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The influence of gender on beginning teachers' perceptions of their Technological Pedagogical Content Knowledge (TPACK)

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TPACK is emerging as an influential framework for conceptualising teacher knowledge in regards to integrating ICT and is generating considerable international research interest. To date, the question of whether gender plays a role in how teachers self-assess their TPACK knowledge has not figured greatly in this research. This paper seeks to explore this possible role by using an adapted form of the Schmidt et al (2009b) instrument to survey two cohorts of beginning teachers (64 in the first cohort and 142 in the second) from Victoria, Australia. It suggests that, while both genders rate their knowledge highly, especially Content Knowledge, there are significant differences in how male and female beginning teachers rated their knowledge, with males rating their knowledge higher in both years of this study.

Introduction

The development of the TPACK framework by Mishra and Koehler (2006) has met with considerable interest by the educational technology research community, particularly in the United States, but also in Australia, the U.K, Singapore and Taiwan (Abbitt, 2011; Baran et al, 2011; Harris, Mishra & Koehler, 2009; Thompson & Schmidt, 2010; Unwin, 2007). In 2013, some 463 papers could be referenced from the TPACK organisation website (see http://tpack.org/). Researchers have had a particular interest in developing a tool to measure TPACK knowledge and a number of instruments have been developed for this purpose. However, little attention has been given to the possible influence of gender on assessment of TPACK knowledge. This gap is of concern, given that research around gender and ICT generally has suggested that it can play a significant role. This paper aims to address this gap in the literature by focusing on the influence of gender in survey findings from two cohorts of beginning teachers.

The TPACK framework builds on Shulman's (1986) premise that Content Knowledge (what to teach) and Pedagogical Knowledge (how to teach) are interconnected, and together they form Pedagogical Content Knowledge (PCK). Mishra and Koehler (2006) argue that, because of the increasing number of technologies that are being appropriated in the classroom, teachers also require explicit Technology Knowledge (TK). Their resulting framework then is built on the notion of the connection between Pedagogical Knowledge

(PK), Content Knowledge (CK) and Technological Knowledge (TK) and the resulting intersecting three pairs of knowledge, Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), and Technological Pedagogical Knowledge (TPK). Where all three knowledges (PK, CK, and TK) intersect is referred to as Technological Pedagogical Content Knowledge (TPACK).

Measuring TPACK

A lot of research activity around the TPACK framework has focused on developing and administering a valid and reliable tool to measure teachers' TPACK (Abbitt, 2011; Jordan, 2012; Voogt et al., 2012). Such a tool would be useful for teacher professional development as well as the future design and evaluation of teacher education programs (Baran et al., 2011; Albion, Jamieson-Proctor, & Finger, 2010). To date though, there is no common agreement around such an instrument and "throughout efforts to further define and measure the multiple domains of the TPACK framework, several persistent challenges have remained" (Abbitt, 2011, p. 287). One of these challenges relates to issues in defining the constructs to be measured. Graham (2011), drawing on Cox's (2008) doctoral research, argues that there have been some 89 different definitions of the central construct as well as other constructs including technology knowledge. Relating to this challenge is the issue around defining the boundaries of the domains (Archambault & Crippen, 2009; Angeli & Valanides, 2009). A further challenge relates to the lack of clarity in the operation of the framework, namely whether TPACK is an integrative form of knowledge, constructed by the integration of other domains of teacher knowledge, or whether it is transformative, and a unique knowledge constructed from other forms of teacher knowledge (Archambault & Barnett, 2010; Angeli & Valanides, 2009).

Abbitt's (2011) review of TPACK instruments, conducted within the context of pre-service teacher education, argues that there have been two parallel approaches to this research. One approach he argues uses performance-based measures, such as artefacts produced by preservice teachers as evidence of TPACK. He cites the study of Graham, Burgoyne and Borup (2010) as an example of this approach. In that study, 133 early childhood and elementary teachers were asked to state how and why they would integrate ICT into three content-based design tasks (literacy, maths, science or social studies). Using the themes that emerged from these planning and decision-making explanations, the researchers then mapped them against the coding categories of TK, TPK and TPACK. The second approach which Abbitt argues involves the use of self-reporting measures, which preservice teachers use to self-assess their knowledge of particular TPACK domains. In this discussion, he highlights the development and use of *The Survey of Preservice Teachers' Knowledge of Teaching and Technology* (Schmidt et al., 2009b), describing it as "among the more mature tools" (p. 290) as "straightforward and useful" and "a valuable instrument in terms of reliability and efficiency" (p. 292). Initially designed as a self-assessment tool for Pk-6 pre-service teachers majoring in elementary and early childhood education, the instrument used 4 subscales within Content Knowledge (social studies, science, literacy and mathematics) to reflect their need to teach in several disciplines. The survey instrument included demographic information and some open-ended questions, around the effectiveness of the teacher education program, as

well as some 47 items to measure the knowledge domains in the framework: TK (7 items), CK (12 items), PK (7 items), PCK (4 items), TCK (4 items), TPK (5 items), TPCK (8 items). For each of these items participants were asked to indicate their level of agreement using a five-point Likert scale, Strongly Agree, Neither Agree or Disagree, Disagree and Strongly Disagree. Each item in the survey was scored and then each construct was scored by averaging item scores.

