Auditing the TPACK Confidence of Australian Pre-Service Teachers: The *TPACK Confidence Survey (TCS)*

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Abstract: This chapter describes the construction and validation of an instrument to measure teachers' Technological Pedagogical Content Knowledge (TPACK). The *TPACK Confidence Survey (TCS)* contains scales that measure teachers' attitudes toward using ICT; confidence to use ICT for teaching and learning tasks (TPACK); competency with ICT; Technology Knowledge (TK); and TPACK Vocational Self-efficacy. The scale measuring TPACK confidence uses the *Learning With ICTs: Measuring ICT Use in the Curriculum* instrument that has been evaluated and reported previously. This paper proposes that the *TCS* provides a valid and reliable instrument with which to audit teachers' TPACK confidence.

Background

Australian governments have repeatedly expressed commitment to an expanding role for information and communication technology (ICT) in education. Almost 10 years ago two overarching goals for school education in the information economy were articulated: that students would graduate with relevant knowledge and skills for using ICT, and that ICT would be integrated to improve student learning (Toomey, 2001). More recently the Digital Education Revolution (DER) has been initiated with a plan (DEEWR, 2008) underpinned by agreement that "Australia will have technology enriched learning environments that enable students to achieve high quality learning outcomes and productively contribute to our society and economy" (MCEECDYA, 2008, p. 1).

Teacher quality is a critical factor in achieving quality learning outcomes for students. An OECD report noted "the quality of an education system cannot exceed the quality of its teachers" (Barber & Mourshed, 2007, p. 7). Although the most visible aspects of the DER are increased numbers of computers in schools and high speed broadband connections, the DER roadmap (AICTEC, 2009) lists six principles including that "educators require the pedagogical knowledge, confidence, skills, resources and support to creatively and effectively use online tools and systems to engage students" (p. 6). The roadmap also refers to "professional learning opportunities for existing teachers to upgrade or develop proficiency in the effective and innovative/creative educational use of ICT" and ensuring "that the national graduate teacher standards include rigorous requirements regarding the use of technology in teaching" (AICTEC, 2009, p. 8). However, there is no detail about the form and content of the professional development for teachers or the nature and measurement of the required standards. This chapter describes an instrument for measuring the knowledge required by teachers for effective use of ICT in learning and teaching.

Defining TPACK

Positive attitudes to ICT and related skills, though necessary, are not sufficient for teachers to solve the "wicked problem" of teaching with technology (Koehler & Mishra, 2008). Shulman (1986) conceptualized Pedagogical

Content Knowledge (PCK) as distinct from knowledge of content (CK) or pedagogy (PK). He saw PCK as the specialized knowledge possessed by teachers and used to transform content into alternative representations that enhance learner understanding and to select pedagogic strategies. PCK has frequently been represented as the intersection of two circles representing pedagogical and content knowledge. Mishra and Koehler (2006) argued that new technologies (ICT) have changed the classroom to a sufficient extent to justify an extension of Shulman's model to incorporate the intersections of technological knowledge (TK) with both CK and PK, producing three more intersections (TPK, TCK, and TPCK) as represented in Figure 1. The acronym, TPCK, was later changed to TPACK to reflect the idea that the three knowledge domains form a "Total PACKage" (Thompson & Mishra, 2007, p. 38). We suggest that TPACK represents the knowledge required to achieve the intent of the DER (AICTEC, 2009).

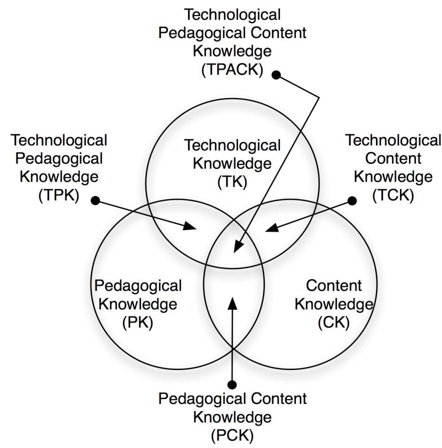

Figure 1: Technological Pedagogical Content Knowledge (TPACK)

Measuring TPACK

If TPACK represents the ICT-related knowledge required of teachers, then it is natural to ask how TPACK might be measured to ensure the effectiveness of teacher development. Although there are several published studies describing instruments for measuring TPACK there is, as yet, no widely accepted instrument.

