INFORMING THE DESIGN OF TEACHER EDUCATION PROGRAMS: THE NEED FOR DEVELOPING TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE

Associate Professor Glenn Finger
Dr Helen Klieve
Wayne Lang
Dr Sarah Prestridge
Dr Jason Zagami
Faculty of Education
Griffith University, Queensland, Australia

Abstract

This paper challenges the assumptions that have informed the design of teacher education programs which have focused on the development of content knowledge and pedagogical knowledge. It remains elusive to convince some teacher educators and teacher education authorities that teacher education programs designed using pedagogical content knowledge (PCK) is no longer adequate in the 21st Century. The authors argue that the conceptualisation of technological pedagogical content knowledge (TPCK) and now referred to as TPACK (Mishra & Koehler, 2006, 2008: AACTE, 2008) is both appropriate and essential to inform teacher education. Through a summary of a 2009 TPACK audit of final year teacher education students, this paper demonstrates the need for a stronger emphasis in programs to develop the TPACK confidence of future teachers.

Introduction – TPACK: Beyond PCK

This paper argues that pedagogical content knowledge (PCK) (Shulman, 1986: 1987) is no longer adequate for teaching in the 21st Century. Few, including Shulman who conceptualised PCK well before the transformational impact of the Internet, could have imagined the technologies now available for use in teaching and learning. The authors argue that technological pedagogical content knowledge (TPCK) (Koehler & Mishra, 2007; Koehler, Mishra & Yahya, 2008; Mishra & Koehler, 2006; 2008: AACTE, 2008) needs to be drawn upon in the development of professional standards for teachers, and the design of teacher education programs to ensure that graduates have the essential TPACK confidence and capabilities needed in a digital age.

It should be noted that 'Technology' is appropriately defined more comprehensively than Mishra and Koehler's reference to 'technology' referring to information and communication technologies (ICT), which is often the case in the United States. Therefore, for this study and the purpose of this paper, technological knowledge (TK) refers to knowledge relating to ICT which includes digital technologies such as computers, software, iPods, digital cameras, handheld mobile devices, interactive whiteboards, and the Internet.

This paper outlines TPCK, now more commonly referred to as TPACK, which refers to 'the total package' for teaching in the 21st Century, and proceeds to propose a conceptualisation relevant to teacher preparation and professional standards in Queensland, Australia. That conceptualisation acknowledges the context of professional standards (Queensland College of Teachers, 2009), continuing

professional development, and the *Smart Classrooms Professional Development* framework (DET, 2010). Subsequently, a summary of the development and administration of a *TPACK Confidence Survey* is outlined. The *TPACK Confidence Survey* was administered to final year preservice teachers in a range of programs at a Metropolitan University in Queensland, Australia. The findings of that survey are discussed, and implications drawn from those findings are presented.

The Aim of the Study
The study investigated the Technological Pedagogical Content Knowledge (TPACK) of teacher education students in their final year of study in their respective programs. Data were collected through the administration of an online survey using LimeSurvey to gather information that would:

a) identify the Technological Pedagogical Content Knowledge of students who are in their final semester/year of the preservice teacher education programs; and

b) inform the future design of the teacher education programs to enhance TPACK of the teacher education students.

PCK, TPACK and the QCT Professional Standards
Shulman made a significant contribution to teacher education by proposing that discipline knowledge by itself was insufficient for teaching. To illustrate, according to Shulman, teachers need to understand the learner, and have deep understandings of theories of learning, curriculum, pedagogy and assessment. According to more recent work by Chick and Harris (2007) there are instances where the act of teaching can be seen as content knowledge being taught in a pedagogical context, and there are examples of pedagogical knowledge in a content context. PCK provides the conceptual guidance that teaching involves transforming content knowledge so that it is accessible by the learner.

