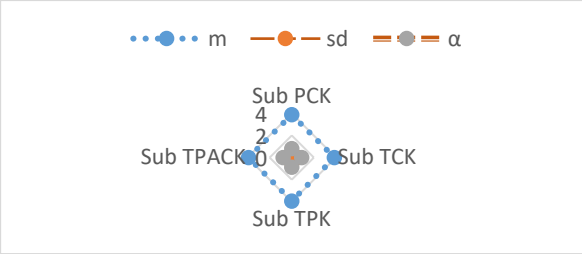

Fig.2.Statistical data of PCK, TCK and TPK

Table 5. Correlation among factors

	TK	PK	CK	PCK	TCK	TPK	TPACK
TK	1						
PK	.433**	1					
CK	.616**	.632**	1				
PCK	.465**	.450**	.696**	1			
TCK	.436**	.522**	.451**	.458**	1		
TPK	.438**	.479**	.493**	.443**	.785**	1	
TPACK	.462**	.588**	.637**	.756**	.671**	.747**	1

**. There was a significant correlation at the level of.01 (bilateral).

The results of correlation analysis among the factors of mathematics teachers are shown in Table 5, which shows that the correlation coefficient with TPACK is in the order of PCK>TPK>TCK>CK>PK>TK from high to low. The highest correlation coefficient with TPACK is PCK, which is 0.756. The correlation coefficient between PCK and other factors is relatively high. It can be considered that subject teaching knowledge is a very basic element for teachers' TPACK knowledge, that is, PCK should be the starting point to improve teachers' TPACK level.

Table 6. TPACK horizontal observation results

	statement	m	sd	α
TPACK-1	I can properly combine mathematics, technology and teaching methods	3.940	0.569	
TPACK-2	I often obtain mathematics teaching resources through mathematics teaching resources website to enrich the teaching means	4.060	0.456	
TPACK-3	When students conduct exploratory experiments, I will use information technology to timely record and guide their performance	3.720	0.841	
Sub TPACK		3.906	0.413	0.757

Overall, the overall TPACK level of math teachers is good. As can be seen from Table 6, the average score of TPACK reached 3.906. However, when the teacher answered whether he would use information technology to timely record students' performance and make guidance questions during the inquiry experiment, the teacher's response was not very good. Therefore, teachers' TPACK ability still needs to be improved. Teachers should not only make use of information technology as a tool for classroom teaching, but also make timely record of students' performance to promote students' development [13]. In addition, Koehler and Mishra [14] believe that the technology used for teaching must be in a specific environment, at which time teachers need to understand the interaction between the three kinds of knowledge and how to organically combine the three in a specific context.

4 Conclusion

The purpose of this study is to analyze the teaching knowledge level of in-service mathematics teachers with integrated technology, and to elaborate how to use technology to help in-service mathematics teachers improve their information-based teaching ability in their work and become professional teachers. Through the quantitative analysis of the questionnaire data, the researchers draw the conclusion that the mathematics teachers have good professional knowledge and ability, the weakness lies in the integration of technical knowledge and subject teaching, and there is still a large room for progress. Even if the teachers have achieved certain achievements in the information teaching ability, they should continue to work hard. Teachers should have a comprehensive understanding of using technology to support mathematics learning and teaching, know how to conduct mathematics teaching with the support of technology, and make subject content easily understood by students with the support of technology.

The limitation of this study is that it tested in-service mathematics teachers' TPACK ability in terms of perception, and only collected in-service mathematics teachers in some areas as samples, which could not represent everyone in China. Future studies may consider testing teachers' TPACK skills and their development in the context of different countries.

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