Koehler and Mishra (2005) asked 13 participants about their perceptions of thinking about elements of TPACK during a course in which they designed an online course. Analysis confirmed increased thinking about all seven TPACK elements. However, the instrument is not suitable for general measurement of TPACK. In a subsequent similar study with 24 participants, interactions among participants were analyzed to trace the development of TPACK. The study confirmed that the initially separate topics of technology, content and pedagogy become more strongly interconnected over time. This is evidence of TPACK development but the methodology is not suitable for measurement among larger groups of teachers.

Angeli and Valanides (2009) considered ICT-TPCK as a strand of TPCK based on knowledge of five domains: ICT, content, pedagogy, learners, and context. Their model is related to Mishra and Koehler's (2006) conceptualization of TPCK with additional elements. Working with 215 pre-service elementary teachers in groups over three successive semesters, they used a combination of peer, expert, and self-assessment of TPCK manifested in two design tasks using criteria for guidance. They found that students' total ICT-TPCK competence increased significantly between the two tasks. ICT-TPCK seems similar enough to TPCK that the criteria could be adapted for use with TPCK but the method is not suitable for obtaining rapid measures for large numbers of teachers.

In a study involving 596 US K-12 online educators, TPACK was measured using a questionnaire containing 24 items developed with content validation by an expert panel and a think-aloud pilot to establish construct validity (Archambault & Crippen, 2009). Alpha reliabilities for the TPACK elements ranged from 0.70 to 0.89 with significant correlations between all pairs of elements. Although the instrument appears to be valid and reliable, the items are specific to teaching online and it is not suitable for assessment of TPCK in broader educational contexts.

A questionnaire linked from the TPACK web site (http://www.tpck.org/) may be the strongest measure thus far published. Items developed from the framework were sent for expert construct validity analysis with results for each of the knowledge types ranging from 3.67 to 9.00 on a 1 to 10 scale and five of the seven types scoring 7.88 or greater (Schmidt, Seymour, Baran, & Thompson, 2009). The questionnaire has been constructed for use with elementary teachers and the CK scale includes multiple items for each of mathematics, social studies, science, and literacy. The scales for the various elements of the TPACK model returned Alpha reliability values ranging from 0.75 to 0.92 (Schmidt, Baran, et al., 2009), suggesting that the instrument is reliable and could be used with confidence in contexts where the subjects represented in the content scales are appropriate.

Graham, Cox and Velasquez (2009) considered both self-report questionnaire and performance assessment based on artifacts as strategies for measuring TPACK. They noted that performance assessment was time consuming and thus unsuitable for use with large groups, especially if a quick result is required. Questionnaires suffered from difficulty in framing questions to address the TPACK constructs and inconsistent interpretation by respondents. Items in their initial questionnaire did not load as intended on the TPACK constructs. In another study, Graham et al. (2009) used a questionnaire to measure TPACK confidence of inservice science teachers. The instrument addressed only the four technology-related elements (TPACK, TPK, TCK, and TK) using 31 items of which the content-related items were specific to science. They found significant increases in each type of knowledge from start to finish of a short professional development but the small number of participants (15) did not permit testing of construct validity.

Arguing that the World Wide Web is a special case of technology, Lee and Tsai (2010) proposed a TPCK-W framework in which W replaces the T of TPACK and the intersections become WPK, WCK, and WPCK, and developed an instrument to measure teachers' self-efficacy in terms of their TPCK-W. The initial bank of items covered WK (general and communicative), WCK, WPK, WPCK, and attitudes to web-based instruction. Exploratory and confirmatory factor analysis of data from 558 Taiwanese teachers found that items intended to measure WPK and WPCK loaded on the same factor, leading to a final instrument with 30 items in five scales. Although there may be useful lessons to be learned from the construction of this instrument, its narrower focus on Web technology makes it unsuitable for a more global measurement of TPACK.

