TPACK: Exploring a Secondary Pre-service Teachers' Context

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Abstract: Twenty-first century teacher educators need to design learning experiences integrating technology for transformative learning. Bringing together the power of deep content knowledge, pedagogical knowledge and technological knowledge in an integrated manner is critical in the design of today's learning experience. The TPACK framework assists educators to gain competency and confidence to design technology-enhanced learning in ways that transform the learning experience for both students and teachers. This paper describes the TPACK findings of secondary pre-service teachers who have just completed their second professional experience placement in conjunction with a curriculum and pedagogy course. Pre-service teachers reported that they were developing the necessary confidence in working with the technology and designing learning using a TPACK framework. From the data, it was apparent that teacher educators are able use the framework to design, model and explore innovative teaching *with* technology to design TPACK learning experiences that are mindful and thoughtful.

Introduction

Pre-service teachers have difficulty finding appropriate information and communication technology (ICT) integration models both within their professional experience placements in schools and in their university courses. Without a robust model or framework, they struggle to develop the knowledge, skills and practice in relation to technology management, content, and pedagogies in conjunction with discipline content and pedagogy.

Further, Niess (2008, 2011) argued that teacher preparation courses need to emphasize the understanding of learning design skills to provide teaching and learning experiences for a diverse range of learners with differing learning needs in a technology-mediated classroom. As teacher educators, our role is to provide pre-service teachers with the knowledge, skills and experiences to be able to design and teach in today's and tomorrow's technology-enhanced learning environments. For pre-service teachers to be able to be designers of learning in these technology-enabled environment, Niess (2008) suggested effective experiences that can be integrated in courses include "exploring students' thinking and understanding when learning with technology" (p. 228).

ICT in classrooms can no longer be viewed as being an "option or a fun activity that is added to daily work" (Redmond & Lock, 2008, p. 4295). Rather, Redmond and Lock (2008) argue for a shift from ICT being viewed as "cute (e.g., something new or different) to being convenient (e.g., increase productivity) to being complementary (e.g., additional) to being core (e.g., integral and necessary to extend and enhance learning)" (p. 4295). The shift in thinking in terms of ICT in teaching and learning being *core* requires a change in how teachers and pre-service teachers view and value digital technology in their personal and professional lives. It also requires them to develop the necessary knowledge and skills in digital technology used, teaching with digital technology, technology supporting the pedagogy, and using technology to support the teaching and learning of content. It is important that the professional development and educational opportunities for teachers and pre-service teachers are not 'technocentric' (Harris, 2005) emphasising the tool rather than how it can support effective learning and teaching.

Koehler and Mishra (2008) described traditional pedagogical technologies as being characterized by *specificity*, *stability*, *transparency of function* and *transparency of perception*. The ever changing nature of digital technology

may result in teachers feeling a lack of expertise and confidence in the use of emerging technology for teaching and learning. As such, "[l]earning to become flexible, creative educators who can transcend functional fixedness and other barriers is an ongoing and complicated process and must be confronted at both pre- and in-service levels" (Koehler & Mishra, 2008, p. 9). No longer can teacher educators and pre-service teachers see the use of ICT as being the domain of some other educational professional (e.g., ICT lead teacher, computer teacher or ICT technician). Rather, it is for them to develop the capacity to meaningfully integrate digital technology to support teaching and learning in knowledge creation environments.

Designing and facilitating rich learning within technology-enabled learning environments is complex. Harris, Mirshra, and Koehler (2009) argued:

> Understanding that introducing new educational technologies into the learning process changes more than the tools used – and that this has deep implications for the nature of content-area learning, as well as the pedagogical approaches among which teachers can select - is an important and often overlooked aspect of many technology integration approaches used to date (p. 395).

In today's teacher preparation programs, teacher educators are confronted with the challenge of how to design learning experiences for pre-service teachers that give them the experience of developing content, pedagogical, and technological knowledge through the integration of technology in their teaching practice. This paper reports on the learning experience *with* technology that resulted in early program secondary pre-service teachers self-reporting on their TPACK competencies prior to completing an ICT required course.