Since 1986, PCK (Shulman, 1986) has been acknowledged as important for informing the design of teacher education programs, and PCK and is evident in Professional Standards for teachers throughout the various Australian States and Territories. For example, in Queensland, the Queensland College of Teachers (QCT, 2009) explicitly state ten standards for graduates to be able to demonstrate. For Higher Education Institutions (HEI's) to obtain program approval (QCT, 2009), HEI's must demonstrate how the program of study will develop and assess those standards. Those standards emphasise the importance of future teachers having appropriate discipline content knowledge and pedagogical knowledge to enable the teaching of the various curriculum learning areas.

Closer analysis of those standards, which are organised according to Professional Knowledge, Professional Practice, and Professional Values, also reveals that they have inherent in them the expectation of teachers using ICT for teaching and learning. It is implicit in the standards and their supporting information, that a graduate must demonstrate Professional Knowledge and Professional Practice appropriate for the digital age. To illustrate with some examples, in relation to Professional Knowledge and Professional Practice, graduates are expected to know:
> **Professional Knowledge**
> *Standard One*

K1.8   ways of identifying, evaluating and selecting teaching, learning and assessment strategies, resources and technology

K1.9   effective teaching, learning and assessment strategies and resources where ICT is embedded

Standard Two

K2.11 how ICT supports, enhances, enables and transforms language, literacy and numeracy expectations and development

Professional Practice

Standard One

P1.5 identify and use teaching, learning and assessment strategies and resources in which ICT is embedded

Standard Two

P2.4 identify, select and use teaching and learning strategies and resources that build on and support the development of students' language, literacy and numeracy skills. (QCT, 2009)

In the international literature, we believe that Mishra and Koehler (2006; 2008) have made a significant contribution by articulating and conceptualising TPCK (now commonly referred to as TPACK). Their work has subsequently been built upon through research studies (see, for example, Jamieson-Proctor et al., 2010, Finger et al., 2010, Finger & Jamieson-Proctor, 2010, Archambault, & Crippen, 2009, Sahin et al., 2009, Terpstra, 2009). We propose that some of QCT professional standards can be identified as TPACK capabilities, and the QCT contextualises TPACK within the professional standards, and DET does similarly with the *Smart Classrooms Professional Development Framework*.

Design of the Study

For Koehler and Mishra (2005), TPACK involves an understanding of the interrelationships between complexity of relationships between content knowledge (curriculum learning areas), technological knowledge (such as computers, Web 2.0 technologies, interactive whiteboards, software applications, etc), and pedagogical knowledge (such as teaching strategies informed by theories of learning).

This addresses the limitations of those who see ICT merely as a values neutral learning tool 'to be integrated' into existing practices and curriculum. We know that ICT is more than this, and TPACK acknowledges that new and emerging ICT transforms 'traditional' information age models of teaching. Archambault and Crippen (2009) make the point strongly, in examining how teachers should be prepared to teach in online environments, by suggesting that:

> *TPACK addresses each of the three major components needed to ensure high quality instruction. This lens offers a way for teacher education programs to begin looking at how these elements are currently covered and how they would need to be altered to specifically meet the needs of teachers entering online classrooms.* (Archambault & Crippen, 2009, p. 1)

However, Archambault and Crippen (2009) caution that, while creating the concept of TPACK by adding the element of technology to Shulman's notion of PCK "makes sense on the surface, it remains to be determined if knowledge in each of these domains truly exists and, if so, how these elements can be accurately measured" (p. 1). Therefore, this study also sought to make a contribution by developing a TPACK

Confidence Survey which attempted to obtain information about final year teacher education students' Technological Knowledge (TK) levels of confidence and their TPACK levels of confidence.

TPACK Confidence Survey

More extensive description of the *TPACK Confidence Survey* instrument can be found elsewhere (see Jamieson-Proctor et al., 2010), and included items from the *Learning with ICT: Measuring ICT Use in the Curriculum* instrument (Jamieson-Proctor, et al., 2007), which measures two statistically validated dimensions of TPACK, namely *enhancing* and *transforming* the curriculum through ICT use.

