Examing the technological pedagogical content knowledge of Singapore pre-service teachers with a large-scale survey

J.H.L. Koh,* C.S. Chai* & C.C. Tsai†

*National Institute of Education, Nanyang Technological University, Singapore 637616
†National Taiwan University of Science and Technology, Taipei 106, Taiwan

Abstract

This paper examined the profile of Singaporean pre-service teachers in terms of their technological pedagogical content knowledge (TPACK). A total of 1185 pre-service teachers were studied with a TPACK survey. An exploratory factor analysis found five distinctive constructs: technological knowledge, content knowledge, knowledge of pedagogy, knowledge of teaching with technology and knowledge from critical reflection. The participants of this study did not make conceptual distinctions between TPACK constructs such as technological content knowledge and technological pedagogical knowledge. There were some differences in their TPACK perceptions by gender. However, the influence of age and teaching level were not strong. The methodological and theoretical implications for the development of TPACK surveys were discussed.

Keywords

pre-service teachers, survey, technological pedagogical content knowledge.

Introduction

Pedagogical content knowledge was used to characterize teachers’ knowledge of how subject matter should be taught. It was described as an integration of teachers’ pedagogical knowledge and content knowledge into a ‘special form of professional understanding’ (Shulman 1986, p. 64). Shulman’s articulation of pedagogical content knowledge was widely used in teacher education. Teacher educators started to develop the concept of technological pedagogical content knowledge by adding technological knowledge to pedagogical content knowledge (Mishra & Koehler 2006; Angeli & Valanides 2009).

Technological pedagogical content knowledge or TPCK was used to describe teachers’ body of knowledge in terms of how they made ‘intelligent pedagogical uses of technology’ (Koehler et al. 2007, p. 741). Its acronym of TPCK was later changed to TPACK for ease of pronunciation and also to emphasize the integrated use of technology, pedagogy and content knowledge for effective technology integration (Thompson & Mishra 2007). Since its conception, many teacher education programmes were restructured with TPACK as an underlying conceptual framework (Niess et al. 2006; Burns 2007; Niess 2007; Shoffner 2007). Attempts have also been made to assess teachers’ TPACK development (e.g. Koehler & Mishra 2005).

A common way of TPACK evaluation was to study teachers’ learning behaviours and learning products throughout their attendance of ICT courses (e.g. Niess 2005; Koehler et al. 2007; Angeli & Valanides 2009). Qualitative data provided deep insights about teachers’ TPACK development in specific course contexts but required more time and effort for collection and analysis (Mishra & Koehler 2006; Schmidt et al. 2009b).
comparison, TPACK survey instruments were more easily replicated and administered across course contexts (Mishra & Koehler 2006; Graham et al. 2009; Schmidt et al. 2009). The comparability of data gathered across course contexts can also be improved by supplementing qualitative TPACK analyses with TPACK surveys. Furthermore, teachers’ technology integration levels were commonly evaluated through surveys of their attitudes and perceptions (Schmidt et al. 2009b). Established technology integration surveys did not assess teachers’ TPACK perceptions (Christensen & Knezek 2002; Schmidt et al. 2009b), which made the need for reliable and valid TPACK survey instruments even more pressing.

Therefore, several TPACK surveys were developed and pilot-tested with teachers in the USA and evaluated for internal reliability (Schmidt et al. 2008; Archambault & Crippen 2009; Graham et al. 2009; Schmidt et al. 2009b). In these studies, small sample sizes limited the analyses of instrument construct validity. This study was designed to address current gaps in TPACK survey development. It first examined the construct validity of a TPACK survey through exploratory factor analysis of responses from 1185 Singapore pre-service teachers. The TPACK perceptions of these teachers will be discussed following which several methodological and theoretical issues involved in developing TPACK surveys will be examined.

**Literature review**

**TPCK and related constructs**

According to Mishra and Koehler (2006), there were seven constructs in the TPACK framework. The first three were:

1. **Content Knowledge** – knowledge of subject matter.
2. **Technology knowledge (TK)** – knowledge of various technologies.
3. **Pedagogical knowledge** – knowledge of the processes or methods of teaching.

