Journal of Mathematics Education
June 2016, Vol. 9, No. 1, pp. 126-135 © *Education for All*

Pre-service Mathematics Teachers' Technology Pedagogical Content Knowledge: An Investigation in China

Tingyan Zhang
Southwest University, China
Li Wang
Beijing Normal University, China

Teachers' technology pedagogical content knowledge (TPACK) has become a international hot research topic for decades. The framework proposed by Mishra and Koehler (2006) has been widely used to investigate teachers' TPACK. Under the guide of this framework, this paper investigated Chinese pre-service mathematics teachers' TPACK with the employment of questionnaire. 260 pre-service mathematics teachers from three universities in China participated this study. Gender differences and differences among teachers from the three universities were identified. Suggestions were further made for the training of pre-service mathematics teachers' TPACK.

Key words: TPACK, pre-service mathematics teacher, investigation,

During the process of education development, the creation of every technology has brought more or less impact on education. At present, information technology is causing extensive and complicated educational reforms, which has directly leaded to the informationization of education. Education informationization has become a heated issue in education in every country in the world. Especially, in mathematics education, ICT has been widely used by teachers in ordinary teaching practice. For future teachers, the ability of pre-service mathematics teachers to integrate ICT into mathematics teaching will heavily influence their future teaching. However, previous studies have found that pre-service mathematics teachers do not equip necessary ICT skills which are needed in practice to integrate ICT in mathematics teaching (Wang, 2009).

In 2006, based on the framework of pedagogical content knowledge (PCK) as proposed by Shulman, Mishra and Koehler proposed the concept of Technological Pedagogical Content Knowledge (TPACK), which offers a clear framework for teachers' professional knowledge in the digital era. TPACK consists of 7 components, and 3 of them are core components : Technology Knowledge (TK), Pedagogical Knowledge (PK) and Content Knowledge (CK); another 4 components are compound ones overlapping the 3 core components, which are: Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK) and

Technological Pedagogical Content Knowledge (TPACK). Mishra and Koehler (2006) pointed out that in teaching practice, the TPACK framework describes the kinds of knowledge that teachers need in order to teach with ICT, and the complex ways in which these bodies of knowledge interact with one another rather than being separated.

Internationally, TPACK has increasingly become one of the hot topics in teacher education, and a large amount of studies on the topic of measuring, training, and developing teachers' TPACK are available in literature (e.g., Hao & Wu, 2009; Jiao & Zhong, 2010; Zhan & Ren, 2012). However, in China, the previous studies mainly focus on how mathematics teachers can integrate ICT into classroom teaching. For example, Yan and Yang (2010) surveyed secondary school mathematics teachers' ability to integrate ICT into mathematics teaching. Wen and Tu (2009) reflected how to effectively integrate ICT into mathematics teaching. Wang et al (2008) analyzed the problems existing in using ICT in mathematics teaching. However, very few studies focus on the investigation of mathematics teachers' TPACK. In view of this, the main aim of this paper is to survey the characteristics of pre-service mathematics teachers' TPACK with the employment of questionnaire in China.

Methods

Participants

A total of 260 pre-service mathematics teachers from three teacher education universities (labeled as A, B and C) in three provinces of China (Chongqing, Shanghai, and Shanxi) participated in the study. 129 of them were male students and 131 were female students. A is a key normal university directly under the control of Ministry of Education, B is a provincial key university and C is a general normal university. Table 1 describes the background information of the participants of the study.

Table 1

Background Characteristics of the Participants

	Male N (%)	Female N (%)
University A	44 (49.4%)	45 (50.6%)
University B	43 (50.1%)	42 (49.9%)
University C	42 (48.8%)	44 (51.2%)

Instruments

To assess Chinese pre-service mathematics teachers' TPACK, questionnaires used in previous studies (e.g., Cox & Graham, 2009; Koehler & Mishra, 2005) adapted in this study. The questionnaire contains the following two sections**:** 1) beliefs about the use of ICT in mathematics teaching, which contains 9 questions; and 2) TPACK, which contains 27 questions. Questions in the section two were divided into seven dimensions as proposed by Schmidt and the questions were also adapted from this questionnaire. Schimidt's questionnaire has been validated in previous studies.

