

AUDITING THE TPACK CAPABILITIES OF FINAL YEAR TEACHER EDUCATION STUDENTS: ARE THEY READY FOR THE 21ST CENTURY?

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Abstract

The expectations for teacher education graduates having appropriate information and communication technology (ICT) capabilities to meet the challenges of learning and teaching in the 21st century are widely accepted. However, it should not be assumed that tomorrow's teachers will enter their profession with those ICT capabilities. The conceptual framework of Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006, AACTE Committee on Innovation and Technology, 2008) was used to guide the study undertaken in 2009 of final year students in two Universities in Queensland, Australia. The findings are compared with those reported in an earlier study (Watson et al., 2004) which found that there was a limited band of applications with which the participants expressed high levels of competence. Importantly, high percentages of participants perceived themselves to have no competence with applications such as multimedia development, visual thinking software and digital video editing which could be particularly stimulating for learning outcomes in their future students. Furthermore, participants' self-perception of their confidence to integrate ICT into student learning also revealed that the percentage of participants who rated themselves as having no or limited confidence with particular integration examples was of concern. This paper provides a summary of some of the findings of the TPACK capabilities of the student teachers studied in 2009, which reveal important insights to inform the review and design of teacher education programs to more directly address TPACK capabilities. The study suggests that teacher education programs tend to have been designed using Pedagogical Content Knowledge (PCK) (Shulman, 1986, 1987) where students undertake studies in a range of curriculum (content, disciplinary) courses, pedagogy courses, and professional studies (practicum, Internship) courses, and this is now insufficient as TPACK capabilities are needed.

Context of the Study - Quality Teaching Agenda and TPACK Capabilities

The quality teaching agenda has been a strengthening theme at all levels of education systems throughout Australia. Underpinning this is the evidence-based research demonstrating that quality teachers are the most important determinant of high-level student learning outcomes. For example, the McKinsey report (Barber & Mourshed, 2007) indicated that "The quality of an education system cannot exceed the quality of its teachers" (p.7). This clearly translates to high expectations for preservice teacher education programs to nurture and produce quality teachers.

Accompanying the quality teaching agenda has been the positioning of teacher education to capitalise upon the technological potential and expectations for teaching in the 21st century. This is best illustrated by the *Digital Education Revolution* with funding of more than \$2 billion as a major policy component of the Australian Government's *Education Revolution* which will contribute to sustainable and meaningful change to teaching and learning in Australian schools aimed at preparing students for further education, training and to live and work in a digital world (DEEWR, 2008).



The design of most teacher education programs in Australia continue to be informed by Shulman's influential work in the late 1980's in which he explored the concept of pedagogical content knowledge (PCK) (Shulman, 1987). Few, including Shulman, could have envisioned the transformational technological developments which have occurred since then. When Shulman was devising PCK, computers were making an appearance in schools, but the Internet and many of the subsequent uses of technologies for teaching – eLearning, mLearning, blended learning, Web 2.0 technologies, and uLearning – were yet to emerge. Most Australian States and Territories have focused on the development of standards for teachers, including standards which refer to information and communication technologies (ICT). For example, the ten professional standards developed by the Queensland College of Teachers (QCT, 2009) refer to ICT capabilities, along with references to pedagogical content knowledge.

Approximately 20 years on from Shulman's description of PCK, Mishra and Koehler (2006) have proposed technological pedagogical content knowledge (TPCK) as a framework for teacher knowledge with respect to teaching with ICT. They argue that “at the heart of good teaching with technology are three core components – content, pedagogy, and technology and the relationships between them” (Mishra & Koehler, 2008, pp. 11-12). TPCK has become more commonly referred to as TPACK – the ‘total package’ for teachers in the 21st century – enabling an understanding of how 21st century “teachers’ understandings of technologies and pedagogical content knowledge interact with one another to produce effective teaching with technology” (Koehler & Mishra, 2008, p. 12).

Aim of the Study

The question needs to be asked: How well are teacher education programs preparing graduates to have TPACK capabilities? This paper presents a summary of an audit of the Technology Knowledge (TK) and TPACK capabilities of final year preservice teacher education students in two Queensland Universities - both with multiple campuses, with one considered a metropolitan university and one considered to be a regional university.