This instrument has been used by a number of other researchers, particularly international researchers who have adapted the instrument to suit their particular context. A recent search of titles of papers available on the TPACK organisation website (using the term 'TPACK' or 'TPCK' or 'pedagogy' or 'pedagogical', as well as 'content', 'technology', or 'technological' and 'knowledge') located some 12 papers which used this instrument. These are listed in Appendix 2. Two of these papers were produced by the survey designers, as part of their efforts to use the tool in other contexts. In one of these studies, the designers used this instrument to evaluate the TPACK of 87 pre-service teachers enrolled in an introductory technology course (Schmidt et al., 2009a) and, in the other (Shin et al., 2009), they investigated the effect of a summer course on 17 teacher's TPACK. The instrument has been adapted for use in both smaller scale surveys, such as the 17 participants in Shin et al. (2009), to larger-scale surveys involving 1185 participants, as in Koh, Chai and Tsai (2010). It has been used both as a single test and a pre-test and post-test design.

Often the process of adapting the instrument for particular use involved removing the initial focus on 4 content areas, and replacing them with items reflecting the particular context. For example, Koh, Chai and Tsai (2010) wanted their adapted instrument to reflect the primary and secondary teaching context in Singapore, and so included the item, 'I know how to select effective teaching to guide student thinking in my curriculum subject'. Chai, Koh and Tsai (2010), to reflect the teaching subjects of secondary teachers in Singapore, replaced the four items with the items, 'Curriculum Study 1' and 'Curriculum Study 2'. Often as well, adaptions to the instrument involved redefining the constructs. Koh, Chai and Tsai (2010) reduced the number of constructs from 7 to 5: Technology Knowledge, Content Knowledge, and Knowledge of Pedagogy, Knowledge of Teaching with Technology, and Knowledge from Critical Reflection, and some 29 items. Chai, Koh and Tsai (2010) reduced the number of constructs further to 4: Technology Knowledge, Pedagogy Knowledge, Content Knowledge and TPACK. Adaptions also involved the number of levels in the agreement scale. Several, namely Koh, Chai and Tsai (2010), Chai, Koh and Tsai (2010) and Chai, Koh and Tsai (2011) increased the number of levels to 7, in the belief that this aided reliability.

TPACK and gender

Investigating the role that gender may have on the assessment of TPACK knowledge is important, given that research around gender and educational computing per se has shown that there are significant gender differences in relation to attitudes to ICT, ICT skills and ICT use (Kay, 1992; 2006). The literature around the latter two areas, relating to skills and use is particularly relevant given their synergies with technology knowledge, defined as knowledge of technologies and how to apply this knowledge productively (Harris, Mishra & Koehler,

2009). Given the operational premise of the TPACK framework that teachers interconnect their knowledge, how teachers assess their technology knowledge has a flow on effect on the interconnected domains of TPK, TCK and ultimately TPACK.

In relation to computer use, Kay (2006) reviewed some 42 studies and concluded that 51% showed higher use by males. In relation to computer ability, he concluded that males reporting higher ability in 8 studies, females in 1, and no difference reported in 7 studies. Markauskaite (2006) also argues that males and females had significant differences in ICT capabilities, with males scoring higher than females. Likewise, the earlier study by Jamieson-Proctor et al. (2006), indicated that female teachers were less confident to use ICT for teaching and learning, being more likely to indicate Very Little or Some confidence (on a four point scale) relating to listed ICT applications compared to male teachers. It is to be noted that, more recently, the literature suggests that these gender gaps may be lessening. Koh and Sing (2011), for example, argue that, as more and more computers become prevalent in schools, this may have the effect of equalising difference in use between males and females. This sentiment is supported by Koh, Chai and Tsai, (2010).

To date though, the question of whether gender impacts on measuring TPACK knowledge has largely not been asked. In part, this could be because researchers have been concerned with questions around defining the constructs to be measured and the validity and reliability of the instrument itself. The few studies which have considered this question have concluded mixed results. Koh, Chai and Tsai (2010) in their study of 1185 pre-service teachers in Singapore, concluded gender differences in Technology Knowledge, Content Knowledge and Knowledge of Teaching with Technology, yet also suggested that this gap may reduce as computers become more common place in schools. In contrast, Koh and Sing (2011) in their study of 214 pre-service teachers, reported no significant differences by gender. The purpose of this paper is to offer further research on this question.

Aims of the study

Using an adapted form of the Schmidt et al. (2009b) instrument, this study compares male and female beginning teachers' self-assessments of their TPACK knowledge. These beginning teachers were in their first year of teaching in P-12 schools across the state of Victoria, Australia. Two cohorts of teachers, one cohort in 2010 and the other in 2011 make up this study, with Cohort 1 comprising 64 beginning teachers and Cohort 2 comprising 142 beginning teachers. Findings from Cohort 1 have been reported elsewhere (Jordan, 2011). This study draws on this data set as well as that by the second cohort.