Despite these efforts, there is no widely accepted instrument for measuring TPACK. If TPACK is to be a key outcome of teacher development it is highly desirable to have a reliable and valid measure. Hence this paper reports on the development and validation of an instrument that appears to have the required characteristics.

Development of the *TPACK Confidence Survey* (*TCS*)

The *TPACK Confidence Survey (TCS)* was developed to audit the TPACK confidence of final year teacher education students at two Queensland universities (one metropolitan and one regional) in August 2009. All 1270 students were invited by email to complete the *TCS* online, resulting in 345 completed surveys (27% response rate). Inspection of the demographic data confirmed that the respondent sample was representative of the student population from which it was drawn.

Based on the literature about the definition and measurement of TPACK as reviewed above and the theoretical framework underpinning an existing instrument, a strong claim can be made that the *Learning With ICTs: Measuring ICT Use in the Curriculum* instrument measures two dimensions of TPACK, namely the pedagogical dimensions related to enhancing and transforming the curriculum through ICT integration. Table 1 displays the final 20 items and 2 factors of that instrument (Jamieson-Proctor, Watson, Finger, Grimbeek, & Burnett, 2007). The statistical validation of this instrument has been reported previously and the instrument has been used in several large-scale studies to evaluate ICT integration in Queensland schools (Jamieson-Proctor & Finger, 2006; Jamieson-Proctor, Burnett, Finger, & Watson, 2006; Jamieson-Proctor et al., 2007; Jamieson-Proctor & Finger, 2009). For the purpose of this chapter only a brief summary of the development of the original instrument is provided.

Based on the *Productive Pedagogy* dimensions and the *New Basics* curriculum organizers (Lingard et al., 2001), 137 items were generated using the stem, "*In my class **students use** ICTs to*". As a consequence, the instrument clearly defined successful ICT integration in relation to the *use* of ICT experienced by students rather than teachers (DEST, 2002). That is, the instrument measured teachers' perceptions of the extent to which their students used ICT in productive ways across the curriculum. A four-point Likert-style scale was used (Never, Sometimes, Often, and Very Often), to gauge the teacher-reported frequency-of-use of ICT by students. Factor analysis using Principal Axis

Factoring (PAF) with Oblimin rotation (SPSS 13) produced a simple and conceptually robust two-factor solution. The first factor comprised 14 items that define ICT as a tool for the development of ICT-related skills and the enhancement of learning outcomes, suggesting the use of ICT to *enhance* teaching and learning. The second factor comprised 6 items that define ICT as an integral component of reforms that change what students learn and how school is structured and organized, implying a *transformative* ICT function.

	Factor and Items	**Factor 1**	**Factor 2**
In my class, **students use** ICTs to			
1.2	acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change.	.66	
2.3	develop functional competencies in a specified curriculum area.	.73	
2.5	synthesize their knowledge.	.82	
2.6	actively construct their own knowledge in collaboration with their peers and others.	.76	
2.7	actively construct knowledge that integrates curriculum areas.	.81	
2.8	develop deep understanding about a topic of interest relevant to the curriculum area(s) being studied.	.80	
2.9	develop a scientific understanding of the world.	.57	
2.12	provide motivation for curriculum tasks.	.79	
2.13	plan and/or manage curriculum projects.	.74	
2.14	integrate different media to create appropriate products.	.68	
2.16	engage in sustained involvement with curriculum activities.	.68	
2.17	support elements of the learning process.	.74	
2.19	demonstrate what they have learned.	.72	
2.20	undertake formative and/or summative assessment.	.45	
3.7	acquire awareness of the global implications of ICT-based technologies on society.		.78
3.9	gain intercultural understanding.		.75
3.10	critically evaluate their own and society's values.		.82
4.1	communicate with others locally and globally.		.54
4.3	engage in independent learning through access to education at a time, place, and pace of their own choosing.		.58
4.4	understand and participate in the changing knowledge economy.		.69
	Alpha Reliability Coefficients	**.94**	**.86**