TPACK

Shulman (1986) introduced the concept of pedagogical content knowledge (PCK). He advocated that effective teachers need to integrate multiple domains of knowledge in the areas of pedagogy and content. He identified the following three distinct content knowledge categories: "(1) subject matter content knowledge, (b) pedagogical content knowledge, and (c) curricular knowledge" (p. 9). Adding to the complex nature of teaching and learning has been further complicated by the introduction of new and emerging digital technologies.

Mishra and Koehler (2006) built on Shulman's (1986) PCK concept in the development of TPACK (initially TPCK). "TPACK emphasizes the connections among technologies, curriculum content, and specific pedagogical approaches, demonstrating how teachers' understandings of technology, pedagogy, and content can interact with one another to produce effective discipline-based teaching with educational technologies" (Harris et al., 2009, p. 396). TPACK is an evolving construct to frame the complex and dynamic nature of learning and the knowledge required for teaching in technology enhanced learning environments (Doering, Veletsianos, Scharber, & Miller, 2009). Effective technology integration requires the intersection among the three key interdependent knowledge areas: pedagogical content knowledge, technology content knowledge and technological pedagogical knowledge. At the intersection of all these knowledge areas is technological pedagogical content knowledge (Koehler & Mishra, 2008). The TPACK framework provides an approach "to examine a type of knowledge that is evident in teachers' practice when they transform their own understanding of subject matter into instruction in which technology and pedagogies support students' understanding and knowledge creation" (Kinuthia, Brantley-Dias, & Clarke, 2010, p. 647).

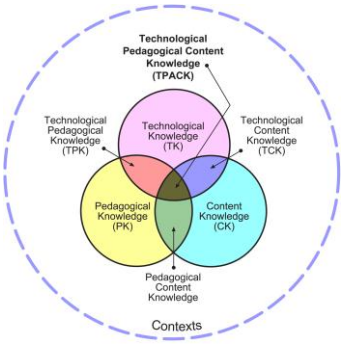

Figure 1. The TPACK Framework and Its Components. (http://www.tpck.org/)

Context

Internationally, there has been greater an emphasis placed on how ICT is being used to support and enhance learning and teaching in all educational contexts. Within Australia, the Federal Government funded the *Teaching Teachers for the Future* (TTF) project which is designed to enable all pre-service teachers "to become proficient in the use of ICT in education" (Australian Government, nd). The project included all 39 Australian teacher education institutions and involved capacity building activities for pre-service teachers and teacher educators. As part of this work, the TPACK framework was used to track and report on pre-service teachers' development of knowledge in using ICTs to transform teaching and to provide new ways to engage learners. In addition to this national project, the Queensland and Australian Professional Standards for Teachers have clearly articulated explicit expectations that support the need for pre-service teachers to develop strong understandings of ICT integration. For example, teachers need to "Use ICT safely, responsibly and ethically" (Australian Institute for Teaching and School Leadership, 2012) and "use teaching, learning and assessment strategies and resources in which ICT is embedded" (Education Queensland, 2006).

In this study, the participants (N=55) were secondary pre-service teachers in their second year of a four year program or in their first semester of a one year after-degree graduate diploma program at a regional university in Australia. At the end of the semester, the pre-service teachers completed their second professional experience placement in schools. Further, the participants were enrolled in a curriculum and pedagogy course for Middle Years learners. The course was designed to model the integration of digital technology to support self-directed and collaborative learning. While inquiring into the issues for middle years learners and investigating curriculum and pedagogy for middle years learner, pre-service teachers participated in an international online collaborative activity to explore issues related to today's diverse and digital classroom, for example, inclusivity, Indigenous perspectives, cyber bullying, ESL and ICT integration. The course was offered in face-to-face, blended and online modes.

Method

Towards the end of the semester, pre-service teachers were asked to complete the online TPACK survey. The survey was modified from earlier studies found at http://www.tpack.org/. The survey originally had an elementary focus rather than secondary. It was modified to include a range of disciplines that secondary pre-service teachers could teach beyond Social Studies, Mathematics, Science and Literacy which were included the initial survey. The following disciplines were added: Languages other than English (LOTE), Computing, The Arts, and Health and Physical Education (HPE) and Business. Given the secondary pre-service teachers were required to teach in two different disciplines, this enabled them to self-report in two discipline areas.

