Auditing the TPACK Competence and Confidence of Australian Teachers: The *Teaching With ICT Audit Survey (TWictAS)*

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Abstract: This paper describes the theoretical construction, statistical validity and reliability of a survey instrument designed to measure teachers' Technological Pedagogical Content Knowledge (TPACK) – 'the total package' (Koehler & Mishra, 2008). The *Teaching With ICT Audit Survey (TWictAS)* contains scales that measure teachers' interest in and attitudes towards using ICT; confidence to use ICT with students for specific teaching and learning tasks (TPACK); access to ICT and the Internet; competency with ICT applications; Technology Knowledge (TK); and their TPACK Vocational Self-efficacy. The scale measuring the teachers' TPACK confidence makes use of the *Learning With ICTs: Measuring ICT Use in the Curriculum* instrument that has been extensively evaluated and reported in the literature to be both a statistically and theoretically robust measure of curriculum integration of ICT (Authors, 2007). This paper proposes that in conjunction with scales to measure TK and *TPACK Vocational Self-efficacy*, the *TWictAS* provides a valid, reliable and multi-dimensional instrument with which to audit teachers' TPACK.

Background

Australian governments have repeatedly expressed commitment to an expanding role for information and communication technology (ICT) in education. Almost 10 years ago the Australian government articulated two overarching goals for school education in the information economy, namely, that students would graduate with relevant knowledge and skills, and that ICT would be integrated to improve student learning (Toomey, 2001). More recently the Australian government has initiated the Digital Education Revolution (DER) initiative with a strategic plan (DEEWR, 2008) underpinned by agreement across federal and state governments 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).

There is strong evidence that teacher quality is the most important factor in achieving quality learning outcomes for students. An OECD commissioned report noted that "the quality of an education system cannot exceed the quality of its teachers" (Barber & Mourshed, 2007, p. 7). Although the aspects of the DER attracting most media attention are funding to increase the numbers of computers in schools and the provision of high speed broadband connections, the DER roadmap (AICTEC, 2009) lists as the second of six principles underpinning the DER that "teachers and educators require the pedagogical knowledge, confidence, skills, resources and support to creatively and effectively use online tools and systems to engage students" (p. 6). In expanding on "support for teachers to make effective use of ICT in teaching and learning" as the fourth and final funding element in the DER, the roadmap 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 provided about the specific form and content of the professional development that should be undertaken by teachers or the nature of the required standards and how their achievement might be measured. This paper aims to contribute to informed discussion of the knowledge required by teachers for effective use of ICT in learning and teaching and of how development of that knowledge might be reliably measured.

Defining TPACK

Numerous studies have investigated teachers' use of ICT. In general, positive attitudes to ICT and related skills, though necessary, are not sufficient for teachers to solve what has been described as the "wicked problem" of teaching with technology (Koehler & Mishra, 2008). More than 20 years ago, Shulman (1986) developed the concept of Pedagogical Content Knowledge (PCK) as distinct from knowledge of either content (CK) or pedagogy (PK). PCK was seen by Shulman as the specialized type of knowledge possessed by teachers and used to guide the transformation of content into alternative representations that enhance learner understanding or to select pedagogic strategies that facilitate learning. Although Shulman's original paper did not include any diagram, PCK has since been represented as the intersection of two partially overlapping circles representing pedagogical and content knowledge. Mishra and Koehler (2006) argued that new technologies (ICT) have changed, or have the potential to change, the nature of 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 "consonant heavy" acronym, TPCK, was later changed to TPACK for ease of pronunciation and to reflect the idea that the three knowledge domains of technology, content and pedagogy form a "Total PACKage" (Thompson & Mishra, 2007, p. 38). We suggest that TPACK represents the knowledge likely to be required of Australian teachers to achieve the intent of the DER (AICTEC, 2009).