Pre-service and Early Career Teacher Education Research

There have been considerable studies which have explored preservice teacher education programs and early career teachers in relation to their ICT confidence and capabilities. For example, Owen and Moyle (2008), in presenting a synthesis of research into teacher education and early career teachers, note the student self-reporting study by Markauskaite et al. (2006) which found that student teachers generally had good basic IT skills such as being able to use word processing and presentation software, and to access and use email and the Internet, but were less confident with applications such as webgroup discussions and webpage design. From their analysis, Owen and Moyle make the link between the attitudes and beliefs of pre-service and early career teachers in determining their actual practice and their capacity to learn new skills.

Various studies of pre-service teachers, such as those by Albion (2003) highlighted the trend of increasing access to computers and the Internet, but also demonstrated that this increased access was accompanied by uneven confidence in skills of preservice teachers. For example, while there was an increase in self-reported basic IT skills, their self-reported skills about databases and spreadsheets usage remained relatively unchanged. Albion also reported that webpage design, online discussion groups, virtual excursions, data loggers, and handheld computers were rarely used. Owen and Moyle (2008) highlight the study of early career teachers by Dawson (2008) which reported the following as being positive influences on early career teachers' use of ICT - positive beliefs about the value of ICT in learning (79%), school culture (73%), the early career teachers' confidence (70%), and ICT skills of the teacher (73%). Internationally, studies have been undertaken using the TPACK conceptualisation and are now appearing in the International literature (Koehler, et al., 2007; AACTE Committee on Innovation and Technology, 2008; Cox, 2008). However, to date, no studies in Australia have explicitly used the TPACK conceptualisation, and this study represents an early exploration of TPACK capabilities of pre-service teachers in two Queensland Universities.



METHOD

Instrument

The *Teacher ICT Audit Survey* used in this study is a new instrument developed in 2009 and designed to include pertinent elements from previous surveys including the statistically robust 20 item *Learning with ICT: Measuring ICT Use in the Curriculum* instrument (Jamieson-Proctor et al., 2005), which arguably measures two dimensions of TPACK, namely *enhancing* and *transforming* the curriculum through ICT integration. Items were also included from a previous pre-service teacher *ICT Audit Survey* (Watson et al., 2004) which measure Technology Knowledge (TK) in order to compare the confidence and competence of the pre-service teachers surveyed in 2003 with the soon-to-be teachers in this study. Finally, new items were created based on a scan of the recent literature to be representative of TK and TPACK as it is currently conceptualized and which were not contained in the previous instruments.

The *Teacher ICT Audit Survey* elicited general demographic information regarding gender, age and program details. The survey also asked about the participants' current access to ICT and the Internet; their technology knowledge (TK) in relation to modern digital technologies; and their competence with a range of ICT applications on a four-point Likert scale from "no competence" to "very competent". The survey provided an opportunity for the pre-service teachers to compose open-ended responses to questions seeking feedback on the strengths and recommendations for improvement of their teacher education program for developing their confidence and competence to use ICT to enhance teaching and learning in classrooms after they graduate. The extent of the participants' interest in using ICT for both personal and professional purposes and the extent to which they believe ICT can improve student learning outcomes were also surveyed on a four-point Likert scale from "not at all" to "very great extent".

Subjects

The subjects were 345 final year pre-service teacher education students from two Queensland universities. Both universities have multiple campuses and the students who were surveyed were representative of all campuses from each university. The students were asked to voluntarily complete the *Teacher ICT Audit Survey* online in August 2009. The students surveyed were in their final semester of their teacher education program.