The study's aim is guided by several questions: How do male and female self-assessments compare? What are the differences and similarities in how they self-assess their domain knowledge? How do they self-assess multiple items in a given domain? What are the similarities and differences in how they self-assess these multiple items? Does this self-assessment remain constant in the two years of the study?

Method

The Schmidt et al. instrument (2009b) commonly used by other researchers was adapted for use in this study (see Appendix 1). This adaption involved the practice used by other researchers of removing the focus on the 4 content areas in the initial instrument, and replacing them with items related to the particular context. Thus, the items, 'I have sufficient knowledge about the content I am teaching' and' I have various ways and strategies of developing my understanding of the content I teach' were used. Other adaptions made to PCK and TCK are shown in Appendix 1. The 5 point scale asking participants to indicate level of agreement (Strongly Agree, Agree, Neither Agree nor disagree, Disagree, Strongly Disagree) remained constant. The adapted survey was then administered online via Survey Monkey.

The participants

The participants in this study are part of a larger Victorian education department initiative, the *Supporting New Teacher's Practice* program, which aims to support beginning teachers in their first year of teaching as they face the challenges of being new to the profession (DEECD, 2010). Costing over $1 million, this three year program involves separate cohorts of beginning teachers from P-12 schools.

This program uses a blended approach to professional learning and includes a two day face-to-face program and is then followed by an extended online program of around 6 months. The face-to-face component aims to provide beginning teachers with opportunities to share their first year experiences as well as discuss some challenges to their practice. It also serves to orientate them to online technologies and prepare them to be able to participate in subsequent online elements. The online component of the program followed the face-to-face component. It essentially has two functions, to provide beginning teachers with further knowledge about issues affecting their practice and to provide a space for them as a community to share experiences and develop shared practice (Wenger, 1998).

The 206 beginning teachers involved in the first two years of this program teach in primary schools, secondary schools, across both these sectors (such as P-10 settings) or in specialist schools (such as special development schools or language schools for new arrivals). The vast majority had completed their teacher education program the year before at a range of institutions across the state. For some this was a four year bachelor qualification, for others it was a one year or two year post graduate qualification. There are around 4000 graduate teachers each year in Victoria. As such, this study provides a snapshot of how beginning teachers teaching in this state self-assess their TPACK knowledge.

Data collection and analyses

As part of this program, the beginning teachers completed a pre-program survey, with a section which sought information about their TPACK, which forms the basis of this paper. In 2010 (Cohort 1), 64 beginning teachers completed this survey, with 52 female and 12 male respondents. In 2011 (Cohort 2), 142 beginning teachers completed the survey, with 112

female and 30 male respondents. This proportion of males and females is consistent with national statistics for teaching.

The survey findings were then analysed to examine how the beginning teachers rated their knowledge in each of the domains of the framework, but no test of significance was chosen to be conducted, given the small number of males in 2010. In keeping with the initial survey designed by Schmidt et al. (2009b), an average or mean result for each item was calculated, by assigning a numerical score of 1 to 5 to the level of agreement scale. Thus a score of 5 was calculated for Strongly Agree, 4 for Agree, 3 for Neither agree or disagree, 2 for Disagree and 1 for Strongly Disagree. In the following section, a more detailed commentary on the beginning teachers' self-assessments is provided. Each cohort of beginning teachers is considered, and these are often referred to as 'All Participants', as well as each gender (male and female).

Results

1. Analysis of domain knowledge

As shown in Table 1 below, the two cohorts of beginning teachers revealed similar trends in how they rated their knowledge of each of the domains. In both years, they rated their knowledge of CK highest (3.98 in 2010, 4.04 in 2011), and those around technology, including TK, TCK, TPK and TPACK lower. Males rated their knowledge higher than females in most domains (6 domains in 2011, 5 domains in 2011), but males rated their PK knowledge lower than females in both years.

Table 1: Domain Knowledge

	2010			2011		
DOMAINS	**ALL(64)**	**FEMALE(52)**	**MALE(12)**	**ALL(142)**	**FEMALE(112)**	**MALE(30)**
TK	3.86	3.80	4.01	3.79	3.78	4.00
CK	3.98	3.95	3.96	4.04	4.04	4.05
PK	3.85	3.88	3.71	3.85	3.90	3.76
PCK	3.81	3.84	3.96	3.90	3.95	3.83
TCK	3.83	3.79	4.00	3.84	3.83	3.83
TPK	3.80	3.72	4.08	3.74	3.75	3.80
TPACK	3.84	3.75	4.08	3.76	3.81	3.87

2. Analysis of domain knowledge – individual survey items

In the following section, how the beginning teachers rated individual items within each of the domains, are analysed.

a. Technology Knowledge

Technology Knowledge (TK) is knowledge about technologies and having the knowledge to use them and to learn new ones. Some four items were used to measure the beginning teachers' knowledge in this domain.