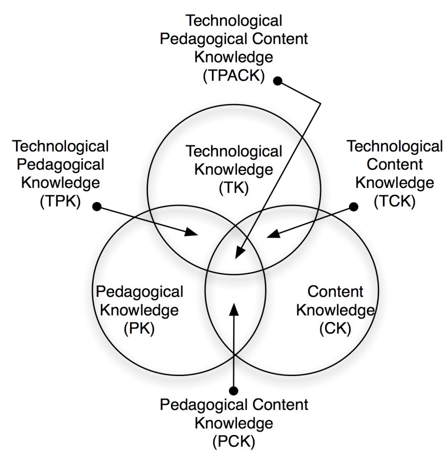

Figure 1: Technological Pedagogical Content Knowledge (TPACK) [after Mishra and Koehler (2006)]

Measuring TPACK

Given that that TPACK provides a representation of the ICT-related knowledge required of teachers then it is natural to ask how TPACK might be measured in order to ensure the effectiveness of professional development and teacher preparation programs intended to enhance TPACK. An ideal instrument would be demonstrably valid and reliable, and would be capable of being conveniently administered and scored in a variety of contexts. Although there are several published studies describing instruments for measuring TPACK there is, as yet, no widely accepted instrument with the desired characteristics.

The earliest attempt to measure TPACK (then TPCK) appears to be that described by Koehler and Mishra (2005) in which 13 participants responded to questions about individual and group perceptions of thinking about elements of the TPACK model during a course in which participants designed an online course. Analysis of the data confirmed increased thinking about all of the TPACK elements (TK, PK, CK, PCK, TCK, TPK, and TPCK). However, although the instrument was appropriate to the particular study it is not suitable for general measurement of TPACK. In a subsequent study of a similar design course with 24 participants, interactions among participants as they worked in small design groups were analyzed to trace the development of elements of TPACK during the experience. The study confirmed that over time the initially separate topics of technology, content and pedagogy become more strongly interconnected. Again this is evidence of development of TPACK but the methodology is not suitable for measurement of TPACK development among larger groups of teachers.

Angeli and Valanides (2009) rehearsed the arguments for TPCK as a distinct body of assessable knowledge, beyond integration of the separate elements. They then considered ICT-TPCK as a strand of TPCK based on knowledge of five domains, ICT, content, pedagogy, learners, and context. Their model is clearly related to Mishra and Koehler's (2006) conceptualization of TPCK with additional elements. Working with a total of 215 pre-service elementary teachers in an instructional technology class with groups of 80, 50, and 85 over successive semesters, they used a combination of peer, expert, and self-assessment of TPCK as manifested in two design tasks using a list of 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, which were not subject specific, could be adapted for use with TPCK but the method of individual task-based assessment is not suitable for obtaining rapid measures of TPCK for large numbers of teachers.

In a study involving 596 K-12 online educators in the USA, TPACK was measured using a questionnaire developed for the purpose (Archambault & Crippen, 2009). The 24 items in the questionnaire were developed from the TPACK framework, with content validation by an expert panel before a think-aloud pilot to ensure consistent interpretation of items and establish construct validity. Alpha reliabilities for the 7 elements of the TPACK model ranged from 0.699 to 0.888 and there were 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 for broader contexts.

Perhaps the closest to an "official" measure of TPACK is linked from the TPACK web site (http://www.tpck.org/). Items have been developed from the framework and 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 5 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.

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

Arguing that the World Wide Web is a special case of technology, Lee and Tsai (in press) proposed a TPCK-W framework in which W replaces the T of TPACK and the intersections become WPK, WCK, and WPCK. Based on this framework they 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. Following administration to 558 Taiwanese teachers, exploratory and confirmatory factor analysis found that items intended to measure WPK and WPCK loaded on the same factor, resulting in 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 more general measurement of TPACK.

Although progress has been made, there is no widely accepted and generally applicable instrument for measuring teachers' TPACK. If TPACK is to be a key outcome of teacher preparation and professional development it is highly desirable to have a reliable and valid measure with which to assess its development. Hence this paper reports on the development and validation of an instrument that appears to have the required characteristics.

