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Evaluating Chinese Pre-Service Mathematics Teachers' Knowledge of Integrating Technology in Teaching

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This study investigates the profile of Chinese pre-service mathematics teachers' Technological Pedagogical Content Knowledge (TPACK) through a sample of 106 people. An adapted scale was developed and validated in the survey. From the data collected from the scale, the findings reveal that Chinese pre-service mathematics teachers rated themselves as most competent in the factor of Content Knowledge (CK) and least competent in the term of TPACK. The survey also suggests that the scores of tech-related factors are generally lower than non-tech-related factors, which indicate that Chinese pre-service mathematics teachers are more familiar with traditional ways of thinking and teaching mathematics. In addition, implications of the current survey in terms of Chinese mathematics pre-service teachers' professional development are discussed.

Key words: Technological pedagogical content knowledge, mathematics, Chinese pre-service teachers

Shulman (1986) believed that good teaching required a complex integration and balance of content knowledge and pedagogical knowledge, and thus he initiated Pedagogical Content Knowledge (PCK) as the necessary knowledge a teacher should possess in order to realize effective teaching. He originally described PCK as "an understanding of how particular topics, problems, or issues are organized, presented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (Shulman, 1987, p.8). Since then, PCK become one of the central concerns within mathematics education and numerous studies have been conducted regarding a comprehensive and inclusive description of PCK. (Baker & Chick, 2006; Van Driel et al., 1998).

However, constrained by the time, Shulman realized the importance of technology in teaching, though he didn't fully understand the potential of technology to impact many aspects of teaching and learning, and therefore merely stated without further discussion that the "special amalgam of content and pedagogy that is uniquely the province of teachers" (Shulman, 1987, p.8) According to Mishra and Koehler, this is because issues surrounding technologies in Shulman's time "weren't foregrounded to the extent that they are today" (Mishra & Koehler, 2006), and thus they perceived that it is time now to deeply recognize the role of technology in the process of education.

In 2005, Koehler and Mishra put forward a new conceptual framework-Technological Pedagogical Content Knowledge (TPACK[1]), which theoretically integrates technology into the teacher knowledge system based on Shulman's framework and presents a way of thinking about essential knowledge that teachers must possess in effective teaching with technology and how they might develop this knowledge.

The notion of Technological Pedagogical Content Knowledge (TPACK) is proposed via a serious of designed experiments focusing on how teachers develop their uses of technology in teaching conducted by Koehler and Mishra, and is regarded as a meaningful tool in teachers' professional development (Niess et al., 2009; Trautmann et al., 2010). Therefore the framework is widely used in empirical studies across the world (Archambault & Crippen, 2009; Chai et al., 2013; Harris et al., 2010; Schmidt et al., 2009) However, little research and investigation have been conducted with Chinese mathematics teachers. To address this gap, this paper seeks first to investigate, through a sample of 106 people, Chinese pre-service mathematics teachers' TPACK by an adapted instrument, and then, to demonstrate the current situation of Chinese pre-service mathematics teachers' proficiency of using technology in teaching.

Literature Review

Based on Shulman's (1986) theory of Pedagogical Content Knowledge (PCK), the Technological Pedagogical Content Knowledge (TPACK) is a model specially initiated for describing and analyzing knowledge "that supports effective technology integration into classroom teaching practice" (Mishra & Koehler, 2006).

Being similar to Shulman's concept of PCK, the TPACK framework is constituted by seven types of knowledge. The fundamental forms of knowledge are Content Knowledge (CK), Pedagogical Knowledge (PK) and Technological Knowledge (TK). The former two have already defined in Shulman's (1986) theory in which CK refers to the subject knowledge within a specific discipline and PK refers to a series of knowledge from students' development and psychology to teaching strategies and classroom management skills. According to Mishra and Koehler (2006), the TK is about, how to handle and work on various types of technology, especially emergent hardware and software. The other four types of knowledge within TPACK

[1] "Technological Pedagogical Content Knowledge" was originally abbreviated to TPCK by Mishra, and then during the 9th Annual National Technology Leadership Summit in America, he (Mishra), according to participants for comments, renamed TPCK to TPACK.