The questionnaire was first translated into Chinese by the author. To enhance the suitability of the questionnaire in Chinese context, two university mathematics education researchers and three highly experienced secondary school mathematics teachers in China were invited to make modification to the translated draft the questionnaire. After this, the questionnaire was piloted and further modifications were made according to the pilot study result. The internal consistency of the questionnaire was estimated using the Cronbach alpha reliability coefficient. The Cronbach alpha reliability coefficient for the whole questionnaire is 0.913, which indicated good reliability.

Data Analysis

Data were analyzed using descriptive statistics and multivariate analysis. To obtain a sample description of Chinese pre-service mathematics teachers' TPACK, item mean score of each scale with standard deviation of the chosen scales were computed. Next, t-test and one-way MANOVA were employed to explore gender differences and differences among different universities.

Findings and Discussion

The structure pre-service mathematics teachers' TPACK. A comparison was made between the total scores, means and standard deviations in each of the dimensions of TPACK in this section (table 2 summarizes the findings). As shown in Table 2, TK, CK and PCK are of the highest means, while TPACK is with the lowest means, which indicates that the knowledge that pre-service mathematics teachers lack is the integrated knowledge resulting from the interacted of each knowledge component as needed in mathematics teaching.

The shortage of TPACK of Chinese pre-service mathematics teachers might mainly cause by Chinese pre-service mathematics teachers training model and pre-service mathematics teacher education curriculum of normal universities in China. For a long time, the training mode of pre-service mathematics teachers in normal universities is "mathematics subject courses + pedagogical courses + pedagogical practicum". In others words, pre-service mathematics teachers take fundamental mathematics subject courses as compulsory courses, optionally take courses about pedagogy, psychology and modern education technology, and finally participate in on campus teaching practice organized by the university (on campus simulation of teaching practice) and off campus teaching practice (go to primary and secondary schools for teaching practice). This training mode might have the following disadvantages: firstly, the design of separating mathematics subject knowledge from pedagogical knowledge in curriculum makes it difficult for pre-service mathematics teachers to integrate their CK, TK and PK, which leads to the low means of integrated knowledge (PCK, TPK and TPACK). Secondly, in the present mathematics teacher education training mechanism, the majority of courses are offered in the form of lectures, which provides few teaching practices for students and makes their knowledge transference ability is relatively poor. In addition, due to the equipment in micro-standard teaching are limited, training time is not adequate, and the time duration of teaching practice in schools is rather short (usually 6 weeks), therefore, pre-service mathematics teachers lack the capability of integrating CK, TK and PK in authentic teaching practice.

Table 2

Descriptive Statistics of Each Dimension in TPACK

Dimension	No. of items	Mean ± SD
TK	4	4.01±0.45
CK	8	4.01±0.48
PK	6	3.97±0.48
PCK	8	3.72±0.64
TCK	8	3.69±0.45
TPK	7	3.50±0.47
TPACK	5	3.41±0.51

Correlation analysis of different knowledge components in TPACK. This section mainly discusses the correlations between the 4 integrated knowledge components and other knowledge components in TPACK (Table 3 reports the results). As shown in Table 3: (1) PCK is positively correlated with other 6 components, and the correlations are significant, $P=0.000 < 0.01$. Among all the correlations, PCK and PK are the two knowledge components that are most closely correlated with each other; (2) TCK is positively correlated with other 6 knowledge components and $P=0.000 < 0.01$. TCK and CK are most correlated with each other, and TCK is less correlated with PK, TK, PCK, TPACK and TPK; (3) TPK is positively correlated with other 6 knowledge components, and the correlations are significant, $P=0.000 < 0.01$. The correlation of TPK and TPACK is the most significant one among all the correlations, followed by the correlations of TPK and PK, CK, TK and PCK respectively; (4) TPACK is positively correlated with other 6 knowledge components, and the correlations are significant, $P=0.000 < 0.01$. Among all the correlations, TPACK and TCK are of the most significant correlation, and TPACK is less correlated with PK, CK, PCK, TPK and TK.