Table 2: Technology Knowledge

TK	**2010**	**2011**

ITEM	ALL(64)	FEMALE(52)	MALE(12)	ALL(142)	FEMALE(112)	MALE(30)
Solve my technical problems technical problems	3.54	3.53	3.71	3.45	3.39	3.83
Learn technology easily	4.07	4.01	4.21	4.06	4.01	4.13
Keep up with new technologies	3.89	3.82	3.97	3.80	3.82	3.93
I have the technical skills	4.01	3.97	4.17	4.00	3.99	4.14

In 2010, the beginning teachers varied somewhat in how they rated their knowledge of the 4 items, from a mean score of 4.07 for 'Learn technology easily' to 3.54 for 'Solve my technical problems'. This pattern was repeated in 2011. When gender is considered, male beginning teachers in both years rated their knowledge higher in each item compared to females.

b. Content Knowledge

Content Knowledge (CK) is knowledge of the content to be learned or taught and how this content knowledge is different in other subject areas. Two items were used to measure Content Knowledge.

Table 3: Content Knowledge

CK	2010			2011		
ITEM	ALL(64)	FEMALE(52)	MALE(12)	ALL(142)	FEMALE(112)	MALE(30)
Knowledge about the content	3.97	3.90	4.21	4.06	4.05	4.10
How to develop content knowledge	4.04	4.07	3.80	4.08	4.09	4.04

The two cohorts similarly rated their knowledge of these two items. Females, however, rated their knowledge of one item, 'How to develop content knowledge' higher than males in both years, and their knowledge in the other item, 'Knowledge about the content' less.

c. Pedagogical Knowledge

Pedagogical Knowledge (PK) is knowledge about the methods of teaching and learning, such as knowledge of lesson planning and knowledge of learning theories. Beginning teachers self-assessed their Pedagogical Knowledge in relation to seven items.

Table 4: Pedagogical Knowledge

PK	2010			2011		
ITEM	ALL(64)	FEMALE(52)	MALE(12)	ALL(142)	FEMALE(112)	MALE(30)
Assess student performance	3.86	3.88	3.83	3.89	3.85	3.77
Adapt teaching	4.04	4.11	3.75	3.87	3.99	3.63
Different learners	3.97	3.97	3.91	4.04	4.04	4.06
Assess in multiple ways	3.91	3.91	3.66	3.94	3.99	3.83
Range of teaching approaches	3.96	4.01	3.63	3.94	3.98	3.87
Understandings and misconceptions	3.57	3.59	3.57	3.68	3.65	3.57
Classroom management	3.78	3.82	3.57	3.84	3.87	3.70

While the male beginning teachers assessed their knowledge higher in CK and TK than females did, this pattern was reversed in this domain, with females rating their knowledge

higher in all items in 2010, and in 6 of the 7 items in 2011. In both years, both males and females rated the same two items 'Understandings and misconceptions' and 'Classroom management' lower than the other items. However, there was a shift in how they rated their knowledge of 'Adapt teaching', rating this highest in 2010, but behind 4 other items in 2011.

d. Pedagogical Content Knowledge

Pedagogical Content Knowledge (PCK) is knowledge of particular pedagogy (methods or practices of teaching and learning) to use in relation to particular content knowledge. Only one item was used to gauge Pedagogical Content Knowledge.

Table 5: Pedagogical Content Knowledge

PCK	2010			2011		
ITEM	**ALL(64)**	**FEMALE(52)**	**MALE(12)**	**ALL(142)**	**FEMALE(112)**	**MALE(30)**
Select effective teaching approaches	3.81	3.84	3.96	3.90	3.95	3.83

Beginning teachers expressed high levels of agreed knowledge in relation to the one item in this domain in both 2010 and 2011. While males indicated higher rates in 2010, this was not the case in 2011.

e. Technological Content Knowledge

Technological Content Knowledge (TCK) is knowledge about the relationship between content and technology and how technologies both constrain and enable new representations of content. Only one item was also used to assess Technological Content Knowledge.

Table 6: Technological Content Knowledge

TCK	2010			2011		
ITEM	**ALL(64)**	**FEMALE(52)**	**MALE(12)**	**ALL(142)**	**FEMALE(112)**	**MALE(30)**
Know about technologies	3.83	3.79	4.00	3.84	3.83	3.83

Beginning teachers self-assessed their agreed knowledge similarly in both years. Males indicated higher rates in 2010, and these were similar to the data for females in 2011.

f. Technological Pedagogical Knowledge

Technological Pedagogical Knowledge (TPK) is knowledge of technologies and of their capabilities or affordances in teaching and learning settings and knowledge that teaching may change as a result of their application. Nine items were used to measure knowledge in this domain.