It was a three-part survey: Part A elicited demographic information (10 questions); Part B was related to specific components of TPACK; and Part C included open ended questions regarding ICT for teaching and learning (6 questions). In Part B the questions asked pre-service teachers to self-rate their competency related to TPACK and the six other sub-elements of the TPACK construct (i.e. technology knowledge, content knowledge, pedagogical knowledge, pedagogical content knowledge, technological content knowledge, technological pedagogical knowledge) and also explore where they see models for TPACK in their teacher education program and while on field experience. The survey used a 5-point Likert scale (1 – Strongly Disagree to 5 – Strongly Agree). The survey was selected because the original survey had been revised based on previous research and included reliability score for each TPACK domain.

Findings and Discussion

Fifty-five (N=55) pre-service teachers completed the online survey. Forty-two percent who completed the survey were male and 58% were female. The majority of the participants (51%) were between the ages of 32 – 50. The next highest group was aged between the ages of 18 – 22 (22%); with 13% between the ages of 27-32; 11% between the ages of 23 – 26; and only 3% were over 50 years of age. The secondary disciplines represented within the study included: English, Mathematics, Sciences, Social Sciences, Computing, LOTE, HPE, The Arts and Business. In Queensland high schools teachers must select two areas to teach in. The most number of participants

for the study were in the Sciences and Mathematics disciplines, followed by the Social Sciences and Business. Further, 67% of the participants were in the first semester of a one year graduate diploma program and 33% were in their second year of a four year Bachelor of Education. None of the participants had yet to complete a course related to integration of digital technology and learning and only 31% had participated in any professional development or other learning opportunities to assist them with the integration of ICTs in teaching and learning.

Table 1 presents the mean rating and standard deviation data for the seven inter-related TPACK components for this study based on the survey responses.

Table 1: Mean and Standard Deviation score responses for TPACK components

TPACK Components	Mean Rating (M)	Std Dev (SD)
Content Knowledge (CK)	4.31	0.62
Technology Knowledge (TK)	3.66	0.75
Pedagogical Knowledge (PK)	3.89	0.68
Pedagogical Content Knowledge (PCK)	4.24	0.52
Technological Content Knowledge (TCK)	4.13	0.71
Technological Pedagogical Knowledge (TPK)	4.02	0.51
Technological Pedagogical and Content Knowledge (TPACK)	4.10	0.71

Overall, the pre-service teachers self-reported confidence in their knowledge in all seven components of TPACK with limited variance. The highest confidence was in their CK (M = 4.31, SD = 0.52). In the CK component those pre-service teachers who had Social Sciences as a teaching area had the highest confidence levels (M = 4.48, SD 0.57) and HPE had the lowest (M = 4.00, SD = 0.82.). This is a similar result to Lee, Chai and Koh (2012) whose research found in the pre-service teachers first teaching area that CK was the component with the highest value of self-report. In this study, the pre-service teachers' self-report indicated that their lowest confidence was in TK (M – 3.66, SD 0.68). In contrast Lee, Chai and Koh (2012) found that PCK had the lowest mean and TK was rated mid-range across the seven TPACK components.

The pre-service teachers TK was the lowest component however the mean was still at 3.66 (SD = 0.75) from a five point scale. This result aligns with the research outcomes of Schmidt, Baran, Thompson, Mishra, Keohler and Shin (2009) who found that TK had the second lowest level of confidence at 3.82 (SD = 0.57). Pre-service teachers reported they were confident in their abilities to learn to use technology with 82% reporting at the combined agree and strongly agree score. On the other hand 24% of them did report that they did not frequently play with technology and did not know about a lot of different technologies.

Pedagogical knowledge (PK) had the second lowest mean of the seven TPACK components (M = 3.89, M = 0.68). Again, Schmidt et al., (2009) had lower levels of self-reporting (M = 4.0, SD = 0.44). The survey question where they had the lowest confidence was in their ability to identify common student understandings and misconceptions. All other question responses had a combined confidence (agree and strongly agree) at or above 79% with 96% self report for their ability to adapt their teaching based on what students currently understand or do not understand.