Items measuring pre-service teachers' technology knowledge (TK) were updated from the earlier work undertaken by Watson et al. (2004). Items were also included which incorporated the ICT Certificate expectations (DET, 2010) which are being encouraged to be achieved by teacher education graduates in Queensland.

For undertaking the data analysis, the Statistical Package for the Social Sciences was used to calculate descriptive statistics, and to undertake further analysis, as discussed in the following sections, which presents a summary of the findings.

Demographic Information – Gender, Age, Program and Confidence

The participant in this study were final year teacher education students at a Metropolitan University in Queensland, Australia., and responses were obtained from 199 final year preservice teacher education students. The following summary of findings is drawn from their responses.

Table 1 provides demographic information about the sample studied, in relation to gender, age, program studied, and confidence in using ICT with school students for teaching and learning.

Table 1: Demographic information (N=199)

	No	%
Gender:		
Male	40	20.1
Female	159	79.9
Age:		
<29	114	57.3
30-39	50	25.1
40-49	28	14.1
50+	7	3.5
Program Type:		
Metropolitan -Bachelor of Education (Primary) (includes early childhood)	65	18.9
Metropolitan -Bachelor of Education (Secondary)	18	5.2
Metropolitan -Bachelor of Education (Special Education)	14	4.1
Metropolitan -Graduate Diploma of f Education (Primary)	36	10.4
Metropolitan -Graduate Diploma of Education (Secondary)	63	18.3
Metropolitan -Double Degree	3	.9
Confidence to use ICT with school students for teaching and learning:		
Very Little Confidence	10	5.0
Some	69	34.7
Confident	85	42.4
Very Confident	35	17.6

The demographics of this group indicate that the majority were female (79.9%) with a range of ages from under 29 (57.3%) to 50+ years (3.5%). Despite being in their final year, almost 2 out of every 5 students indicated that they had either 'very little confidence' (5%) or only 'some' confidence (34.7%) in using ICT for teaching and learning.

Summary of the Findings and Discussion

Computer Ownership and Internet Access
Students were asked to indicate their perceived technological knowledge (TK), and they showed a high level of familiarity with basic ICT and the Internet with 197 (99%) reporting that they owned a computer and had regular broadband access, but only 81 (40.7%) reporting access to mobile computing devices. There was also a relatively high reported interest in and positive attitude toward the use of ICT with 77.9% reporting interest to a Great or Very Great Extent in using ICT for personal purposes, with only 1 (0.5%) respondent expressing no interest.

This interest extended to their view of the role of ICT in education with 106 (53.3%) reporting the use of ICT for teaching and learning to a Great or Very Great Extent. An even stronger response of 177 (89.0%) was gained with regard to the perception of the belief that ICT could improve student learning outcomes with ranking.

Perceived ICT Competencies
The survey also asked the respondents about their perceived ICT competencies. Students rated their perceived competencies with a range of digital technologies (see Table 2), providing a picture of a diversity of capability with these various applications and technologies. The average level of competency for each item was between 2 and 3, thus between "Some Competency" and "Competent".

Table 2: Perceived technological knowledge (TK) of digital technologies (N=193)
Scale: 1 to 4, where 4 is very confident

	No Competence	Some	Competent	Very Competent	Mean (SD)	Males: Mean (SD)	Females : Mean (SD)
I am comfortable using digital technologies	3.6	29.0	47.7	19.7	2.83 (.78)	3.03 (.65)	2.79 (.80)
I learn about new digital technologies easily	6.7	33.2	40.9	19.2	2.73 (.85)	2.97 (.88)	2.67 (.84)
I keep informed about new digital technologies	16.6	44.6	28.5	10.4	2.33 (.87)	2.69 (.92)	2.24 (.84)
I know how to solve my own technical problems	18.7	47.4	25.4	8.3	2.23 (.85)	2.67 (.86)	2.13 (.82)
I have the technological skills I need to use digital technologies to achieve personal goals	8.8	30.6	45.1	15.5	2.67 (.94)	2.94 (.79)	2.61 (.85)