Table 3

Correlation of Different Knowledge Components in TPACK

	TK	CK	PK	PCK	TCK	TPK	TPACK
PCK	.326**	.434**	.528**	1	.509**	.292**	.469**
TCK	.549**	.616**	579**	.509**	1	.498**	.506**
TPK	.330**	.394**	.452**	.292**	.498**	1	.484**
TPACK	.457**	.573**	.604**	.469**	.606**	.514**	1

Note: ** stands for significant correlation at the level of 0.01 (2-tailed).

Previous studies (e.g., Yan & Huang, 2012) have proved that reflection after teaching is an effective way to improve and enhance teachers' pedagogical competence. Pre-service mathematics teachers' acquisition of TPACK and the development of their pedagogical competence are closely related to teaching practice in authentic context and the acquisition of implicit knowledge. Moreover, pre-service mathematics teachers' acquisition of TPACK emphasizes pre-service mathematics teachers personal participation and their deep reflection after teaching practice during the process of attaining and developing their teaching abilities. That is to say, the improvement of TPACK and pedagogical competence needs pre-service mathematics teachers' practice, reflection and contemplation. When reflecting their teaching practices, pre-service mathematics teachers can quickly find out the knowledge they lack from all dimensions of TPACK. Therefore, they can improve the knowledge accordingly.

Gender Differences

This section tests the variance significance of gender among components in TPACK, and further explores structural characteristics of pre-service mathematics teachers' TPACK. As shown in Table 4, the left side shows the variance test values of Lenven homogeneity, under the null hypothesis of homogeneity of variance, the probability value of each dimension is greater than 0.05, therefore, there is no adequate evidence to reject the variance homogeneity assumption, hence equal variance t test results can be adopted to explain the results of t test. 2-talied probability in the technological knowledge dimension is 0.002, less than 0.05, so the variance in the dimension of "TK" about gender is statistically significant. Besides, the 2-tailed probabilities in the dimensions of "CK", "PK", "PCK", "TCK", "TPK" and "TPACK" are greater than 0.05, so the variances among these dimensions are not statistically significant.

The variance of "TK" between male students and female students is mainly caused by their innate characteristics and their different ways of thinking. Male students' interest in TK is far higher than female students'. Male students' proficiency, practicability and spontaneity in computer operation are much higher than female students'. With the development of Internet, both male and female students have been using it more frequently, but they are different in their purposes and contents (Chu, 2010). Relatively speaking, male students have higher frequency of using computers, and their attitude towards using computers is more active compared with female students (Shaw & Gant, 2002). It is reported that male students using computers is interesting as well as worthwhile. At the same time, male students are more interested in computer operation procedures and more willing to learn knowledge about software and hardware. While female students seem to be more anxious about computers, they are less interested in using computers (Chu & Tsai, 2009). These differences lead to male students' master of TK is better than female students.

Table 4
Difference of Gender among Pre-Service Mathematics Teachers

	F	t	df	p
TK	1.287	3.201	257	.002
CK	.131	1.111	257	.268
PK	.863	1.213	257	.226
PCK	1.620	-.047	257	.963
TCK	.009	1.601	257	.111
TPK	2.618	-1.729	257	.085
TPACK	.622	.000	257	.999

Differences across Universities

In order to fully describe the characteristics of pre-service mathematics teachers ' TPACK structure, this section mainly focuses on the differences among the participants in the three universities on pre-service mathematics teachers ' TPACK. As shown in Table 5, in the dimensions of CK, TK, PK, PCK, TCK and TPK, there is no significant variance between all the three universities, but in TPACK, there are significant variances between the three universities. Further analysis found that University A is significantly different from University B and University C, and there is no significant difference between University B and University C. Moreover, University A is higher than B University and University C.