framework are shown and can be derived from the overlapping of the three basic knowledge domains containing Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and finally Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006). These types of knowledge are the knowledge produced by combining the corresponding two or three knowledge domains. PCK refers to the unique form of teachers' knowledge regarding teaching concrete subject matters, including knowledge about appropriate methods for teaching a given subject matter or about how elements of the content can be arranged for better teaching, etc; TCK is knowledge about the manner in which technology and content are reciprocally related (Lesser & Groth, 2008), including knowledge of technology that has influenced and is used in exploring a given content discipline, etc. A good example of TCK can be the knowledge that most scientists understand how to use modeling or statistic software to analyze data and predict conclusions within a specific field; TPK is, according to Mishra (2005), knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies. A popular online learning tool-Webquest (Dodge, 2001) - can be served for our better understanding of TPK, as it provides an approach for students to inquire the unknown world via the Internet, regardless of the concrete knowledge in which students involved. TPACK represents an emergent form of knowledge that is derived from but goes beyond all three components (content, pedagogy, and technology). This is a kind of knowledge different from that of a specific disciplinary or technology expert as well as from the general pedagogical knowledge shared by teachers of various disciplines (Richardson, 2010). Table 1 here is adopted to list the descriptions of the above seven types of knowledge. Just like Shulman's (1986) idea that pedagogical content knowledge identifies the distinctive bodies of knowledge for teaching, Mishra and Koehler (2006) believe that TPACK is "the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies."

The emerging importance of the TPACK framework has prompted substantial scholars to create questionnaires and scales to survey teachers' perception and attitude of their TPACK profiles (Chai, 2013) for a valid and reliable scale based on the theory that can be used as an effective tool for teacher educators, and can also serve as a means of course evaluation for a cohort of students. Among all the existing instruments, the most influential would be two: one designed by Mishra and Koehler together with Schmidt, Baran et al. from Iowa State University, and the other one designed by Leanna Archambau from Arizona State University and Kent Crippe from University of Nevada.

Table1
Brief Description of Knowledge in the TPACK Framework

Knowledge Domain	Description
Content (CK)	Knowledge about the actual subject matter that is to be learned or taught (e.g. mathematics, science, etc.)
Pedagogical (PK)	Knowledge about the process and practice or methods of teaching and learning, including instructional planning, teaching method, classroom management, assessment of students' performance, etc.
Technology (TK)	Knowledge of technology for information processing, communications and focuses on the productive applications of technology in both work and daily life, including knowledge of how to install and remove peripheral devices, install and remove software programs, etc.
Pedagogical Content (PCK)	Knowledge about appropriate methods for teaching a given subject matter or about how elements of the content can be arranged for better teaching, etc.
Technological Content (TCK)	Knowledge about the manner in which technology and content are reciprocally related, including knowledge of technology that has influenced and is used in exploring a given content discipline, etc.
Technological Pedagogical (TPK)	Knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies.
Technological Pedagogical Content (TPCK)	Knowledge of the complex interaction among the principle knowledge domains (content, pedagogy, technology)

The former instrument initially appeared under the research title *Survey of Teachers' Knowledge of Teaching and Technology* (Schmidt et al., 2009) which aimed at measuring pre-service teachers' understanding of technology, content and pedagogy and their relationships. While the latter one is used for an online investigation of K-12 teachers' TPACK level in America, with a total 596 people from 25 states including Alaska, Arkansas and California. (Archambault et al., 2009) Both questionnaires cover all knowledge domains of the TPACK framework, and clearly demonstrated the internal consistency value of each knowledge domain subscale using Cronbach's alpha reliability technique. In Schmidt's paper (2009), he explained in detail the construction and revision of the questionnaire and exhibited the consistency between each item and its subscale using the value of factor loading. The findings, based on 124 pre-service teachers, in Schmidt's paper also indicate that the scale "is a promising instrument for measuring pre-service teachers' self-assessment of the TPACK knowledge domains." Consequently we supposed the above two scales as being valid and reliable, and utilized both scales with appropriate revision to specifically examine Chinese student teachers' TPACK.

Based on the information identified in the literature review, the research questions were:

1. Is the adapted survey a valid and reliable instrument to measure Chinese pre-service mathematics teachers' TPACK?
2. What is the profile of Chinese pre-service mathematics teachers' TPACK?

Method

Participants

One hundred twenty three pre-service teachers from Hunan majoring in Mathematics participated in this survey. They were invited to complete a paper questionnaire through their course lectures. Participation was totally voluntary with no bearing towards their course grade. A total of 106 teachers responded, resulting in a respond rate of 86.18％. Their mean age was 21.6 (SD=0.94). 41 of them are males (38.6％), and 65 are females (61.4％).