Table 7: Technological Pedagogical Knowledge

TPK	2010			2011		
ITEM	**ALL(64)**	**FEMALE(52)**	**MALE(12)**	**ALL(142)**	**FEMALE(112)**	**MALE(30)**
Choose technologies to enhance teaching	3.94	3.86	4.21	3.83	3.83	3.96

Choose technologies to enhance learning	3.83	3.80	4.17	3.81	3.82	3.94
Influence of teacher preparation on thinking about deeply	3.86	3.78	4.09	3.88	3.89	3.94
Think critically about use of technology	3.86	3.78	4.09	3.86	3.80	3.94
Adapt technologies to teaching activities	3.82	3.79	4.04	3.81	3.80	3.83
Select to enhance teaching/learning	4.01	3.93	4.17	3.77	3.78	3.74
Use strategies from teacher preparation	3.78	3.69	3.96	3.73	3.71	3.77
Provide leadership	3.49	3.45	3.84	3.34	3.22	3.63
Choose technologies to enhance content	3.92	3.87	4.08	3.84	3.85	3.77

The beginning teachers varied in how they rated their knowledge in these 9 items, ranging from 3.49 to 4.01 in 2010 and 3.34 to 3.88 in 2011. One item, relating to 'provide leadership' they rated lower in both years. Males rated their knowledge higher in this domain. In 2010, they rated all items higher, while in 2011 they rated some 7 items higher, but these rates were less than in 2010.

g. TPACK

Technological Pedagogical Content Knowledge (TPACK) is emergent knowledge of good teaching with technology involving understanding of three sources of knowledge; namely, pedagogy, content and technology knowledge. Only one item was used to measure TPACK.

Table 8: TPACK

TPACK	**2010**			**2011**		
ITEM	**ALL(64)**	**FEMALE(52)**	**MALE(12)**	**ALL(142)**	**FEMALE(112)**	**MALE(30)**
Teach lessons	3.84	3.75	4.08	3.76	3.81	3.87

The beginning teachers similarly assessed their knowledge in both years, with males rating their knowledge higher than females.

Discussion

This paper reports on how 206 beginning teachers from P-12 schools across Victoria, self-assessed their TPACK using an instrument adapted from Schmidt et al. (2009b). This survey instrument was administered to one cohort in 2010, and the other cohort in 2011. Using the findings from both surveyed years, this paper seeks to better understand the possible role that gender has on teacher self-assessment of TPACK knowledge.

In this section, I discuss the results of this study in relation to previous research which has also measured teacher's TPACK. As stated earlier, however, multiple instruments have been developed to do so, in part because researchers have wanted to measure the TPACK of particular participants, in particular contexts, and sometimes, when using particular technologies. However, researchers such as Graham (2011) and Angeli and Valanides (2009) also suggest that multiple instruments abound as researchers face considerable challenges in designing them, as defining the domains to be measured and the boundaries between them is difficult. In an effort to provide more of a like-minded comparison of results, this discussion concentrates on research which also used the Schmidt et al. (2009b) instrument as well as mean findings to report on domain knowledge. Thus, only 5 of the papers included in Appendix 2 (those in bold text) are utilised; that is, Bos and Lee (2012), Chai, Koh and Tsai (2010), Koh, Chai and Tsai (2010), Koh and Sing (2011), and Schmidt et al. (2009a). It is to be noted that when doing so, while a paper may report on pre- and post- survey findings (such as Bos & Lee, 2012; Chai, Koh &Tsai, 2010; and Schmidt et al., 2009a) only pre-test results are discussed.

Beginning teacher domain knowledge

Findings have suggested that, in both years of this study, male and female beginning teachers rated their knowledge highly in all domains, recording mean data of 3.80 in the first year and 3.98 in the second. This finding is confirmed by other studies, although these studies used a different scale and constructs. For example, Chai, Koh and Tsai (2010), reported means scores of 4. 39 to 4.95, from their study using a 7 point scale and 4 constructs and likewise Koh, Chai and Tsai (2010) reported scores of 4.71 to 5.45, also using a 7 point scale, but 5 constructs.

A closer analysis of how the beginning teachers rated their knowledge in each of the domains revealed higher mean ratings in Content Knowledge in both years (3.98 in 2010 and 4.04 in 2011). Only one other study, that by Koh and Sing (2011), reported likewise, and this was for only one of the two content areas being measured, while two studies (Bos & Lee, 2012; Koh, Chai & Tsai, 2010) scored CK lowest. Other studies reported higher ratings in other domains. In two of these, PK was reported highest (Bos & Lee, 2012; Chai, Koh & Tsai, 2010), while in another (Koh, Chai and Tsai (2010), Knowledge from Critical Reflection (KCR) was rated the highest, with TPK rated highest in the study by Schmidt et al. (2009a).

Of particular interest was how they assessed their Technology Knowledge, given that research around gender and educational computing generally has suggested that males rate their ICT skills more highly than females. Beginning teachers in this present study also assessed their knowledge around technology, including TK, TCK, TPK and TPACK lower than Pedagogy Knowledge and Content Knowledge. This finding was not evident in other studies to any great degree. Thus, research around the self-assessment of domain knowledge has revealed different conclusions.