Table 1 displays the demographic information with respect to gender, university attended, program type by university, age of the pre-service teachers and their confidence to use ICT with school students for teaching and learning. As shown in the table, 79% of the pre-service teachers surveyed were female, which is consistent with the teaching profession generally in Queensland. Further, almost 48% of the pre-service participants were not recent school leavers with ages in excess of 30 years. The recent school leavers (<30 years) might have been expected to have had reasonable exposure to ICT at school, although it should not be assumed that all school leavers have extensively used ICT in their prior learning (Winship, 2001). With the exception of the Graduate Diploma programs in each university, the percentage of students in each major program type is reasonably similar (e.g., Secondary graduates are approximately equal to 5% of each cohort; Primary graduates are approximately equal to 20% if early childhood and primary are summed for the regional university as they together comprise the primary cohort of the metropolitan primary program). Finally, 63% indicated that they were confident or very confident in using ICT with school students for teaching and learning.



Table 1: *Demographic information detailing pre-service teacher numbers by gender, university attended, program type by university, age and confidence to use ICT with school students for teaching and learning (N=345)*

	Number	%
Gender:		
Female	273	79
Male	72	21
Total	345	100
University Attended:		
The Metropolitan University	199	57.7
The Regional University	146	42.3
Total	345	100
Program Type by University:		
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 Education (Primary)	36	10.4
Metropolitan - Graduate Diploma of Education (Secondary)	63	18.3
Metropolitan - Double Degree	3	0.9
Metropolitan University Total	199	100
Regional - Bachelor of Education (Early Childhood)	30	8.7
Regional - Bachelor of Education (Primary & Middle Schooling)	40	11.6
Regional - Bachelor of Education (Senior & Middle Schooling)	19	5.5
Regional - Graduate Diploma in Learning and Teaching	54	15.7
Regional - Bachelor of Education (Primary & Middle Schooling Honours)	3	0.9
Regional University Total	146	100
Age of Pre-service Teachers:		
Less than 20 years	4	1.2
20-29 years	177	51.3
30-39 years	90	26.1
40-49 years	61	17.7
50 + years	13	3.8
Total	345	100
Confidence to use ICT with school students for teaching and learning:		
No confidence	14	4.1
Some confidence	113	32.8
Confident	151	43.8
Very confident	67	19.4
Total	345	100

The results described in the following section of this paper aim to highlight the pre-service teachers' Technological Knowledge (TK) and Technological Pedagogical Content Knowledge (TPACK) in relation to their demographic characteristics listed in Table 1 and their confidence and beliefs about using ICT with students in classrooms. The results are compared with those obtained in a similar audit conducted in 2003 at the metropolitan university used in this study and reported in Watson et al., (2004). Data were analysed using SPSS V17. Chi-square tests were used to investigate relationships between the pre-service teachers' university attended, gender, age, program of study and their confidence and competence to use computers for both personal and professional (teaching and learning) purposes. Chi-square is a non-parametric test of significance suitable for nominal and ordinal data where the data are classified into discrete categories such as gender or confidence levels and then treated as frequencies. "Chi square tests hypotheses [sic] about the independence (or alternatively the association) of frequency counts in various categories" (Burns, 1990, p. 153). The following section will summarise the results for each analysis individually.



RESULTS

Availability of and interest in using ICT resources

The participants indicated very high levels of computer ownership (99.4%) and regular access to broadband Internet (96.5%). However, less than half (41.2%) indicated that they had access to mobile computing devices. Results were within 1% of difference for each university for computer ownership and access to mobile technologies. However, in respect to regular access to broadband Internet, the students at the regional university indicated that they have regular access 93% of the time while their metropolitan colleagues have regular access 99% of the time.

On the whole, the level of ownership of a personal computer and access to broadband Internet could be considered to be very high for both student cohorts. Further, these results are similar to the 2003 student audit results (Watson et al., 2004) where 99.5% of primary and 92.6% of secondary students had access to a computer, and 89.9% of primary and 80.9% of secondary students had Internet access in their home. However, it might be concluded from the 2009 results that the affordances for teaching and learning of mobile computing technologies for both student cohorts are still to be realised.