Instrument

The instrument administered was based on Schmidt's (2009) survey and Archambault's (2009) survey. Schmidt's scale comprised 58 items for the TPACK test, and Archambault's scale covered only 24 items. In addition, the questions in the latter one were expressed in a more general way, regardless of specific discipline, while the former one can only be used in 4 specific disciplines because the CK portion of it contained 16 items constituted by equal number of items of Mathematics, Sociology, Science and Literature. Comparison of these two scales is illustrated in Table 2.

First, we translate all questions of the Schmidt's scale into Chinese and deleted questions related to non-mathematics discipline in all domains, thus ending with a total of 29 items. At this step, we obtained a shorter scale for testing TPACK, but there was only one question in the PCK and TCK portions respectively. So additional items, according to Archambault's scale, were created for PCK (3 items) and TCK (4 items), making the final scale for this survey having 36 items total. Each participant was asked to rate to what extent each question measured one of the seven TPACK knowledge domains using a 5-point scale (with 1 being to the least extent as “Strongly disagree” and 5 being to the greatest extent as “Strongly agree”).

Table2
Comparison of the Two Scales

Number of items / Domain / Scale	CK	PK	TK	PCK	TCK	TPK	TPACK	Total
Schmidt’s scale	16	7	7	4	4	5	8	51
Archambault’s scale	3	3	3	4	3	4	4	24

Data Analysis

The adaptations mentioned above made the scale different from Schmidt’s survey, and thus it was necessary to examine if the validity still held. Confirmatory Factor Analysis (CFA) by AMOS 17.2 was conducted here. Items displaying multicollinearity properties as well as those with insufficient loading (<0.5) were removed, and then alpha reliabilities together with the mean scores of factors with the remaining items were computed to answer the research questions mentioned above.

Findings and Discussions

Validating the TPACK scale

The CFA yielded seven factors as hypothesized, and two items within TPK exhibiting multicollinearlity and insufficient loading (TPK3 and TPK5 <0.6) were removed. The remaining 27 items retained for the seven factors are illustrated in Table 3. The seven factors yielded a serious fit of indices providing support for the construct validity of the scale (CMIN=572.389, df =303, p<0.001, CMIN/DF=1.889, TLI=0.915, RMSEA=0.063), and thus this model can be accepted. The overall alpha reliability of the seven factors is 0.901. Alpha reliabilities for the factors are reported in Table 3, and these data indicate that the revised TPACK scale possesses satisfactory construct validity and reliability for Chinese pre-service mathematics teachers’ TPACK profile.

Teacher educators can use such an instrument to help them target professional development activities for the knowledge that a good teacher needs by needs analysis, or evaluate whether a course is effective and successful in promoting teacher’ abilities of integrating technologies into teaching and learning processes. Based on Schmidt’s scale (2009), supplemented with careful consideration of Archambault's scale (2009), this study provides a TPACK survey specifically for Chinese pre-service mathematics teachers. The validation of the scale in this survey may allow other researchers to examine their pre-service mathematics teachers with this instrument, and it is believed that scholars of other disciplines can also reference this scale, or with several adaptations, to do a further study. However, this survey targeted only pre-service mathematics teachers in China, so retesting the validity and reliability is a necessity if this scale is to be used by different circumstances, as past researchers pointed out that "TPACK surveys could easily suffer from merged factors" (Archambault & Barnett, 2010; Lee & Tsai, 2010).

Table 3
Factors & Item Loadings of TPACK

Factors	Items	Factor loading	Cronbach's Alpha reliability	Mean (SD)
CK1	1	0.800	0.812	3.53 (0.31)
CK2	2	0.800		
CK3	3	0.740		
PK1	4	0.810	0.920	3.28 (0.54)
PK2	5	0.970		
PK3	6	0.800		
PK4	7	0.850		
PK5	8	0.840		
TK1	9	0.720	0.879	3.32 (0.62)
TK2	10	0.860		
TK3	11	0.720		
TK4	12	0.720		
TK5	13	0.710		
TK6	14	0.730		
PCK1	15	0.830	0.808	3.22 (0.49)
PCK2	16	0.750		
PCK3	17	0.710		
TCK1	18	0.750	0.797	3.08 (0.46)
TCK2	19	0.890		
TCK3	20	0.660		
TPK1	21	0.820	0.867	2.84 (0.61)
TPK2	22	0.980		
TPK4	23	0.930		
TPACK1	24	0.940	0.903	2.62 (0.54)
TPACK2	25	0.950		
TPACK3	26	0.630		
TPACK4	27	0.720		

The Profile of Chinese Pre-Service Mathematics Teachers' TPACK

Table 2 demonstrates the mean scores as well as standard deviations for each factor measured focused on answering research question 2. From the table, it can be readily seen that teachers perceived themselves strongest in the factor of CK with the Mean Score= 3.53 with SD=0.31, and weakest in terms of TPACK with Mean Score=2.62 with SD=0.54. The second lowest Mean Score was for TPK (2.84 with SD=0.61). Overall, the scores of tech-related factors are lower than non-tech-related factors.