Just as PCK embodied a unique form of teacher professional knowledge, Harris et al. (2007) emphasized that teachers’ technology integration expertise laid within the interactions between TK, pedagogical knowledge and content knowledge. The four other constructs were therefore:

4. **Technological content knowledge (TCK)** – knowledge of subject matter representation with technology.
5. **Technological pedagogical knowledge (TPK)** – knowledge of using technology to implement different teaching methods.
6. **Pedagogical content knowledge** – knowledge of teaching methods for different types of subject matter.
7. **TPACK** – knowledge of using technology to implement teaching methods for different types of subject matter.

TPACK constructs addressed a theoretical void in the field of educational technology by describing the different types of technology integration knowledge teachers required (Mishra & Koehler 2006; Angeli & Valanides 2009).

**Surveys of teachers’ knowledge perceptions using the TPACK framework**

Koehler and Mishra (2005) first attempted to assess TPACK perceptions through survey items. In their survey of students’ course experiences, 14 items were used to track 12 graduate students’ TPACK development as they designed a technology-integrated lesson. Schmidt et al. (2009b) commented that these items were not generalizable as they specifically measured knowledge development for the design project in the study (e.g. I have been thinking and working a lot on the technology of the course we are designing). Therefore, Schmidt et al. (2009b) developed a 58-item Survey of Preservice Teachers’ Knowledge of Teaching and Technology to measure pre-K-6 teachers’ generic perceptions of TPACK for content areas of mathematics, social studies, science and literacy (e.g. I can teach lessons that appropriately combine mathematics, technologies and teaching approaches). Three national experts of TPACK in the USA evaluated and validated revisions for these survey items before pilot-testing with 124 pre-service teachers. Internal reliability of this survey was established with high Cronbach’s alphas of 0.80 and above for each TPACK construct. Establishment of construct validity for this instrument through factor analysis of large sample data was reported as ongoing (Schmidt et al. 2008, 2009b).
TPACK surveys for specific areas were also developed. Graham et al. (2009) developed a 30-item TPACK in Science survey to measure teachers’ TPACK for science teaching. This survey focused on the four TPACK constructs that involved technology, i.e. TK, TCK, TPK and TPACK. The items specifically assessed the eight pedagogical uses of technology in science teaching described by McCrory (2008), e.g. ‘I am confident to help students use digital technologies to organize and identify patterns in scientific data’. Pilot-testing with 15 in-service teachers found high Cronbach’s alphas of at least 0.90 for the four constructs. However, the authors conceded that the small sample size limited further statistical analysis for construct validity. Archambault and Crippen (2009) also developed a 24-item survey to assess K-12 teachers’ TPACK for online teaching (e.g. my ability to encourage online interactivity among students). Content validation was established with teachers from an online virtual school. Subsequent administration with 596 teachers from 25 states in the USA found Cronbach’s alphas ranging from 0.70 to 0.93 for the seven TPACK constructs. This analysis too did not include construct validation, which was identified by the authors as an area for future research.

The TPACK surveys reviewed so far have all been administered on teachers in the USA. Lee and Tsai (2010) developed a 30-item TPACK-Web Survey to measure Taiwanese teachers’ TPACK with respect to educational use of the World Wide Web (e.g. be able to guide students to use Web resources to study a certain course unit). Similar to the studies conducted with teachers in the USA, high internal reliability for the survey was established during an administration on 558 Taiwanese teachers. However, exploratory factor analysis found that items for pedagogical knowledge and pedagogical content knowledge were merged into one factor. The authors commented that this could be because of survey design or that the teachers surveyed lacked expertise in Web-based tools to distinguish between these two constructs. These postulations cannot be further examined as the construct validities of other TPACK surveys are not available for comparison. Lee and Tsai (2010) also explored TPACK with respect to the teachers’ demographic profile and found that it was significantly correlated with their age and teaching experience. ICT training can be more effectively organized if the TPACK perceptions of teachers in different demographic groups are better understood. However, a comparison with existing TPACK survey studies (e.g. Archambault & Crippen 2009; Graham et al. 2009; Schmidt et al. 2009b) cannot be made as this area was also not investigated.