Male and female domain knowledge

The main objective of this study was to compare how male and female beginning teachers rated their domain knowledge. It suggests that there were considerable differences in the self-assessment patterns of males and females, with males consistently rating their domain knowledge higher than females. However, they rated PK lower in both years, as well as PCK in 2011.

There were similarities in the way that male and female beginning teachers self-assessed multiple items in domains. Both males and females similarly assessed items in CK and TK, with both rating less knowledge in relation to solving technical problems. In relation to PK, both males and females rated their knowledge lower in two items, 'I am familiar with common student understandings and misconceptions' and 'I know how to organize and maintain classroom management'. In relation to TPK, both genders rated their knowledge lower around providing leadership.

Of the studies selected for inclusion in this discussion, only two explicitly examined findings in relation to gender and these reported conflicting findings. In one of these studies, Koh, Chai and Tsai (2010), surveyed 1185 primary and secondary pre-service teachers (809 females and 376 males) in Singapore, using an instrument with 5 constructs, a 7 point scale and some 29 items. The researchers used T-tests to consider the influence of gender as well as age, and teaching level. The results showed gender differences in relation to TK, CK, and Knowledge of Teaching with Technology (KTT), with male pre-service teachers rating their knowledge higher. While these differences were small in relation to CK and KTT, they were largest for TK. The researchers, when commenting on these findings, suggested that females needed more TK support, however added that this was probably only needed in the short-term, as the increased use of computers in schools would likely increase female ICT experiences in the future. In the other study, Koh and Sing (2011) measured 214 preservice teachers (149 female and 65 male), also in Singapore. They used the *TPACK for Meaningful Learning Survey*, an instrument underpinned by constructivist learning (also used by Chai, Koh and Tsai, 2011), which had 7 constructs, a 7 point scale and some 33 items. The researchers considered the possible relationship between gender and the domains through independent sample T-tests, concluding however that there were no significant gender differences.

This present study also considered whether or not the patterns in self-assessment by gender were consistent in both years. Findings suggest that female patterns were more constant, with male patterns in the second year indicating some decline in knowledge of some domains (PCK, TCK, TPK and TPACK). This finding cannot be verified, as the studies by Koh, Chai and Tsai (2010), and Koh and Sing (2011) were not conducted over the same period.

Implications for pre-service teacher education

This study suggests that the beginning teachers studied generally rate their TPACK knowledge highly, particularly in relation to their CK. This finding, however, is not consistent with other research which concluded higher rates of knowledge in a range of domains. Given that the TPACK framework is underpinned by the notion of interconnecting

knowledge, pre-service teacher education providers could pay closer attention to undertaking similar studies of their teacher education students and monitoring findings over time to inform their programs of study.

This study also suggests that there are considerable differences in how male and female beginning teachers self-assess their domain knowledge, with males consistently self-assessing their knowledge higher than females. Pre-service teacher programs could consider giving more attention to increasing knowledge levels of females. Further research could consider the possible role that female confidence levels have on these findings. Both genders revealed some similarities in how they rated individual items within knowledge domains. Their similar rating of the item around 'having the knowledge to solve technical problems' suggests this is a possible area that could be attended to in education programs.

Future directions

The findings from this study suggest that there are major differences in how male and female beginning teachers assess their knowledge of the TPACK framework. Previous research has not really focused on the influence of gender, and the few studies which have, have reported inconsistent findings. Further studies are therefore warranted, so that we can gain a much clearer understanding of its possible role. These studies could focus on pre-service and in-service teachers, and consider possible similarities and differences in how both rate their knowledge. Further studies might also examine age and gender.

Further gender-orientated research is also needed 'to test' the argument expressed by Koh, Chai and Tsai (2010) that gender inequities in ICT knowledge are not likely to be so important in the future, as the rates of ICT adoption increase. As well, further studies could examine the possible connections between measurement of TPACK knowledge and subsequent practice. Is there a relationship, and if so, what is it? For example, if male beginning teachers are more likely to rate their TPACK knowledge highly than females, will this higher rating be carried over to their practice? Related to this question around connections of knowledge to practice, is the question of to what extent could this knowledge be used as a predictor of practice.

This study examined beginning teachers, those in their first year of teaching. It would be interesting to examine their TPACK knowledge over time and to consider the influence of various factors on their ratings. For example, this research could consider the role of a teacher mentor in schools, the school leadership team, and professional development in influencing teacher assessment of knowledge.

Conclusion

There is a growing body of research interest in measuring teachers' TPACK, evident in a considerable body of research involving a multitude of instruments. The Schmidt et al. instrument (2009b) initially devised as a self-report instrument for Pk-6 preservice teachers, has been one of the most adapted instruments, particularly outside the United States. A number of researchers such as Graham (2011) and Angeli and Valanides (2009) have urged

caution in drawing too many conclusions from research reporting to measure TPACK knowledge, arguing that there are a number of theoretical issues that need to be addressed. To date though, this research has not focused much on the possible influence of gender on teacher self-assessment and this gap is significant, given that research around gender and educational computing in general has suggested that males rate their ICT skills more highly than females.