In mastering of TPK, pre-service mathematics teachers in University A are better than students from University B and University C, which is related to the difference of curriculum design in these three universities. With the development of technology, a extensive common agreement has achieved for integrating technology with mathematics courses (Ye, 2002), and normal universities in China have developed courses about information technology. This study found that all the three universities have offered courses about mathematics software, courseware preparation and modern education technology-aid teaching, but only University A opens courses about micro-teaching. The acquisition of TPK requires more emphasis on teaching practice during pre-service mathematics teachers' learning process. Although current courses related to information technology strongly stress the application of technology, the contents of these courses mainly theoretically oriented or mainly focus on a brief introduction of the general use of technology, which on one hand neglects the needs for teaching practice to some extent, and on the other hand, it also limits pre-service mathematics teachers' use of technologies in teaching. Through micro-teaching, however, pre-service mathematics teachers can experience the whole teaching procedures from teaching design, implementation and reflection. These procedures need pre-service mathematics teachers to think about the teaching content, integrate teaching methods and technology, and finally reflect their teaching. Therefore, pre-service mathematics teachers also experience a smooth transfer from theories to practices, which will help to develop their TPK.

Table 5
Difference of University among Pre-Service Mathematics Teachers

	MS	F	p
CK	.317	1.400	.249
TK	.486	2.381	.094
PK	.021	.089	.915
PCK	.218	.528	.591
TCK	.158	.767	.466
TPK	.382	1.452	.236
TPACK	4.875	25.932	.000

Factor Analysis of Technology Integration

This section tries to figure out which factor is the crucial one for pre-service mathematics teachers to apply technology into mathematics teaching practice. Statistics show that the percentage of students who consider "new teaching ideas", "teaching media", "education information technology" and "technology based teaching design" is respectively 22.6%, 27.7%, 26.8% and 22.9. Pre-service mathematics teachers assume that education information technology is the primary factor, followed by the application of modern education media, and new teaching ideas and technology based teaching design are relatively neglected. Therefore, it can be seen that pre-service mathematics teachers perceive technology itself as the key to reasonably applying the technology into teaching mathematics and reduce the functions of teaching ideas, teaching design and other soft technologies. In other words, pre-service mathematics teachers have not fully understood TPK.

The integration of technology and mathematics curriculum mainly aims at improving teaching efficiency by effectively using technology and enhancing the overall development of students' technology and mathematics attainment. But not all teaching practices need the aid of technology, that is, not all teaching practices adopting technology are good as well. If just switch teaching content from textbooks to screen and use “whiteboard” instead of blackboard, it is not a efficient integration; if teaching activities can carry out just by using projectors, then using multimedia devices is a kind of waste. As a result, the realization of integrating technology with mathematics courses should be consistent with improving teaching efficiency and cultivating students’ proficiency. This requires teachers, through effectively designed teaching plan, integrate TPACK, CK and TK, and apply them to mathematics teaching practices, so as to achieve efficient integration of technology and mathematics curriculum.

Educational Implementation

From the comparison of different dimensions in TPACK, what Chinese pre-service mathematics teachers lack most is the integrated knowledge. This might be due to the factor that the present knowledge-centered teaching mode is more helpful for pre-service mathematics teachers to acquire TK, CK and PK, but is less helpful for them to acquire PCK, TPK and TCK, and they may even not get the core knowledge in modern teaching – TPACK. From the perspective of correlation analysis of TPACK in pre-service mathematics teachers, the four integrated components in TPACK are significantly correlated with the other 6 components. In reflections of teaching, pre-service mathematics teachers can quickly find out the knowledge they lack based on correlations between each element, make up that knowledge, and then develop their TPACK.

From the gender differences of TPACK, male and female pre-service mathematics teachers are significantly different. Female students are less competent than male students in TK, which is caused by different thinking styles and innate characteristics of male and female students. From the differences of TPACK among pre-service mathematics teachers in different universities, differences between different universities are significant. Compared with University B and University C, pre-service mathematics teachers from University A were found to master higher TPACK, which is closely related to different curricula design of these universities. From factor analysis of technology and mathematics curriculum among pre-service mathematics teachers, they put more emphasis on hard technology, such as “education media” and “education information technology”, while relatively ignore the functions of soft technologies like “TPACK”.

The framework of TPACK meets the needs of society and clearly defines the characteristics of knowledge system and its generation of teachers in information age. In cultivating pre-service mathematics teachers’ TPACK, the present Chinese training system is not satisfactory in teaching mode, curriculum design and cultivation methods, therefore, based on improving TPACK, this section puts forward some suggestions to develop pre-service mathematics teachers’ TPACK.