Gaps

With the exception of Lee and Tsai (2010), majority of the existing TPACK survey studies has been administered with teachers in the USA. The internal reliability of TPACK survey items appeared to be fairly consistent across the studies reviewed. However, more studies of teachers outside the USA are still needed to explore the possibility of cultural differences in teachers’ TPACK perceptions. The preceding review also showed two visible gaps in extant development of TPACK surveys. First, studies examining the construct validity of TPACK surveys were lacking. With the exception of Archambault and Crippen (2009) and Lee and Tsai (2010), the other surveys reviewed were pilot-tested with small samples of less than 500. Comrey and Lee (1992) recommended a sample size of at least 500 for a robust factor analysis, which could be used to establish construct validity of survey instruments. Second, the relationship between teachers’ demographic profile and TPACK perceptions has not been examined. Lee and Tsai (2010) found that older teachers with more teaching experience were less confident about their Web-TPACK. While there are no published TPACK survey studies of Singapore teachers, Teo (2008) found that Singapore teachers’ attitudes for computer use were influenced by age, gender and teaching level. These demographic variables may also be related to their TPACK perceptions and need to be further examined.

Purposes of study

Given the gaps in extant research, this study proposes to examine issues related to the development of TPACK surveys with a study of Singapore teachers. The two purposes of this study were:

1 to examine the construct validity of a TPACK survey through an exploratory factor analysis of a large sample of pre-service teachers from Singapore.
2 to examine the TPACK perceptions of Singapore pre-service teachers and its relationship with their demographic variables (i.e. age, gender, teaching level).

Method

Subjects

The initial sample included 1664 pre-service teachers who just began the first semester of their teacher education training during August 2009. These teachers were enrolled in the Postgraduate Diploma/Diploma in Education programme at a higher education institute in Singapore. A TPACK survey was administered at the beginning of the semester to capture their baseline TPACK profile before they began any form of ICT instruction during teacher training.

At the beginning of the August 2009 semester, an invitation to participate in the survey was sent to the entire cohort via email. Participation was voluntary, and respondents accessed the web-survey via a link listed in the email. A total of 1185 responses were received, constituting a response rate of 71.2%. Among the respondents, 68.3% were female (N = 809), and 545 respondents were trained for primary education, whereas the rest of them (N = 640) were for secondary education. The respondents were fairly young (mean = 26.4, sd = 5.9) as 75% of them were below the mean age. The age range of respondents was between 18 and 51 years.

Instrument development

The teachers sampled for this study had diverse subject specializations, some of which were mother tongue languages, mathematics, physics, biology, music and history. After a review, the researchers found that these curriculum areas could be incorporated into the Survey of Preservice Teachers’ Knowledge of Teaching and Technology developed by Schmidt et al. (2009b) without substantial changes to survey items. On the other hand, the surveys developed by Graham et al. (2009), Lee and Tsai (2010), and Archambault and Crippen (2009) were subject-specific and need to be adapted more extensively for the study participants. Schmidt et al.’s survey was therefore chosen as it catered for the study participants’ profile.

Given these considerations, an expert committee composed of five faculty members specializing in ICT education conducted a content review of Schmidt et al.’s (2009b) survey and suggested adaptations. Schmidt et al. originally measured content knowledge, TCK, pedagogical content knowledge and TPACK with respect to curriculum areas of mathematics, social studies, science and literacy. The questions were made more generic in this study. For example, ‘I know how to select effective teaching approaches to guide student thinking and learning in mathematics’, was changed to ‘I know how to select effective teaching approaches to guide student thinking and learning in my Curriculum Subject’. In this study, 11 questions that were not relevant to its objectives were also removed. These were questions related to pre-service teachers’ assessment of their professors’ TPACK. All other questions designed to measure TK, pedagogical knowledge and technical pedagogical knowledge were retained.

The final survey was composed of 29 questions for TPACK. Thorndike (2005) recommended that the larger the number of options within a range, the more reliable a scale; The five-point Likert scale designed by Schmidt et al. (2009b) was therefore changed to a seven-point Likert-type scale in this study where: (1) strongly disagree; (2) disagree; (3) slightly disagree; (4) neither agree nor disagree; (5) slightly agree; (6) agree; and (7) strongly agree. Administration of the survey found its overall reliability to be high (α = 0.96). Besides questions for TPACK, we also collected information on pre-service teachers’ gender, age and teaching level (i.e. primary or secondary), which were demographic variables studied by Teo (2008) for Singapore teachers.