Method– development of the Teaching With ICT Audit Survey (TWictAS)

The *Teaching With ICT Audit Survey (TWictAS)* was developed to audit the TPACK capabilities of final year teacher education students at two universities in Queensland, Australia in 2009. Both universities have multiple campuses and the students who were surveyed were representative of all 6 campuses from the two universities. The students were asked to voluntarily complete the *TWictAS* online in August 2009 and 345 completed surveys were obtained. Participants were soon to graduate from either early childhood, primary, secondary or special education specializations and 79% were female which is consistent with the teaching profession generally in Queensland.

From an extensive review of the recent literature pertaining to the definition and measurement of TPACK (Angeli & Valanides, 2009; Archambault & Crippen, 2009; Graham, Burgoyne, et al., 2009; Graham, Cox, & Velasquez, 2009; Lee & Tsai, in press; Schmidt, et al., 2009) and from an investigation of the theoretical framework underpinning an existing instrument it was determined that a strong claim could be made that the *Learning With ICTs: Measuring ICT Use in the Curriculum* instrument could potentially measure two dimensions of TPACK, namely enhancing and transforming the curriculum through ICT integration. Table 1 displays the final 20 items and 2 factors of the *Learning With ICTs: Measuring ICT Use in the Curriculum* instrument (Authors, 2007).

The statistical validation and reliability of this instrument has been extensively reported in the literature and the instrument has been used in several well documented large-scale studies over the past 5 years to evaluate the quantity and quality of ICT integration in Queensland schools (Authors, 2006a; 2006b; 2007; 2009). For the purpose of this paper only a brief summary of the development of the instrument will be provided.

Initially, a suite of 137 items was generated, based on a matrix configured from the four *Productive Pedagogy* dimensions and the *New Basics* curriculum organizers (Lingard et al., 2001). The sentence stem, "*In my class* ***students use*** *ICTs to*" was used to generate all 137 items. This decision was made to ensure that the instrument's structure clearly defined successful professional performance with respect to ICT integration specifically in relation to the quantity and quality of *use* of ICT experienced by students rather than teachers (DEST, 2002). Hence, the instrument purposely measured the extent to which students used ICT in productive ways across the curriculum. A four-point Likert-style response scale was initially used (Never, Sometimes, Often, and Very Often), to gauge the frequency-of-use of ICT by students, as reported by their teachers. Factor analysis using Principal Axis Factoring (PAF) with Oblimin rotation (SPSS 13) was used to determine the factor structure of the instrument. The analysis produced a simple and conceptually robust two-factor solution, in which the first two theoretical dimensions of use clustered together as one factor while the second two theoretical dimensions of use clustered together as a second factor. That is, 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)

The authors contend that as each item in this instrument is asking teachers to indicate how frequently their students in their class use ICT to undertake each of the learning tasks, that the instrument is measuring the teachers' technology (T) knowledge, as without knowledge of the available ICT teachers would not be able to facilitate the use of ICT by students. It can therefore be argued that, unless teachers had a reasonable level of technology knowledge, then their students would not be able to undertake these classroom learning tasks with ICT. Further, teachers who indicate that their students use ICT Often or Very often to undertake these learning tasks are also indicating that they have the pedagogical (P) knowledge in order to facilitate the students' learning with ICT Often or Very Often in their class. Thus, this instrument, originally designed to measure ICT curriculum integration in classrooms, we contend, could also be used to measure the T and P of TPACK.

Also, teachers who indicate that their students Often or Very often use ICT to undertake the listed curriculum tasks, would most certainly have a commensurate level of curriculum content (C) knowledge 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 believe 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 - 'the total package' (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 a measure of student outcomes as a result of the teachers' TPACK.

In addition to the scale described above which is proposed to measure teachers' TPACK, *The Teaching With ICT Audit Survey (TWictAS)* 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. Table 2 displays the interest in, attitudes towards, confidence with and access to ICT items from the *TWictAS* instrument. Table 3 displays the *TWictAS* ICT applications competency items and digital technology knowledge (TK) items. Table 4 displays the items and alpha coefficients from the *TPACK Vocational Self-efficacy* scale which was validated with the data obtained from the audit of 345 graduating pre-service teachers.