Pedagogical Content Knowledge (PCK) had the highest mean in the self report at 4.24 (SD = 0.52) within a five point scale. Those pre-service teachers who had LOTE as a teaching area had the lowest levels of comfort in PCK,

with 32% of them suggesting they would have difficulty selecting effective teaching approaches to guide student thinking and learning in LOTE. The highest confidence in PCK was in the discipline of Business with over 80% agreeing or strongly agreeing they can select teaching approaches to guide student thinking and learning. The next highest were in Math, English and Social Science all with over 70% agree and strongly agree responses. Although the LOTE pre-service teachers did not report a low confidence in their content knowledge when combined with pedagogical knowledge they self reported much lower than all of the other disciplines.

The pre-service teachers self reported a Technological Content Knowledge (TCK) mean of 4.13 (SD = 0.71). Again the LOTE pre-service teachers reported lowest in their confidence to know about technologies that can be used to enhance understanding in their discipline (33%). HPE pre-service teachers also reported low with 21% unsure about technologies for their discipline. The low TCK is not unexpected given they reported the lowest mean for CK. The disciplines with the highest levels of confidence with TCP were Business and Computing having over 70% with a combined agree/strongly agree self-rating. This should not be unexpected given high levels of technology in both disciplines.

The mean for Technological Pedagogical Knowledge (TPK) was 4.02 (SD = 0.51). The self report from pre-service teachers in the Schmidt et al, (2009) study was 4.3 (SD – 0.48). The weakest element the pre-service teachers reported was in their confidence to provide help to others in TPK. All other components of TPK had a combined agree and strong agreement at over 80%.

The participants mean score for Technological Pedagogical and Content Knowledge (TPACK) was 4.1 (SD = 0.71). Figure 2 below provides the percentage responses for all nine disciplines for each of the five response options.

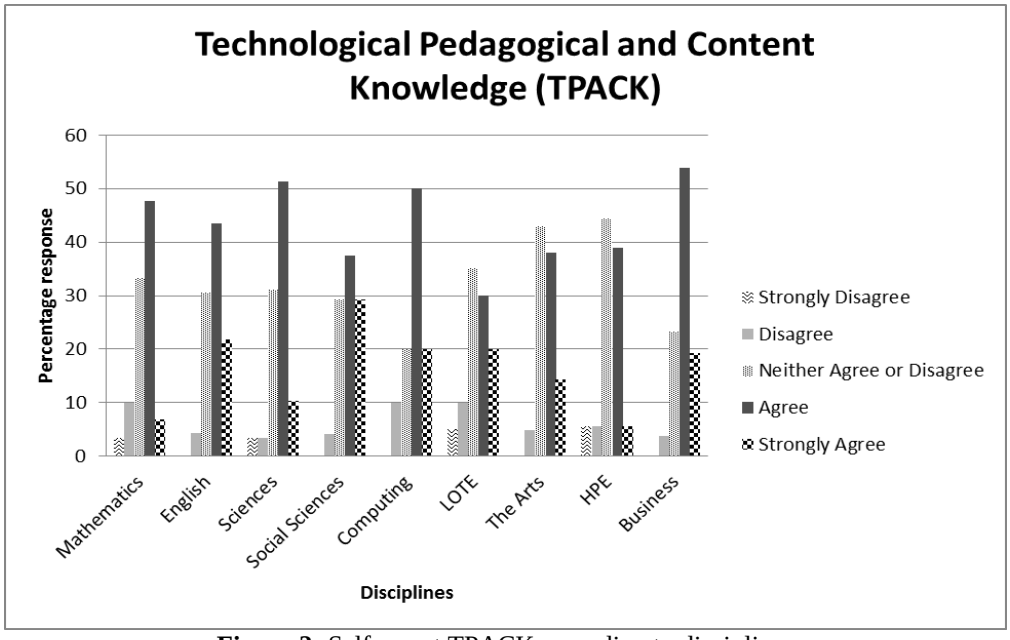

Figure 2: Self report TPACK according to disciplines

As indicated in Figure 2, the lowest level of confidence in TPACK was for pre-service teachers in the Mathematics discipline and the highest levels of strong agreement was in English (21.7%) and Social Sciences (29%). The highest level of agreement was for Business (53.8%). In all disciplines there were low levels of disagreement and strong disagreement about their TPACK confidence.