Data analysis

Exploratory factor analysis was used to determine the construct validity of this TPACK survey, i.e. the first purpose of this paper. This methodology was used to reduce a set of variables into factors without prespecification of the number of factors that can emerge (Brown 2006). It also helped to determine if test items clustered towards the factors they were designed to measure (Thorndike 2005). The factors were extracted using principal component analysis and rotated using varimax rotation. The items were eliminated if loadings were less than 0.50 (Fish & Dane 2000; Walker & Fraser
2005), or when there were cross-loadings (Bentler 1990). The exploratory factor analysis was re-run until there were no factor loadings below 0.50 and cross-loading of factors.

The factors derived from the exploratory factor analysis were then used to describe the TPACK perceptions of Singapore teachers; i.e. the second purpose of this paper. Pre-service teachers’ TPACK rating for each factor was examined with descriptive statistics. The relationship between TPACK factors and age were analysed using Pearson correlation, and t-tests were used to examine if their TPACK ratings differed by the categorical background factors of gender and teaching level.

**Results**

**Research question 1 – construct validity of TPACK survey**

During factor analysis, one item in the TPK scale with cross-loadings was eliminated from analysis. The final model was composed of five factors that explained 75.75% of the total variance. The five sources of teacher knowledge were (See Table 1) TK, content knowledge, knowledge of pedagogy (KP), knowledge of teaching with technology (KTT) and knowledge from critical reflection (KCR). The construct validity of this TPACK survey was supported with respect to TK and content knowledge. The items designed to measure these constructs emerged as two distinct factors as postulated by the TPACK framework. The third factor was composed of items for pedagogical knowledge and pedagogical content knowledge. The participants of this study did not distinguish between their knowledge of general pedagogies (e.g. assessment, classroom management) and how these were used to teach particular subject areas. Therefore, the items for pedagogical knowledge and pedagogical content knowledge were re-labelled as ‘Knowledge of Pedagogy’ (KP). The items measuring TPK, TCK and TPACK formed the fourth factor. The participants of this study interpreted the items related to technology as being conceptually similar. Therefore, these items were re-labelled as the fourth factor ‘Knowledge of Teaching with Technology’ (KTT). The fifth factor was composed of the items TPK3 and TPK4 that were related to the teachers’ reflecting about technology integration (See Table 1). Therefore, these items were re-labelled as the fifth factor ‘Knowledge from Critical Reflection’ (KCR). The alpha coefficients for these factors ranged from 0.83 to 0.96, indicating highly adequate internal consistency in assessing the pre-service teachers’ constructs of TPACK (See Table 1).

**Research question 2 – examining the TPACK perceptions of Singapore pre-service teachers**

TPACK ratings by factor

The mean score of each factor showed that pre-service teachers generally rated themselves as slightly above average for each factor: TK (M = 4.84, sd = 1.06), content knowledge (M = 4.71, sd = 1.04), KP (M = 5.00, sd = 0.89), KTT (M = 4.89, sd = 0.95) and KCR (M = 5.45, sd = 0.97). However, they were slightly more confident about KP and KCR as these factors were rated above ‘5’.

TPACK ratings by demographic variables

Age, gender and teaching level were three demographic variables analysed. The relationship between the respondents’ age and TPACK perceptions were examined through Pearson correlations (N = 1185). There were significant negative correlation between age and four factors: TK (r = -0.074, P < 0.05), content knowledge (r = -0.13, P < 0.01), KP (r = -0.13, P < 0.01) and KTT (r = -0.15, P < 0.01). However, these correlations were considered weak as they were below the 0.35 guideline proposed by Fraenkel and Wallen (2003).

For the factors of TK, content knowledge and KTT, t-tests found significant gender differences (see Table 2). The male pre-service teachers (N = 376) generally rated themselves higher than females (N = 809) for these factors. The effect sizes of gender with respect to content knowledge and KTT were small as they were lower or close to 0.25 (Cohen 1965). The largest effect size was for the factor of TK (d = 0.45).