Table 1: Items with Oblimin Rotated Factor Loadings and reliability coefficients for the *Learning with ICTs: Measuring ICT Use in the Curriculum* Instrument (N = 929) (Jamieson-Proctor et al. 2007)

The authors now contend that, because items ask teachers to indicate how frequently students use ICT for each learning task, the instrument indirectly measures teachers' technology knowledge (TK), which is essential for them to facilitate the use of ICT by students. That is, unless teachers have a reasonable level of technology knowledge, students will not be able to undertake the learning tasks with ICT described by the items. Further, teachers who indicate that their students use ICT for these tasks are also indicating that they have the pedagogical knowledge (PK) needed to facilitate students' learning with ICT. Thus, this instrument, originally designed to measure ICT curriculum integration in classrooms, we contend, could also validly measure the TK and PK of TPACK.

Also, teachers who indicate that their students use ICT to undertake the listed curriculum tasks, would require a commensurate level of curriculum content knowledge (CK) in order to be able to facilitate the use of ICT to either enhance or transform the curriculum. For example, item 2.8 states "In my class, students use ICTs to develop deep understanding about a topic of interest relevant to the curriculum area(s) being studied." We argue that it would be functionally impossible for a teacher to have a low or limited knowledge of curriculum content and have students use ICT in order to achieve 'deep' understanding in a curriculum area. Therefore, we argue that the *Learning With ICTs: Measuring ICT Use in the Curriculum instrument*, originally designed to measure ICT curriculum integration, could also be used to measure the newer construct of TPACK (Koehler & Mishra, 2008).

In the 2009 audit of pre-service teachers' TPACK, the response set for this scale was changed to reflect the requirement for a measure of the soon-to-be teachers' TPACK *confidence*. The new 4-point Likert response categories were: No confidence, Some confidence, Confident and Very confident. In this way, the participants were able to indicate how confident they felt to facilitate ICT integration with their future students as described by each item in the scale. This modification to the original scale allows it to be used as a measure of teachers' TPACK confidence, as well as an indicator of student outcomes as a result of the teachers' TPACK. For in-service teachers, TPACK confidence would be rooted in their ongoing classroom experience. For pre-service teachers, as in the 2009 audit, TPACK confidence would be based on their experience during practicum as well as their self-assessment of their knowledge and anticipated capability to translate it into action.

Table 2 presents mean scores on each of the two factors in the TPACK confidence scale obtained for the pre-service students in this study. The overall mean values on the scales (2.60 and 2.56) are just above the midpoint of the 1 to 4 scale, corresponding to a response between some confidence and confident. The questionnaire also included a broad question about confidence for using ICT with school students for teaching and learning using the same scale. The mean response on that item was 2.79, which compares with a mean value of 2.62 recorded for the same question when it was asked of 929 practicing teachers (Jamieson-Proctor et al. 2007).

	Metropolitan University (N = 199)	**Regional University (N = 146)**
Factor 1: Enhancing student learning outcomes	2.59 (0.06)	2.62 (0.08)
Factor 2: Transforming student learning outcomes	2.55 (0.06)	2.58 (0.07)

Table 2: Comparison of mean (with standard error) TPACK confidence for students in two universities

In addition to the scale described above which is proposed to measure teachers' TPACK or TPACK confidence (depending upon the scale and context), *The TPACK Confidence Survey (TCS)* contains items that measure teachers' interest in, and attitude toward, using ICT; access to ICT and the Internet; competency with ICT applications; digital technology knowledge (TK); and TPACK Vocational Self-efficacy.