Results for interest in and perceived attitudes towards using ICT were also very similar to the 2003 audit results (Watson et al., 2004). Means were calculated using a 4-point Likert scale where a mean of 1 = Not at all; 2 = Some extent; 3 = Great extent; and 4 = Very great extent were used. The pre-service teachers surveyed in this study expressed strong *interest* in using ICT for personal purposes (M = 3.06); strong *interest* in using ICT for teaching and learning purposes (M = 3.25); extensive *use* of ICT for personal purposes (M = 3.01); a moderate level of *use* of ICT for teaching and learning purposes (M = 2.68); and a strong belief that computers can *improve* student-learning outcomes (M = 3.19). A Pearson Chi-square test of significance indicated no significant difference between the two universities in this study. An interesting finding here is the lower mean for the extent that the pre-service teachers actually use ICT for teaching and learning purposes in comparison to their belief in the value of ICT to improve student learning outcomes. The lower mean for use of ICT for teaching and learning purposes might be explained either by limited opportunities to integrate ICT when students are at practicum, or the fact that these respondents are pre-service teachers and have had limited opportunities to use ICT for teaching and learning with students.

Competence with digital technologies – Technology Knowledge (TK)

Table 2 displays the means (with Standard Deviations) for each of the six items that aimed to measure the graduating students' perception of their technology knowledge (TK). TK is a measure of competence with current digital technologies that affords individuals the ability to achieve both personal and professional goals with the available technologies. "It enables teachers to understand information technology, apply it properly, identify useful technologies, and continually adapt to changes in technology" (Koehler & Mishra, 2008). A 4-point Likert scale was used: 1=No Competence, 2=Some competence, 3=Competent and 4=Very competent and means were calculated to align with the scale. A Pearson Chi-square test of significance indicated no significant difference between the two universities on any of the items. As can be seen in Table 3, none of the items resulted in a high level (mean >3) of perceived competence from the graduating pre-service teachers and more than 10% of the soon-to-be teachers expressed no competence at all with keeping informed about new digital technologies or about being able to solve their own technical problems (Items 3 and 4).

Table 2: *Perceived competence with digital technologies – a measure of Technology Knowledge (TK) (N=345)*

	Technology Knowledge (TK) – Digital Technologies	Mean (SD)	% No Competence
1	I am comfortable using digital technologies.	2.76 (.96)	2.9
2	I learn about new digital technologies easily.	2.64 (.98)	5.2
3	I keep informed about new digital technologies.	2.28 (.99)	14.8



4	I know how to solve my own technical problems.	2.18 (.95)	16.2
5	I have the technological skills I need to use digital technologies to achieve personal goals.	2.61 (.98)	7.2
6	I have the technological skills I need to use digital technologies to achieve professional (teaching and learning) goals.	2.48 (.95)	7.0

Competence with ICT software applications - Technology Knowledge (TK)

Table 3 shows the range of applications for which participants were asked to rate their perceived competence; the mean (with standard deviation) for each of the applications; the percentage of participants who perceived themselves as having no competence for the particular application; as well as the mean score, standard deviation and % with no perceived competence for the student cohort audited in 2003 for comparison. A 4-point Likert scale was again used: 1=No Competence, 2=Some competence, 3=Competent and 4=Very competent. Means were calculated to align with this scale.

A Pearson Chi-square test of significance found a non-significant difference between the two universities for all applications except for 5 (Databases) and 16 (Online Learning). In both items the metropolitan university's mean was slightly higher than the regional university's mean (Item 5: 1.86 to 1.84; Item 16: 2.53 to 1.84). The difference in means for Online Learning may have resulted from poor item wording as the regional university does not use Blackboard which was the only example presented to the participants. They may simply not have known what Blackboard was as that university uses the Moodle environment.

As can be seen from the table, there has been little change in the perceived competence of graduating students between the two audits (2003 and 2009). Both groups expressed high levels (mean >3) of competence with word processing, presentation software, email, web browsers and web searching. Very low levels (mean <2) of competence were perceived for multimedia development and authoring, visual thinking software, digital video editing, and web page development at both audits. Further, students generally did not express a high level of competence (mean >3) for any of the applications that have evolved since the initial audit (Items 15-19) and in view of the access that pre-service and practicing teachers have to digital learning object repositories, predominantly paid for by state and National funds, the very low level of perceived competence with reusable learning objects is of particular concern.