The pre-service teachers’ TPACK knowledge perceptions were also compared by the level of teaching they were trained for, i.e. primary versus secondary. The t-tests found significant differences for content knowledge and KCR (See Table 3). Nevertheless, these effect sizes were also small as they were less than 0.25 (Cohen 1965).

**Discussion**

**Construct validity of the TPACK survey**

This study supported the results of Schmidt et al. (2009b) with respect to the internal reliability of
TPACK survey items. The exploratory factor analysis established construct validity for items of TK and content knowledge. The other items, however, were interpreted as three factors: KP, KTT and KCR. The participants of this study perceived conceptual differences between teaching with and without technology (i.e. KP and KTT). However, they could not distinguish the related constructs within each factor. A new factor, KCR, also emerged in this study. The following is a discussion of these findings.

**Table 1. Factor loadings from exploratory factor analysis.**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 1 – Technological Knowledge (TK, α = 0.87)</td>
<td>0.824</td>
</tr>
<tr>
<td>TK1 – I have the technical skills I need to use technology</td>
<td>0.824</td>
</tr>
<tr>
<td>TK2 – I can learn technology easily</td>
<td>0.838</td>
</tr>
<tr>
<td>TK3 – I know how to solve my own technical problems</td>
<td>0.835</td>
</tr>
<tr>
<td>Factor 2 – Content Knowledge (CK, α = 0.93)</td>
<td>0.796</td>
</tr>
<tr>
<td>CK1 – I have sufficient knowledge about my Curriculum Subject 1</td>
<td>0.796</td>
</tr>
<tr>
<td>CK2 – I can think about the subject matter like an expert who specializes in my Curriculum Subject 1</td>
<td>0.778</td>
</tr>
<tr>
<td>CK3 – I have various ways and strategies of developing my understanding of my Curriculum Subject 1</td>
<td>0.805</td>
</tr>
<tr>
<td>CK4 – I have sufficient knowledge about my Curriculum Subject 2</td>
<td>0.753</td>
</tr>
<tr>
<td>CK5 – I can think about the subject matter like an expert who specializes in my Curriculum Subject 2</td>
<td>0.820</td>
</tr>
<tr>
<td>CK6 – I have various ways and strategies of developing my understanding of my Curriculum Subject 2</td>
<td>0.784</td>
</tr>
<tr>
<td>Factor 3 – Knowledge of Pedagogy (KP, α = 0.93)</td>
<td>0.715</td>
</tr>
<tr>
<td>PK1 – I know how to assess student performance in a classroom</td>
<td>0.715</td>
</tr>
<tr>
<td>PK2 – I can adapt my teaching based upon what students currently understand or do not understand</td>
<td>0.754</td>
</tr>
<tr>
<td>PK3 – I can adapt my teaching style to different learners</td>
<td>0.772</td>
</tr>
<tr>
<td>PK4 – I can use a wide range of teaching approaches in a classroom setting</td>
<td>0.697</td>
</tr>
<tr>
<td>PK5 – I know how to organize and maintain classroom management</td>
<td>0.724</td>
</tr>
<tr>
<td>PCK1 – I know how to select effective teaching approaches to guide student thinking and learning in my Curriculum Subject 1</td>
<td>0.649</td>
</tr>
<tr>
<td>PCK2 – I know how to select effective teaching approaches to guide student thinking and learning in my Curriculum Subject 2</td>
<td>0.614</td>
</tr>
<tr>
<td>Factor 4 – Knowledge of Teaching with Technology (KTT, α = 0.96)</td>
<td>0.757</td>
</tr>
<tr>
<td>TPK1 – I can choose technologies that enhance the teaching approaches for a lesson</td>
<td>0.757</td>
</tr>
<tr>
<td>TPK2 – I can choose technologies that enhance students’ learning for a lesson</td>
<td>0.759</td>
</tr>
<tr>
<td>TCK1 – I know about technologies that I can use for understanding and doing my Curriculum Subject 1</td>
<td>0.605</td>
</tr>
<tr>
<td>TCK2 – I know about technologies that I can use for understanding and doing my Curriculum Subject 2</td>
<td>0.697</td>
</tr>
<tr>
<td>TPACK1 – I can teach lessons that appropriately combine my Curriculum Subject 1, technologies and teaching approaches</td>
<td>0.751</td>
</tr>
<tr>
<td>TPACK2 – I can teach lessons that appropriately combine my Curriculum Subject 2, technologies and teaching approaches</td>
<td>0.805</td>
</tr>
<tr>
<td>TPACK3 – I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn</td>
<td>0.766</td>
</tr>
<tr>
<td>TPACK4 – I can use strategies that combine content, technologies and teaching approaches that I learned about in my coursework in my classroom</td>
<td>0.745</td>
</tr>
<tr>
<td>TPACK5 – I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district</td>
<td>0.675</td>
</tr>
<tr>
<td>Factor 5 – Knowledge from Critical Reflection (KCR, α = 0.83)</td>
<td>0.787</td>
</tr>
<tr>
<td>TPK3 – My teacher education programme has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom</td>
<td>0.787</td>
</tr>
<tr>
<td>TPK4 – I am thinking critically about how to use technology in my classroom</td>
<td>0.796</td>
</tr>
</tbody>
</table>