This study has aimed to add to this gap in research by examining how two cohorts of male and female beginning teachers (64 in Cohort 1 and 142 in Cohort 2) rate their TPACK knowledge. It has suggested that while male and female beginning teachers rate their domain knowledge highly, particularly around Content Knowledge, they rate their knowledge around technology lower, including their capacity to interconnect this knowledge to form TCK, TPK and TPACK. It has suggested there are significant differences in how male and female beginning teachers rated their knowledge with males consistently rating their domain knowledge higher. Females however rated their knowledge higher than males in one domain, Pedagogy Knowledge. This study has also made numerous recommendations for future research, particularly around examining the possible connection between measurement of TPACK knowledge and practice.

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Appendix 1: Adapted Schmidt et al (2009b) instrument

Schmidt et al (2009b) survey instrument	**Adapted version**
TK Technology Knowledge 1.I know how to solve my own technical problems. 2.I can learn technology easily. 3.I keep up with important new technologies. 4.I frequently play around the technology. 5.I know about a lot of different technologies. 6.I have the technical skills I need to use technology.	**TK Technology Knowledge** 1.I know how to solve my own technical problems. 2.I can learn technology easily. 3.I keep up with important new technologies. 4.I have the technical skills I need to use technology.
CK (Content Knowledge) **Mathematics** 7.I have sufficient knowledge about mathematics. 8.I can use a mathematical way of thinking. 9.I have various ways and strategies of developing my understanding of mathematics. **Social Studies** 10.I have sufficient knowledge about social studies. 11.I can use a historical way of thinking. 12.I have various ways and strategies of developing my understanding of social studies. **Science** 13.I have sufficient knowledge about science. 14.I can use a scientific way of thinking. 15.I have various ways and strategies of developing my understanding of science. **Literacy** 16.I have sufficient knowledge about literacy. 17.I can use a literary way of thinking. 18.I have various ways and strategies of developing my understanding of literacy.	**CK (Content Knowledge)** 5. I have sufficient knowledge about the content I am teach 6. I have various ways and strategies of developing my understanding of the content I teach.
PK (Pedagogical Knowledge) 19.I know how to assess student performance in a classroom. 20.I can adapt my teaching based-upon what students currently understand or do not understand. 21.I can adapt my teaching style to different learners. 22.I can assess student learning in multiple ways. 23.I can use a wide range of teaching approaches in a classroom setting. 24.I am familiar with common student understandings and misconceptions. 25.I know how to organize and maintain classroom management.	**PK (Pedagogical Knowledge)** Nil adaptions
PCK (Pedagogical Content Knowledge) 26.I can select effective teaching approaches to guide student thinking and learning in mathematics. 27.I can select effective teaching approaches to guide student thinking and learning in literacy. 28.I can select effective teaching approaches to guide student thinking and learning in science. 29.I can select effective teaching approaches to guide student	**PCK (Pedagogical Content Knowledge)** 14. I can select effective teaching approaches to guide stude thinking and learning in the content areas I teach.

thinking and learning in social studies.	
TCK (Technological Content Knowledge) 30. I know about technologies that I can use for understanding and doing mathematics. 31. I know about technologies that I can use for understanding and doing literacy. 32. I know about technologies that I can use for understanding and doing science. 33. I know about technologies that I can use for understanding and doing social studies.	**TCK (Technological Content Knowledge)** 15. I know about technologies that I can use for understand and doing what I teach.
TPK (Technological Pedagogical Knowledge) 34. I can choose technologies that enhance the teaching approaches for a lesson. 35. I can choose technologies that enhance students' learning for a lesson. 36. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom. 37. I am thinking critically about how to use technology in my classroom. 38. I can adapt the use of the technologies that I am learning about to different teaching activities. 39. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn. 40. I can use strategies that combine content, technologies and teaching approaches that I learned about in my coursework in my classroom. 41. I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district. 42. I can choose technologies that enhance the content for a lesson.	**TPK (Technological Pedagogical Knowledge)** Nil adaptions
TPACK (Technology Pedagogy and Content Knowledge) 43. I can teach lessons that appropriately combine mathematics, technologies and teaching approaches. 44. I can teach lessons that appropriately combine literacy, technologies and teaching approaches. 45. I can teach lessons that appropriately combine science, technologies and teaching approaches. 46. I can teach lessons that appropriately combine social studies, technologies and teaching approaches.	**TPACK (Technology Pedagogy and Content Knowledge** 25. I can teach lessons that appropriately combine content knowledge, technologies and teaching approaches.

Appendix 2: Studies which adapted the Schmidt et al (2009b) instrument

Note: Studies in bold text are included in the discussion section.