Table 3: *Perceived competence with ICT applications*

		2009 (N=345)		2003 (N=285)	
Technology Knowledge - ICT Software Applications (<i>Examples of Software</i>)		Mean (SD)	% No Competence	Mean (SD)	% No competence
1	Word Processing (e.g. <i>Microsoft Word</i>)	3.51 (.89)	.6	3.61 (.56)	.4
2	Desktop Publishing (e.g. <i>Microsoft Publisher</i>)	2.47 (1.11)	16.8	2.70 (.99)	10.9
3	Presentation Software (e.g. <i>Microsoft Power Point</i>)	3.22 (.94)	1.2	3.01 (.92)	6.3
4	Spreadsheets (e.g. <i>Microsoft Excel</i>)	2.66 (1.05)	8.7	2.56 (.88)	9.5
5	Databases (e.g. <i>Microsoft Access, Filemaker</i>)	1.85 (.97)	37.1	2.06 (.89)	27.4
6	Graphics creation and/or editing (e.g. <i>Paint Shop Pro, Adobe Photoshop</i>)	2.03 (.97)	26.7	2.19 (1.00)	27.4
7	Digital image capture (e.g. by <i>Digital camera, scanning</i>)	2.92 (1.07)	5.8	2.35 (1.04)	23.9
8	Multimedia Development and Authoring (e.g. <i>Macromedia Director, Flash</i>)	1.59 (.89)	52.8	1.82 (.89)	42.1



9	Visual Thinking Software (e.g. <i>Inspiration, Kidspiration, CMap</i>)	1.50 (.89)	61.2	1.52 (.87)	65.3
10	Digital Video Editing (e.g. <i>iMovie, Adobe Premiere, MovieMaker</i>)	1.86 (1.06)	42.3	1.48 (.87)	65.6
11	Email (e.g. <i>Microsoft Outlook, Gmail, Lotus</i>)	3.36 (.97)	2.0	3.33 (.90)	4.2
12	Web Browsers (e.g. <i>Internet Explorer, Netscape, Safari, Firefox</i>)	3.38 (.94)	1.2	3.42 (.88)	2.8
13	Web Searching (e.g. <i>Google</i>)	3.50 (.89)	.3	3.45 (.78)	1.1
14	Web Page Development (e.g. <i>Macromedia Dreamweaver</i>)	1.73 (1.01)	49.6	1.92 (1.00)	38.9
15	Web 2.0 and Social Networking (e.g. <i>Facebook, MySpace, Flickr, Twitter, YouTube, Nings</i>)	2.90 (1.12)	9.6	NA	NA
16	Online learning (e.g. <i>Blackboard</i>)	2.24 (1.14)	27.8	NA	NA
17	Online publishing (e.g. <i>Blogging, Podcasts, YouTube</i>)	2.27 (1.06)	20	NA	NA
18	Access repositories of reusable learning objects	1.88 (1.0)	36.8	NA	NA
19	Create reusable learning objects	1.87 (1.02)	38.6	NA	NA

NB. NA = Not Available

Relationship between university attended, gender, age, program of study and confidence to use ICT with school students for teaching and learning

Using the Pearson Chi-square test of significance, a non-significant difference was found between the two universities with respect to the pre-service teachers' confidence to use ICT with school students for teaching and learning. Further, there were no significant differences in confidence by age of the participants. There was however a significant difference between male and female pre-service teachers with respect to their confidence to use ICT with students for teaching and learning, $\chi^2(3, N = 345) = 16.31, p = .001$. Female teachers were more likely to indicate No confidence or Some confidence, while male teachers were more likely to indicate that they were Very confident. Table 4 displays the frequencies for each category for male and female subjects.

This result appears to mirror that of previous studies involving 2652 Queensland teachers from both the state and Catholic systems (Jamieson-Proctor & Finger, 2008). Looking at the current and previous studies, it would seem that male and female pre-service teachers differ in their confidence to use ICT with students and this difference is maintained during their teaching career, irrespective of years of experience, age and professional development initiatives. However, this study's result shows a positive trend that graduating female teachers are becoming more confident, as 45.8% of the female participants indicated they were confident about using ICT with students for teaching and learning. In the 2008 study involving practising teachers, fewer female teachers (39.5%) indicated that they were confident (Jamieson-Proctor & Finger, 2008). However, this continues to represent a major challenge for teacher education programs with more than 1 out of every 3 future female teachers perceiving themselves to be unconfident, and females make up the majority of the teaching workforce across Australia.