Pre-service teachers acknowledged strong support of modelling of TPACK by both their faculty instructors and their mentor teachers. More than 65% of the pre-service teachers indicated that their instructors in foundation and curriculum and pedagogy courses modelled various approaches of teaching and learning *with* technology. In open ended responses, the pre-service teachers explicitly provided examples from a range of courses that demonstrated the TPACK model by making the following statements: "In [course name] we used SimSchool. We were taught about differentiating tasks for students." and "[course name] consistently focused on the combination of teaching strategies

alongside of ICTs and content. Every lesson that was taught by her was sufficiently detailed and acted as an excellent reminder for the implementation of these areas into our planning and teaching".

The percentage of modelling was lower (45%) for instructors in other faculties. This is concerning because the majority of pre-service teachers will have 43% of their courses for the four year program completed in other faculties as they gain their content knowledge for their teaching areas. During their professional experience placement, 75% of the pre-service teachers indicated that their mentor teacher provided modelling of TPACK. The majority of pre-service teachers provided examples that went beyond the traditional use of PowerPoint, Internet searching and students using MS Word. They shared many examples of online collaboration, and the use ICT devices such as interactive whiteboard, iPods, probes, and graphic calculators used in various disciplines. Disappointingly several pre-service teachers commented that they did not see any modelling of TPACK during their professional experience: "No mentor has modelled any IT".

The majority of pre-service teachers self-reported high levels of comfort with regard to using and teaching with digital technology. One pre-service teacher stated "I'm quite comfortable using ICTs within my classes, as long as I've had time to play around with it and understand its functions". They were able to provide an example of how they have already done so on one of their professional experience placements. Most of the examples were discipline specific which positively emphasised the relationship between content, pedagogy and technology. For example, when "teaching natural disasters in SOSE I combined theory with a virtual national geographical natural disaster survival game"; and "I was teaching a senior art class and we used an Interactive whiteboard and located websites, images (artworks) and virtual tours of galleries".

What was disappointing was that it appeared from the data they have limited knowledge of what is possible using ICT for teaching and learning beyond what has been demonstrated or modelled to them within their teacher education program or on professional experience. For example, they are asked to collaboratively create a wiki as part of assessment within their teacher education program and then on professional experience they have their students do the same. There was an acknowledgement by one pre-service teacher that

> "What is possible only relates to what is available in the school and class. To learn a bunch of technologies you are never going to use is disheartening and time consuming. This course teaches that knowledge is evolving and so my current knowledge of what is possible in terms of teaching with ICT depends on what is available".

However, within teacher education, as well as during their professional experience, pre-service teachers need to explore possibilities of how they can use ICTs beyond duplicating what they have already seen. This is affirmed by Harris and Hofer (2011) whose research suggest that professional development should not focus on the affordances of hardware and software but provide opportunities for exploring and sharing technological possibilities and consider "how best to select and combine them to match the student's standards-based learning needs" (p. 228). One pre-service teacher commented "Many things are possible with ICT and as technology continues to expand so does the numerous opportunities to integrate ICT in student learning. It is clear that ICTs can be used in all subject areas and enhance them".

Implications

Teacher education programs strive to create rich learning experiences and model effective practices using technology to enhance teaching and learning. Irrespective of location, the mandate to integrate technology to enhance learning and teaching requires teachers to have strong content knowledge, pedagogical knowledge and technological knowledge and practice. In the Queensland (Australia) context the recently funded *Teaching Teachers for the Future* project placed additional pressure on Australian teacher education providers to further develop the knowledge and experience of both teacher educators and pre-service teachers in the area of technology enhanced learning. The National and Queensland professional standards for teachers demand pre-service teachers demonstrate levels of knowledge and practice in this area also.