(1) Integrating theoretical knowledge and practices in classroom

teaching to improve pre-service mathematics teachers' TK, CK and PK. In the meantime, this will develop their competence to solve problems in authentic teaching environment and offer them more opportunities to develop their TPACK.

(2) Providing more ways of learning to remedy shortcoming of present curriculum design. For example, the establishment of on-line learning platform for pre-service mathematics teachers could be useful to enforce communications, interactions, and information share between students. This could be a strategy to enhance pre-service mathematics teachers' TPACK.

(3) Creating more opportunities for teaching practice, improving mechanism of internship, fully utilizing relevant resources of micro-teaching, offering a platform for pre-service mathematics teachers to solve authentic teaching problems, and asking students to effectively reflect their practice in accordance with frame of TPACK for enlarging their TPACK.

(4) Noticing the gender differences in TK and asking male and female students to work in groups to create a learning atmosphere of helping each other. In each group, all members can express their own opinions and comments, listen to others views, observe each other, and encourage each other to make progress, making learning TK a pleasant thing.

(5) Enhancing pre-service mathematics teachers ' understanding the functions of TPACK in the integration of TK and mathematics courses, fostering their awareness for actively applying TPACK, and helping them efficiently integrate modern TK with mathematics courses in their teaching practices, in order to improve their teaching efficiency and optimize their teaching practice.

Acknowledgement: This study was supported by Research Project of Teaching Reform in Colleges and Universities in Chongqing (Grant No. 143116).

References

Chu, R. J. (2010). How family support and Internet self-efficacy influence e-learning outcomes among higher aged adults-Analysis of gender and age differences. *Computers & Education*, *55*(1), 255-264.

Chu, R. J. & Tsai, C. C. (2009). Self-directed learning readiness, Internet self-efficacy, and preferences toward constructivist Internet-based learning environments among adult learners. *Journal of Computer Assisted Learning*, *25*, 489-501.

Cox, S. & Graham, C.R. (2009). Diagramming TPACK in Practice: Using an Elaborated Model of the TPACK Framework to An analyze and Depict Teacher Knowledge. *Tech Trends*, *53*(5), 60-69.

Hao, N. & Wu, Q. (2009). Technology- Pedagogy-Content: a new requirement to the teacher. *Journal of Capital Normal University (Social Science Edition)*, *1*, 138-142.

Jiao, J. & Zhong, H. (2010). The research and progress of Technology - Pedagogy - Content. *Journal of Distance education*, *L*, 9-45.

Koehler, M. J. & Mishra, P. (2005). Teachers learning by design. *Journal of Computing in Teacher Education*, *21*(3), 94-10.

Mishra P. & Koehler. M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *The Teachers College Record*, *108*(6), 1017-1054.

Shaw, L. H. & Gant, L. M. (2002). Users divided? Exploring the gender gap in internet use. *Cyber Psychology & Behavior*, *5*(6), 517-527.

Wang, A. (2009). The investigation and research on application and status of mathematics education in the modern information technology. *Journal of Mathematics Education*, *18*(2),69-71.

Wang, L., Yuan, X. & Liu, Yan. (2008). Problems of the computer-assisted mathematics education. *Journal of Mathematics Education*, *17*(2), 97-99.

Wen, J. & Tu, R. (2008). Views on effective usage of information technology in mathematics teaching. *Journal of Mathematics Education*, *17*(1), 91 – 94.

Yan, D. & Huang, Y. (2012). The connotation of education technology of mathematics teacher in primary and middle schools. *Journal of Mathematics Education*, *21*(2), 14-16.

Yan, D. & Yang, X.(2010). Investigation and analysis of present situation of mathematics teachers' educational technology ability in middle school of Henan province. *Journal of Mathematics Education*, *19*(2), 53-57.

Ye, L. (2002). On professional curriculum reform of normal university mathematics and mathematics teachers specialization. *Journal of Mathematics Education*, *11*(4), 68-71.

Zhan, Y. & Ren, Y. (2010). The brief introduction of research and connotation of integration technology of course knowledge. *Journal of Distance Education*, *28*(4), 78-87.

Authors:

Tingyan Zhang
Southwest University, China
Email: zhangtingyan@yahoo.com

Li Wang
Beijing Normal University, China
Email: 545651996@qq.com