NAME	YEAR	PARTIC--IPANTS	CONSTRUCTS See Note	ONE TEST OR PRE-TEST AND POST-TEST	FINDINGS (mean)	FOCUS
Bos & Lee	2012	43 (7% M and 93% F	7 constructs: TK, Mathematical Content Knowledge, PK, PCK, TPK, TCK and TPCK	Pre-test and post-test and 1 year later	From pre-test: TK: 3.55 CK: 3.53 PK: 3.91 PCK: 3.87 TPK: 3.65 TPCK: 3.60	To analyse mathematics teachers' TPACK knowledge at various points and their integration of TPACK knowledge into their lesson plans
Chuang & Ho	2011	335	unclear	One test	Significant correlation between five modelled uses and TPACK knowledge. Use of CMC and digital materials/software are predictors of TPACK.	Effects of modelling on in-service early childhood teachers' TPACK knowledge
Jordan	2011	64	7 constructs: CK (2 items), TK (4 items), PK (7 items), TPK (9 items), PCK (1 items), TCK (1 item) and TPACK (1 item)	One test	TK: M 4.04, F 3.82 CK: M 4.04, F 3.99 PK: M 3.71, F 3.90 PCK: M 4.00, F 3.81 TCK: M 4.00, F 3.75 TPK: M 4.07, F 3.77 TPACK: M 4.08, F 3.81	To analyse beginning teachers' TPACK knowledge
Shin et al	2009	17	7 constructs: TK (7 items), CK (12 items), PK (7 items), PCK (8 items), TCK (4 items), TPK (8 items), TPCK (8 items)	Pre-test and post-test	Reports on matched-pairs means	To analyse how in-service teachers developed TPACK knowledge after participation in an educational technology course
Chai, Koh & Tsai	2010	889 (208 M and 248 F in pre-test)	4 constructs: TK (4 items) , PK (5 items), CK (4 items) and TPACK (5 items)	Pre-test and post-test	From pre-test: TK: 4.39 CK: 4.87 PK: 4.95 TPACK: 4.91	To analyse a TPACK-focused ICT program, "ICT for Meaningful Learning"
Chai, Koh and Tsai	2011	214	7 constructs: TK (6 items), CK (6 items), PK (6 items), TCK (4 items), TPK (3 items), PCK (4 items), TPACK (5 items)	One test	Results report on the constructs	To design an instrument to measure Singapore pre-service teachers' TPACK knowledge, underpinned by a constructivist orientation
Galstaun, Kennedy-Clark & Hu	2011	216 pre-test (48 M and 168F) , and 172 post-test	3 constructs: TK, TPK, TPACK	Pre-test and post-test	Presented pre and post test results as percentages	To analyse pre-service teachers' confidence to integrate ICT into their practice by measuring TPACK knowledge
Hu & Fyfe	2010	172	3 constructs: TK, TPK, TPACK.	Pre-test and post-test	Presented pre and post test results as percentages	To measure impact of new curriculum on pre-service teachers' TPACK knowledge
Koh, Chai & Tsai	2010	1185 (F 809, M 376)	5 constructs: TK (3 items), CK (6 items), Knowledge of Pedagogy (7 items), Knowledge of Teaching with Technology (9 items), Knowledge from Critical Reflection (2 items)	One test	From one test: TK: 4.84 CK: 4.71 KP: 5.00 KTT: 4.89 KCR: 5.45 Gender differences in relation to TK, CK, KTT, with males scoring higher especially TK	To examine TPACK perceptions of pre-service teachers in Singapore
Koh & Sing	2011	214 (149 F and 65 M)	7 constructs: TK (6 items), CK (6 items), PK (6 items),	One test	TK 5.10 PK 5.01 CK(1) 5.13	To analyse Singapore pre-service teachers' TPACK perceptions with consideration of demographics

			TCK (2 items), TPK (4 items), PCK (4 items), TPACK (5 items)		CK(2) 4.72 TPK 4.72 TCK 4.41 PCK 4.62 TPCK 4.76 No significant gender differences	(gender and age)
Liu	2011	401(136 M and 265 F)	3 constructs: TCK (3 items), PCK (3 items), TPK (3 items), TPACK (3 items)	One test	Compares those enrolled in course and those not enrolled	Influence of an integrated course on pre-service teachers' TPACK knowledge
Schmidt et al	2009a	87 (f 71 and M 16)	7 constructs: TK (7 items), CK (12 items), PK (7 items), PCK (4 items), TCK (4 items), TPK (5 items), TPCK (8 items)	Pre-test and post-test	From pre-test TCK 3.18 TPACK 3.62 TK 3.43 PK 3.74 TPK 3.96 CK-Literacy 3.82 CK Math 3.50 CK Science 3.52 CK Social Studies 3.67 PCK 3.62	To analyse pre-service teachers' TPACK knowledge following participation in instructional technology course
Schmidt et al	2009b	124	7 constructs: TK (7 items), CK (12 items), PK (7 items), PCK (4 items), TCK (4 items), TPK (5 items), TPCK (8 items)	One test	Describes the development of the instrument and pilot study	To analyse pre-service teachers' TPACK knowledge