Pre-service teacher education in Singapore trains every teacher to teach at least two subject areas in the national curriculum. These subject areas are termed Curriculum Subject 1, and Curriculum Subject 2. TK, technological knowledge; CK, content knowledge; PK, pedagogical knowledge; PCK, pedagogical content knowledge; TPK, technological pedagogical knowledge; TCK, technological content knowledge.
Inexperience of the pre-service teachers

The relative inexperience of the study participants explained the merging of pedagogical knowledge and pedagogical content knowledge items into the factor KP. Studies in the area of pedagogical content knowledge have found that the pre-service teachers were less able to consider linkages between content and pedagogy when envisioning their lesson agendas as compared with expert teachers (Leinhardt 1989; Sabers et al. 1991; Copeland et al. 1994). The participants of this study were just beginning their teacher training and therefore lacked deep knowledge and experience of the teaching practice. This explained why they were unable to distinguish between pedagogical knowledge and PCK, which were consistent with the findings of Lee and Tsai (2010). The relative inexperience of the study participants also explained why the items for TCK, TPK and TPACK were merged into the factor KTT.

General versus contextualized TPACK

The participants of this study may have also failed to distinguish between TCK, TPK and TPACK items because these were not anchored upon specific examples of technological integration. Angeli and Valanides (2009) proposed that TPACK had a transformative epistemological nature. In the transformative view, knowledge was described as a unique synthesis rather than a simple combination of parts (Gess-Newsome 1999). Cox and Graham (2009) further suggested that TPACK was contextualized to specific topics and lesson activities while TPK and TCK could exist as more general forms of knowledge. When Lee and Tsai (2010) implemented a subject-specific survey, TCK and TPACK emerged as two factors. More comparisons of construct validation results between generic and contextualized TPACK surveys will be useful. However, this is currently limited by the dearth of...
Critical reflection and TPACK

The four TPK items were split between KTT and KCR during factor analysis (See Table 1). This implied that the study participants perceived conceptual differences between the choosing of technology tools (i.e. TPK1 and TPK2) and the reflection of technology use (i.e. TPK3 and TPK4). Shulman (1999) proposed that reflection helps teachers formulate new insights of content, pedagogy and students, which enhances their pedagogical reasoning. Therefore, KCR may be an important TPACK construct that warrants further examination. On the other hand, it could also be a factor idiosyncratic to Singapore teachers as Lee and Tsai (2010) did not have similar findings. Cross-cultural comparison with US-based studies cannot be made at this point as there is a dearth of studies in the area of TPACK construct validation (see Schmidt et al. 2009a,b). Therefore, the relevance of KCR needs to be analysed in future studies.

TPACK perceptions of Singapore teachers

The participants of this study had moderately high confidence about their TK, content knowledge and pedagogical knowledge. These results were consistent with an earlier study of Singaporean pre-service teachers’ general ICT skills and pedagogical competence with using ICT (Lee et al. 2008). Interestingly, their TPACK perceptions were not strongly related to age, gender or teaching level.