I have the technological skills I need to use digital technologies to achieve professional (teaching and learning) goals	8.3	42.0	38.9	10.9	2.52 (.79)	2.69 (.71)	2.48 (.81)

However, the data suggest that most teacher education students had competency in a limited range of applications, and some students self-identified as having no competencies in some applications. For example, in relation to *"I know how to solve my own technical problems"*, 18.7% reported no competency and another 47.4% that they only have "some" competency – a total of 66.1% with very limited or no competency in this area. While the most positive response was to the first item *"I am comfortable using digital technologies"*, 32.6% reported a very low level of competence. It should also be noted that females consistently had a lower average score on each item – suggesting, on average, a lower perceived competence – but with a relatively high level of variation in this report (given the far higher sample size of females to males).

It is interesting also to capture the actual familiarity of the sample with different technology applications. Figure 1 summarises identified levels of competencies, by gender, for a range of ICT applications - on against a Scale of 1: No Competence to 4: Very Competent. This shows a very wide range of competencies with the highest in applications such as word processing email, web browsing and web searching and the lowest in multimedia, Visual Thinking Software and Web Page Development. While the reported levels of competence were relatively similar for males and females, females reported a slightly higher level of competence in word processing, presentation software, emails and social networking systems, males appeared to have a greater level of competence in some of the less familiar applications such as Visual thinking software, multimedia and databases.
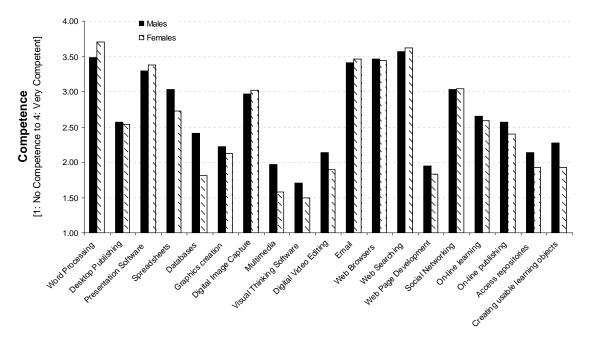

Figure 1: Stated level of competence (on a 1-4 scale) for a range of ICT applications by gender - males (n=37) and females (n=157).

Confidence with ICT Integration – Technological Pedagogical Content Knowledge (TPACK)

In summarising the response to TPACK items, Table 3 data show considerable variation between competencies with 25.9% feeling highly competent to *"communicate with others locally and globally",* but only 7.4% felt very confident about whether they could *"understand and participate in the knowledge economy".*

The TPACK 20 item scale has been shown to contain 2 strong factors (as identified in the above table 1.1-1.14 and 2.1-2.6). An assessment of these items (using a Reliability Analysis) supported this, with high levels of reliability (in excess of the normal threshold level of a Cronbach's α of .70) with reliabilities of α=0.97, and α=.91 on Factor's 1 and 2 respectively. By constructing Factor variables through summing scale items, and recalling to a 1-4 score, 2 scores representing individuals' scores on the TPACK factors, facilitated a comparison of TPACK performance against other variables.

While no significant difference was found in responses by gender (F1: t=.645, F2: t=-.016) a significant difference was found on Factor 1 against age (using 3 groups: <29, 30-39 and 40+ years) (F1: $F_{2,186}$=3.390, p=.021) and a very highly significant difference was found against reported levels of confidence in using ICT in teaching and learning (Q8) (F1: $F_{3,185}$=48.136, p<.000; F2, $F_{3,185}$=.55.507, p<.000) with *post hoc* tests showing highly significant differences consistent with levels of confidence – thus those with the most confidence had significantly higher TPACK scores.