	The Professional Capabilities of the TPACK Vocational Self-efficacy Scale	**Factor Loading**	**Mean (SD)**
Professional Values:			
1	As a life-long learner, I will be able to set my own short and long term learning goals based on regular reflection of my own professional practice and determined needs. I will be able to devise and enact a plan to achieve these.	.92	2.71 (1.17)
2	I will be able to collaborate with staff and/or students to critically reflect on and evaluate the learning opportunities and implications of digital resources, technologies and environments.	.92	2.77 (1.14)
3	I will be able to operate safely, legally, ethically and in accordance with departmental policy when using digital resources, technologies and online environments. I will be able to teach and model these practices with students and colleagues.	.94	2.91 (1.18)
Professional Relationships:			
4	I will be able to use ICT to communicate with others for professional purposes.	.93	3.09 (1.21)
	Professional Knowledge:		
5	I understand that ICT can be used to benefit teaching and learning and is most effective when used in the context of learning and not as an end itself.	.93	2.94 (1.16)
Professional Practice:			
6	I will be able to provide opportunities for students to use ICT as part of their learning.	.95	2.77 (1.15)
7	I will be able to provide opportunities for students to use ICT to gather information and to communicate with a known audience.	.95	2.81 (1.15)
8	I will be able to manage the access to and use of ICT resources in meeting student learning needs.	.93	2.63 (1.12)
9	I will be able to use a range of ICT resources and devices for professional purposes.	.95	2.75 (1.16)
10	I will be able to use ICT to locate, create and record information and resources.	.96	2.88 (1.16)
11	I will be able to store, organise and retrieve digital resources.	.95	2.94 (1.18)
12	I will be able to use ICT to access and manage information about student learning.	.95	2.88 (1.16)

Table 3: Items with Varimax Rotated Factor Loadings and mean scores for the *TPACK Vocational Self-efficacy* scale of the *TPACK Confidence Survey (TCS)* (N=345)

Table 3 displays the items from the *TPACK Vocational Self-efficacy* scale which was validated with the data obtained from the audit of graduating pre-service teachers. The 12 items of the *TPACK Vocational Self-efficacy* scale describe the foundational competencies of ICT use for teaching in the 21st century derived from the ICT Pedagogical Certificate level of the *Smart Classrooms Professional Development Framework* (DET, 2009). This framework is a professional learning guide to assist teachers to embrace digital pedagogy. Twelve indicators from the ICT Certificate level of the framework that describe professional values, relationships, knowledge and practice were used to construct the *TPACK Vocational Self-efficacy* scale, as they indicate the foundational ICT capabilities required by all teachers. A four-point Likert-type response set was used for participants to indicate their level of confidence for each item (1=No confidence, 2=Some confidence, 3=Confident, 4=Very confident).

Because the 12 items were hypothesized to measure one construct (TPACK vocational self-efficacy) a factor analysis using Principal Components extraction with a Varimax rotation was used to assess the factor structure of the *TPACK Vocational Self-efficacy* scale. Then, alpha coefficients were computed to evaluate the internal consistency of the scale and a Pearson Correlation was used to establish the relationships that exist between the individual items in the scale. The factor analysis revealed a single factor solution with an eigenvalue greater than one and accounting for 88% of the variance. The scale's internal reliability Alpha Coefficient was calculated at 0.99. Pairwise correlations between items ranged from 0.82 to 0.94 with all values significant at $p < 0.01$ (two-tailed). These very high correlations indicate that, while the items are theoretically distinctive, in empirical terms they are collinear. However, removing items from the scale to accommodate the statistical redundancy would render the scale theoretically meaningless, so it was decided to tolerate the highly correlated items. Table 3 presents the alpha coefficients for each item together with the means and standard deviations for the individual items. The overall mean score on the scale was 2.84, which is slightly higher than the means obtained on the TPACK Confidence scale (2.60 and 2.56) and on the question about general confidence for teaching and learning with ICT (2.79).