Weak relationships between TPACK perceptions and age

Lee and Tsai (2010) also found weak negative correlations between age and TCK \( (r = -0.22) \), and TPACK \( (-0.16) \). However, their study found moderate correlation of \(-0.45\) between age and TK while this study found such correlation to be close to zero. This could be because Lee and Tsai (2010) studied an older sample of in-service teachers \( (M = 34 \text{ years}) \) as compared with the younger pre-service teachers in this study \( (M = 26.4 \text{ years}) \). In-service teachers with more teaching experience tend to be less confident with using computers (Yaghi 2001), which may explain why the correlations between age and TK were more pronounced in Lee and Tsai (2010). The \( t \)-tests also found no significant differences between the age of the primary \( (M = 26.33, \text{sd} = 6.66) \) and the secondary teachers \( (M = 26.52, \text{sd} = 5.26) \) in this study. This could also explain why their TPACK perceptions did not differ by teaching level. Therefore, the relationship between age and TPACK perceptions may be more evident for in-service teachers; while years of teaching experience may be a variable that should also be considered.

Gender differences

Male pre-service teachers rated their TK higher than females. This was consistent with research findings that male teachers had more positive attitudes, higher confidence and higher competency perceptions with respect to computer use (Markauskaite 2006; Tsai 2008). These results showed that the female pre-service teachers in this study needed more support for TK as they entered teacher training. However, such gender gaps may close as computers become more prevalent in schools (North & Noyes 2002), which is also the case in Singapore where a series of Information and Communication Technologies (ICT) master plans have been launched to spearhead ICT-driven curriculum and pedagogical changes in schools (Teo & Ting 2010). Future cohorts of Singapore pre-service teachers are expected to have rich ICT-driven educational experiences, which may close these gender gaps in terms of TPACK. Therefore, the gender differences in future cohorts of Singapore teachers should be closely monitored with longitudinal TPACK studies.

Future research

The results of this study point to several areas for future research. First, more KCR-type items can be added to strengthen the measurement of this construct. Examples of these are the critical reflection of personal education experiences with ICT and critical reflection of student teaching experiences. Second, construct validation studies can be carried out in various ways. For example, this study can be replicated with teachers known to be exemplary technology integrators to determine if they could make clear distinctions between TPACK constructs. This could not be explored in this study as the participants were pre-service teachers. Comparative studies of generic and subject-specific TPACK surveys can also be carried out to ascertain the robustness of context-specific TPACK items, while the cross-cultural
validity of this TPACK survey can be examined through replication in different countries. Third, the relationship between TPACK constructs and teacher demographic variables need to be further investigated. The study results show that pre-service teachers’ TPACK perceptions were fairly consistent regardless of age, gender and teaching level. There is a need to examine if these variables had stronger influence on the TPACK perceptions of in-service teachers because this will inform the planning of teacher development programmes.

Future research can also investigate the role of TPACK surveys in supporting ICT programme evaluation. There have been many qualitative studies that provide rich details about interventions used to develop teacher TPACK. Some of those studied were teacher engagement in designing ICT lessons (Mishra & Koehler 2006; Angeli & Valanides 2009), microteaching activities (e.g. Cavin 2008), action research projects (e.g. Lundeberg et al. 2003) and participation in communities of practice (e.g. Rodrigues et al. 2003). Pre- and post-course TPACK surveys can be used to supplement qualitative analysis of teachers’ TPACK development during such kinds of programmes. Triangulation of qualitative findings with survey results can contribute to the development of a common vocabulary to describe teachers’ TPACK development.

Conclusion

In this study, exploratory factor analysis has found support for TK and CK being distinctive within pre-service teachers’ knowledge perceptions. KP, KTT and KCR were the other sources of their knowledge perceptions. While PK, PCK, TPK, TCK and TPACK were postulated to be distinct constructs, these have not been perceived so by the participants of this study. More studies are needed to validate the TPACK framework. A better understanding of its epistemological foundations, components and methods of measurement will contribute immensely to improving the predictive ability of this model.

References