The pre-service teachers' self-perceptions of their confidence of the TPACK elements were high not only at the individual content, pedagogical and technology levels but also improving learning at the TPACK level. The course

provided a lived experience of working in a technology-enhanced environment to develop content, pedagogical and technological knowledge and skills that pre-service teachers can draw from for their professional practice and was supported by learning in other courses and their professional experience placements. Further, pre-service teachers were able to provide specific examples from different courses where TPACK was effectively modelled for them. At this is prior to them completing a specific course focusing on ICT integration.

Although this paper reports on a snapshot of data from one course within teacher education, working in a TPACK framework has a number of consequences for educators at all levels.

1) Teaching teacher educators. "[T]houghtful pedagogical uses of technology require the development of a complex, situated form of knowledge" (Mishra & Koehler, 2006, p. 1017). Teacher educators often see themselves as content experts or even pedagogical content experts. Very few would consider themselves technological pedagogical content experts. As such, teacher education programs require the right mix of experts and expertise to speak to content, speak to pedagogy, speak to technology, and to speak to TPACK.

2) Modelling and exploring options. Angeli and Valanides (2008) recommended that "teachers need to be explicitly taught how tool affordances can be used to transform content into powerful pedagogical forms" (p. 19). Practicing teachers and teacher educators need to provide these models and also opportunities for exploration and implementation of innovative learning experiences for pre-service teachers to integrate technology as part of their everyday teaching practices.

3) Designing for TPACK learning experiences. When designing learning experiences, teachers guide their thinking and decision-making based on their theoretical knowledge, contextual knowledge, epistemological beliefs, and practical experiences. In preparing to design TPACK experiences in teacher education, it must take into account teachers' current knowledge but also extend their knowledge about how to teach with technology (Angeli & Valanides, 2008).

4) Knowledge and context impact on practice. Doering et al, (2009) remind us that in terms to TPACK "teachers do not use all three of the knowledge domains equally" (p. 336). The level of content, pedagogical or technological knowledge used in practice is related to the individual context at the time and also an educator's personal knowledge of each domain. "[C]ontext influences both teacher knowledge and practice. In turn, teacher knowledge influences practice, and practice influences which types of knowledge are used more in the classroom" (p. 336).

Limitations and Conclusion

A limitation of this study was that the data were limited to one course in one regional university in Australia. This limits the ability to generalise beyond the initial context. A second limitation is that the data were collected through pre-service teachers self-rating their competencies for each of the elements of TPACK. Data collected through self-rating is subjective, although the impact of this is reduced through the use of a previously validated survey instrument. A third limitation is the fuzzy boundaries related to TPK, TCK and PCK. Researchers have difficulty articulating the boundaries around these areas (Graham, 2011) and it may be that the pre-service teachers similarly had difficulties distinguishing between these components and the questions related to them in the survey may be misleading. Future research in this area could include a longitudinal study tracking pre-service teachers over time. Further, the use of pre- and post-test within a course or over a program would provide additional information with regard to growth and change areas.

TPACK is a "unique body of knowledge that is constructed from the dynamic interaction of its constituent knowledge bases namely knowledge of content, pedagogy, learners, context, and technology" (Angeli & Valanides, 2008, p. 16). It provides a framework to build learning opportunities to enhance both the individual components of TPACK and TPACK overall. This paper forms part of an ongoing dialogue around the use of TPACK as we explore and embrace new possibilities of teaching and learning *with* technology. Specific teaching and modelling is required so that pre-service teachers adopt and use TPACK as part of their repertoire of practice, as well as, for teacher educators to be able to design and implement such a framework within their course contexts.

Teacher education programs can no longer teach basic technology skills in isolation from content and pedagogical contexts. The development of TPACK in teacher educators, practising teachers and pre-service teachers is a messy and ill-structured problem. The content, pedagogy and technology knowledge of teacher education are dynamic, complex and interrelated. The complexity of developing the next generation of teachers is compounded with the infusion of technology in both homes and in classrooms. TPACK provides a framework to unpack and repack the parts and the whole so to design and facilitate meaningful learning and teaching *with* technology. Our challenge as teacher educators is to design and model robust learning experiences using TPACK as a way to provide pre-service teachers with a lived experience to best inform their professional practice.

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