Discussion

The *TPACK Confidence Survey (TCS)* provides a statistically validated instrument that, depending upon the response scales used (frequency of use or confidence) and the context of application, can be used to measure aspects of teachers' TPACK or the TPACK confidence of pre-service teachers. In this study it was used to audit the TPACK confidence and TPACK vocational self-efficacy of pre-service teachers and it is appropriate to consider any limitations of the methodology and the implications of the results.

As used in the current study with pre-service teachers, the *TCS* asked respondents to rate their confidence for performing behaviors that they may not have performed previously, except perhaps to a limited extent in the supported context of teaching practicum. The principal reason for seeking such estimates is to serve as an indicator of the likelihood that the pre-service teachers providing the estimates will engage in the relevant behaviors in their post-graduation appointments, based on the reasonable expectation that individuals who have greater confidence in their ability to perform in particular ways are more likely to do so. The accuracy with which pre-service teachers can gauge their ability, and hence their confidence, to perform unfamiliar behaviors is clearly open to question. Consequently, scores on the *TCS* scales, if not accurate, could represent either under-estimates or over-estimates of confidence. If pre-service teachers report low levels of confidence, those responsible for the teacher education program are likely to take action to adjust the program to effect an increase in confidence. In this case there is little risk of any adverse effect on future graduates' TPACK capabilities. However, if pre-service teachers report unjustifiably high levels of confidence, those responsible for the program may assume wrongly that appropriate levels are being achieved and see no need for additional action. In this case there is a risk that current and future graduates from the program may not have the desired TPACK capabilities.

Hence it is important to consider how likely it is that pre-service teachers might over-estimate their capabilities, and thus their confidence, in relation to TPACK. Studies of pre-service teachers and ICT have repeatedly reported low levels of confidence for integrating ICT in learning and teaching. Handler (1993) reported that only 18.8% of 133 recent graduates in the USA felt prepared to use computers in instruction. An Australian study using an earlier version of the instrument presented in Table 1 (Finger et al., 2004) reported low levels of confidence for integrating ICT, with between 25% and 48% of respondents reporting no or limited confidence on the various items and an average score of 2.81 on the same 4 point scale, compared to 2.59 for the present study. These results suggest that pre-service teachers are probably not grossly over stating their confidence for working with ICT. However, a recent paper by Milman and Molebash (2008) reported on a longitudinal study in which 99 USA pre-service teachers surveyed in 1998-2000 responded to a further questionnaire in 2006. In that study average scores on a similar 4-point scale rose from 2.67 prior to a required ICT course to 3.42 immediately afterwards and declined to 3.32 over 5 to 7 years following graduation. These studies suggest that any over-estimation of confidence by pre-service teachers may be minimal. On the balance of evidence from these studies it seems reasonable to use a measure of TPACK confidence, such as the *TCS*, as an indicator of the effectiveness of teacher education programs in preparing graduates with appropriate levels of TPACK but further longitudinal studies would add to our knowledge of how that knowledge fares beyond graduation. Such studies would provide guidance for future development of more effective programs of teacher education and support further refinement of the *TCS* as a valid, reliable and multi-dimensional instrument with which to audit teachers' TPACK.

In conclusion, the TPACK Confidence Survey (TCS) instrument, is underpinned by a sound theoretical basis, and is informed by contemporary Australian and international literature relating to recent trends in the definition and measurement of teachers' Technological Pedagogical Content Knowledge (TPACK) and current theoretical pedagogical and curriculum frameworks. It has undergone a preliminary evaluation process that has refined the instrument's statistical and theoretical structure and which has yielded promising results indicating that the instrument is capable of measuring TPACK on a large scale in multiple education contexts. However, the researchers caution that in view of the rapidly changing scene with respect to ICTs, teaching and learning, the instrument will need regular review if it is to continue to measure meaningful elements of TPACK. Further, as with all self-report instruments, data collected with this instrument should be complemented with other data collection methodologies to overcome the often-reported difficulties of all self-report instruments.

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