From profiles of quantitative survey, we can conclude that pre-teachers were confident about their subject matter, i.e. mathematics content knowledge, and they held a relatively positive attitude towards the pedagogical knowledge of mathematics. This information indicates that Chinese pre-service mathematics teachers are more familiar with mathematics knowledge itself and traditional ways of teaching and thinking of mathematics as described by Shulman's PCK (1987), which aligns with what we expected to learn about pre-service mathematics teachers' TPACK level. This is perhaps a request of the fact that Chinese per-service mathematics teachers mainly major in mathematics and thus spend a very long time focused on thinking and doing mathematics (usually over 4 years), so these pre-service teachers received a high score in the term of CK; Besides, pre-service teachers in China receive their higher education in Normal Universities which provide them a series of education-related courses including Education Principle, Educational Psychology and subject-based teaching theory, and therefore pre-service teachers obtain some knowledge about mathematics education which made them a little more confident about their pedagogical knowledge as shown in Table 3, however, regarding procedural knowledge, these teachers have little experience using such knowledge in designing and implementing real lessons, and consequently they are not quite sure about the reliability of utilizing PK in classroom teaching activities.

Another conclusion which can be drawn from the scale is that although pre-teachers are familiar about new technologies and have some experiences in using technology when solving mathematics problems (Mean Score for TK and TCK are 3.31 and 3.08, ranking second and fifth respectively of all factors), they accumulated little knowledge about how to integrate technology into teaching (Mean Score for TPK is 2.84, ranking second and fifth respectively of all factors). It is supposed that pre-service teachers today can have more access to technologies and are provided more courses related to education in universities, notwithstanding they rarely obtain opportunities to design tech-based lessons especially in real situations. This also indicates that ICT may still be peripheral to mainstream teaching, and so TPACK are perceived as the weakest factors by the pre-service students in this questionnaire, as TPACK refers to the ideas and abilities related to subject matter as well as how to convey certain knowledge in an appropriate and effective avenue to potential learners. Another potential reason for the difference between TK and TPK bay be based on the fact that pre-service teachers actually learn issues about education, to a large extent, from their observation of old teachers' instructional practices, just like what Fan's (2003) research stated, and since before 2000, ICT in classroom was not as popular as it is in today, so these pre-service teachers may rarely have chances to see how their mathematics teachers use ICT to teach concepts and theorems.

The findings also support Graham's (2011) observation that TPK is an area needing attention and that teacher educators need to think about the issue of how pre-service teachers can promote their knowledge of and understanding of technology-related pedagogies, especially in today's society where technologies have penetrated into various aspects of our lives. In order to get a deep understanding about the process of developing TCK, case-studies should be conducted to complement quantitative results. It is believed that professional development aiming at enhancing pre-teachers' education-related technology knowledge and then drawing upon this knowledge to create ICT-integrated lessons is necessary. Besides, as a procedural knowledge, knowledge of teaching can only be mastered when universities provide pre-service teachers enough opportunities to face real classroom environments and situations, as well as to encourage teachers to reflect upon their teaching activities from planning to implementing Polanyi's (1966) theory of tactic knowledge, which goes beyond the explained ideas ones and cannot be clearly and easily interpreted can also give support to such an idea.

Conclusion

A survey scale for pre-service teachers' self-reports of their TPACK profile was formulated and validated in this research. This is the first study based on a large number of participants investigating Chinese mathematics pre-service teachers' TPACK levels, and future research in other regions or other disciplines could be implemented through the adaption of this instrument. The findings drawn from this study can provide valuable information regarding pre-service teachers' needs in professional development which is a key field for education reform and to which we should pay much attention. For a national reform of teacher education, a survey of this level and nature is essential if information upon which to make decisions is to be obtained. Finally, it should be pointed out that even though quantitative data can provide useful information, it is also helpful for educators and policy-makers to observe facts from a statistical point of view. This way, a more comprehensive understanding of the results, would also be supported by various qualitative research methods including classroom observation and in-depth interviews about pre-service teachers' beliefs, knowledge and practices. This can be a future direction of such investigation. It is believed that only mixed methods can address the limitations of a one dimensional study.

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