Table 3: Perceived confidence to integrate ICT into student learning (TPACK) (N=199)

In my class I could support *students'* use of ICT to:	Very little confidence	Some confidence	Confident	Very Confident	Mean (SD)
1.1 acquire the knowledge, skills abilities, and attitudes to deal with ongoing technological change	7.4	34.9	48.1	9.5	2.60 (.76)
1.2 develop functional competencies in a specific curriculum area.	3.2	33.3	50.8	12.7	2.73 (.72)
1.3 synthesise their knowledge.	5.3	31.2	52.9	10.6	2.69 (.73)
1.4 actively construct their own knowledge in collaboration with their peers and others.	5.8	30.7	48.1	15.3	2.73 (.79)
1.5 actively construct knowledge that integrates curriculum areas.	3.7	38.1	44.4	13.8	2.68 (.75)
1.6 develop deep understanding about a topic of interest relevant to the curriculum area(s) being studied.	3.2	27.0	54.0	15.9	2.83 (.73)
1.7 develop a scientific understanding of the world.	6.9	34.9	47.1	11.1	2.62 (.77)
1.8 provide motivation for curriculum task.	3.7	21.2	57.7	17.5	2.89

					(.72)
1.9 plan and/or manage curriculum projects.	5.8	31.7	50.8	11.6	2.68 (.75)
1.10 integrate different media to create appropriate products.	10.1	29.1	47.1	13.8	2.65 (.84)
1.11 engage in sustained involvement in curriculum activities.	5.3	37.0	47.1	10.6	2.63 (.74)
1.12 support elements of the learning process.	2.1	27.0	55.6	15.3	2.84 (.70)
1.13 demonstrate what they have learned.	4.2	22.8	56.1	16.9	2.86 (.74)
1.14 undertake formative and/or summative assessment.	3.2	29.6	51.3	15.9	2.80 (.74)
2.1 acquire awareness of the global implications of ICT-based technologies on society.	9.5	33.9	44.4	12.2	2.59 (.82)
2.2 gain intercultural understanding	7.4	31.7	48.7	12.2	2.66 (.79)
2.3 critically evaluate their own and society's values.	7.4	34.4	47.6	10.6	2.61 (.76)
2.4 communicate with others locally and globally.	3.2	20.1	50.8	25.9	2.99 (.77)
2.5 engage in independent learning through access to education at a time, place, and pace of their own choosing.	3.7	29.6	55.0	11.6	2.75 (.71)
2.6 understand and participate in the changing knowledge economy.	7.4	39.7	45.5	7.4	2.53 (.74)

Finally, an assessment of individuals' TPACK Factors was made against the stated confidence on achieving the values included in the *Smart Classroom Professional Development Framework* capabilities, reported in Table 4, which represent the expected level of students leaving the university to begin teaching. It is apparent from Table 4 that there is a very strong alignment between students' responses on the TPACK scale and their perceived capabilities on this Framework. Therefore, TPACK provided a reliable indicator of how students might perform in their future teaching, against expected performance standards. The use of this model provides a good early indicator of learning needs within the context of the teacher education program.

Table 4: Results from ANOVA reporting on relationship between levels of confidence in Smart Classroom Professional Development Framework and TPACK Factors.

	Factor 1		Factor 2	
	$F_{3,180}$	P	$F_{3,80}$	P
Professional Values				
As a life-long learner, I will be able to set my own short and long term learning goals based on my regular reflection of my own professional practice and determined needs. I will be able to devise and enact a plan to achieve these.	45.127	<.000	44.905	<.000
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.	29.837	<.000	28.298	<.000
I will be able to operate safely, legally, ethically and in accordance with departmental policy when using digital resources and technologies and online environments. I will be able to teach and model these practices with students and colleagues	33.603	<.000	27.001	<.000
Professional Relationships				