Interest in and Attitudes toward using ICT (please choose the appropriate response for each item):	Not at all	Some extent	Great extent	Very great extent
To what extent are you interested in using ICT for personal purposes?				
To what extent are you interested in using ICT for teaching and learning purposes?				
To what extent do you use ICT for personal purposes?				
To what extent do you use ICT for teaching and learning purposes?				
To what extent do you believe that ICT can improve student learning outcomes?				

Confidence in using ICT with school students for teaching and learning (please choose the appropriate response):	Very little confidence	Some confidence	Confident	Very confident
How confident do you feel about using ICT with students for teaching and learning?				

Access to ICT and the Internet (please choose the appropriate response for each item):	Yes	No
Do you have your own computer?		
Do you have regular access to broadband Internet?		
Do you have access to mobile computing devices such as a 3G mobile phone or iPhone?		

Table 2: Interest in, attitudes towards, confidence with and access to ICT items from the *TWictAS* instrument

Please rate your **competence** to use each of the following ICT Applications				
ICT Applications (Examples of Software)	No Competence	Some Competence	Competent	Very Competent
Word Processing (e.g. Microsoft Word)				
Desktop Publishing (e.g. Microsoft Publisher)				
Presentation Software (e.g. Microsoft Power Point)				
Spreadsheets (e.g. Microsoft Excel)				
Databases (e.g. Microsoft Access, Filemaker)				
Graphics creation and/or editing (e.g. Paint Shop Pro, Adobe Photoshop)				
Digital image capture (e.g. by Digital camera, scanning)				
Multimedia Development and Authoring				
(e.g. Director, Flash)				
Visual Thinking Software (e.g. Inspiration, Kidspiration, CMap)				
Digital Video Editing (e.g. iMovie, Adobe Premiere, MovieMaker)				
Email (e.g. Microsoft Outlook, Gmail, Lotus)				
Web Browsers (e.g. Internet Explorer, Netscape, Safari, Firefox)				
Web Searching (e.g. Google)				
Web Page Development (e.g. Dreamweaver)				
Web 2.0 and Social Networking (e.g. Facebook, MySpace, Flickr, Twitter, YouTube, Nings)				
Online learning management systems (e.g. Blackboard)				
Online publishing (e.g. blogging, podcasts, YouTube)				
Access repositories of reusable learning objects				
Create reusable learning objects				
Other (please specify):				
Please rate your **competence** against each of the following statements				
Digital Technologies (ICT) Competence	No Competence	Some Competence	Competent	Very Competent
I am comfortable using digital technologies.				
I learn about new digital technologies easily.				
I keep informed about new digital technologies.				
I know how to solve my own technical problems.				
I have the technological skills I need to use digital technologies to achieve personal goals.				
I have the technological skills I need to use digital technologies to achieve professional				

(teaching and learning) goals.				

Table 3: Technological Knowledge (TK) - ICT Applications and Digital Technology Knowledge

The Professional Capabilities of the ICT Vocational Self-efficacy Scale		Factor Loading
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	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
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
Professional Relationships:		
4	I will be able to use ICT to communicate with others for professional purposes.	.93
	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
Professional Practice:		
6	I will be able to provide opportunities for students to use ICT as part of their learning.	.95
7	I will be able to provide opportunities for students to use ICT to gather information and to communicate with a known audience.	.95
8	I will be able to manage the access to and use of ICT resources in meeting student learning needs.	.93
9	I will be able to use a range of ICT resources and devices for professional purposes.	.95
10	I will be able to use ICT to locate, create and record information and resources.	.96
11	I will be able to store, organise and retrieve digital resources.	.95
12	I will be able to use ICT to access and manage information about student learning.	.95

Table 4: Items with Varimax Rotated Factor Loadings for the *TPACK Vocational Self-efficacy* scale of the *Teaching With ICT Audit Survey (TWictAS)* (N=345)

The 12 items of the *TPACK Vocational Self-efficacy* scale in Table 4 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).

As the 12 items were hypothesised 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 a decision was made to tolerate the highly correlated items in the scale.

Conclusion

This paper has described the development and empirical validation of a new instrument to measure teachers' TPACK. The *Teaching With ICT Audit Survey (TWictAS)* provides a valid, reliable and multi-dimensional instrument with which to audit teachers' TPACK.

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