I will be able to use ICT to communicate with others for professional purposes	40.450[+]	<.000	40.447[+]	<.000
Professional Knowledge				
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 in itself	28.116[++]	<.000	22.397[++]	<.000
Professional Practice				
I will be able to provide opportunities for students to use ICT as part of their learning	50.095[++]	<.000	37.221[++]	<.000
I will be able to provide opportunities for students to use ICT to gather	52.826	<.000	36.974	<.000
I will be able to manage the access to and use of ICT resources in meeting student learning needs	50.056	<.000	39.340	<.000
I will be able to use a range of ICT resources and devices for professional purposes	44.523	<.000	30.514	<.000
I will be able to use ICT to locate, create and record information and resources	44.753[++]	<.000	33.326[++]	<.000
I will be able to store, organise and retrieve digital resources	32.829	<.000	25.454	<.000
I will be able to use ICT to access and manage information about student learning	39.882	<.000	31.931	<.000

[+] Note that the df are 2, 181 as no responses were recorded on Very Little Confidence

[++] Note that while df=3,180 - but only 1 response in Very Little Confidence, so no post hoc analysis undertaken

This very close alignment found between students' responses on the TPACK scale and their perceived capabilities on the *Smart Classrooms Professional Development Framework* was explored more deeply for one standard of Professional Practice, and the results are displayed in Table 5. An ANOVA assessing the mean Factor scores for those with different levels of confidence was undertaken. This showed significantly different factor scores (aligned to the 1-4 confidence levels on TPACK) for each level of confidence, with the highest factor scores related to the greatest level of confidence on the standard thus those with a very low confidence in achieving this Professional Practice standard (n=5) had a mean score on Factor 1 of 1.34, and 1.33 on Factor 2, significantly lower than the score of those with "some confidence" (n=47), having scores of 2.33 and 2.34 respectively.

Table 5: ANOVA results: differences in TPACK Factor scores (scaled to a 1-4 measure) for differing confidence in Smart Classroom Professional Development Framework Standards

Professional Practice : *I will be able to manage the access to and use of ICT resources in meeting student learning needs*		N	Mean (SD)	ANOVA Results
Factor 1	Very Little Confidence	5	1.34 (.34)	Very highly significant difference between responses : Factor 1: F $_{3,180}$ = 50.056, p<.000 Post hoc results – all levels significantly different[#]
	Some Confidence	47	2.33 (.52)	
	Confident	99	2.77 (.43)	
	Very Confident	33	3.42 (.51)	
Factor 2	Very Little Confidence	5	1.33 (.31)	Very highly significant difference between responses : Factor 2: F $_{3,180}$ = 39.340 p<.000 Post hoc results – all levels significantly different[#]
	Some Confidence	47	2.34 (.57)	
	Confident	99	2.70 (.47)	
	Very Confident	33	3.37 (.52)	

[#] Bonferroni post hoc results : all means different - thus "V Confident" > "Confident" > "Some Confidence" > "V Little Confidence"

Disturbingly, the data for Professional Practice (see Table 5) suggest that more than 50 of the 199 students studied, or approximately 2 out of every 5 teacher education students about to graduate have either *"Very Little Confidence"* or *"Some Confidence"* to be *"able to manage the access to and use of ICT resources in meeting student needs"*. Given that many of these students have undertaken considerable studies, assessment tasks, and professional experience throughout their teacher education programs, we infer that those programs have not ensured that all graduates have TPACK confidence. We suggest that the programs which have been designed to include stand alone ICT courses, and designed using PCK have been inadequate. Questions emerge relating to why other curriculum courses and professional experiences in schools have not assisted in 40% of those about to graduate not having the confidence expected of future teachers.

Conclusion

This paper presented the importance of TPACK and the need to go beyond PCK. We suggested that the current QCT professional standards inherently expect approved teacher education programs in Queensland to develop graduate TPACK capabilities in using ICT with their students in teaching and learning. A conceptualisation incorporating relevant QCT standards for Professional Knowledge and Professional Practice which could be considered to align with TPACK capabilities. Subsequently, the methodology which involved the online administration of a TPACK Confidence Survey developed for the study was summarised. Findings from our quantitative data analysis relating to TK and TPACK confidence clearly suggest that PCK is no longer adequate in designing teacher education programs to produce graduates with the capabilities expected of them for teaching in the 21st Century.

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