Table 4: Frequency of confidence in using ICT with school students for teaching and learning for male and female pre-service teachers (N=345)

	Teacher Gender		% Of Total
	% Female	% Male	
No confidence	4.4	2.8	4.1
Some confidence	34.8	25	32.8
Confident	45.8	36.1	43.8
Very confident	15	36.1	19.4
Total %	100	100	100



Interestingly, there were also significant differences in confidence to use ICT with school students for teaching and learning at the metropolitan university related to the students' program of study, $\chi^2(21, N = 345) = 55.61, p = .000$. From an analysis of the results summarised in Table 5, it appears that the students graduating from the Bachelor of Education (Primary) at that university are more confident than any of the other cohorts, with 72.3% either Confident or Very confident to use ICT with students. The Graduate Diploma (Primary) students were the least confident with 58.4% indicating that they had No confidence or only Some confidence. The differences between programs might be explained by a close examination of the program structures and the opportunities for students to engage with ICT during their degree. This examination was outside the scope of this study. There were no significant differences in the confidence of graduating students to use ICT with school students for teaching and learning at the regional university.

Table 5: Frequency of confidence in using ICT with school students for teaching and learning among pre-service teachers at the metropolitan university from different programs of study (n=199)

	No confidence %	Some confidence %	Confident %	Very confident %	Total %
Metropolitan - BEd (Primary):	1.5	26.2	53.8	18.5	100
Metropolitan - BEd (Secondary):	5.6	33.3	44.4	16.7	100
Metropolitan - BEd (Special Education):	14.3	21.4	50	14.3	100
Metropolitan - GDE (Primary):	2.8	55.6	33.3	8.3	100
Metropolitan - GDE (Secondary):	4.8	34.9	36.5	23.8	100

NB. BEd=Bachelor of Education; GDE=Graduate Diploma of Education

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

Technological Pedagogical Content Knowledge (TPACK), as conceptualized by Koehler and Mishra (2008), refers to the knowledge that emerges from the interaction of a teacher's content, pedagogy, and technology knowledge bases. They believe that quality teaching requires teachers to develop an understanding of the complex interplay between these three key knowledge bases and how they are interpreted in specific teaching and learning contexts (Koehler & Mishra, 2008). To measure the pre-service teachers' TPACK in this study, the statistically robust 20 item *Learning with ICT: Measuring ICT Use in the Curriculum* instrument (Jamieson-Proctor et al., 2005) was incorporated into this survey. The *Learning with ICT: Measuring ICT Use in the Curriculum* instrument has been shown to contain two strong factors. The first factor is comprised of 14 items that define student use of ICT as a tool for the development of ICT-related skills and the *enhancement* of curriculum learning outcomes ($\alpha = 0.94$). The second factor comprises 6 items that define ICT use as an integral component of reforms that *transform* what students learn and how school is structured and organised ($\alpha = 0.86$). The complete validation data for the instrument has been previously reported (Jamieson-Proctor, et al., 2005; 2007). This instrument utilises the theoretical constructs described in Good Practice and Leadership in the Use of ICT in Schools (Department of Education Training and Youth Affairs (DETYA, 2000) and The Queensland School Reform Longitudinal Study (Lingard et al., 2001) when defining ICT curriculum integration. Each of the items asks teachers to rate how their students use ICT for learning rather than how they use ICT. While that instrument was developed prior to the conceptualisation of TPACK, because the instrument describes how students use and experience ICT for learning as a consequence of how teachers integrate ICT into the curriculum, we contend that the 20 items measure teachers' TPACK as described by its underpinning theoretical constructs.

Table 6 shows the range of TPACK ICT integration examples for which subjects were asked to rate their confidence from no confidence (1) to very confident (4). The first 14 items in the table comprise the enhancement factor of the instrument and the last 6 items comprise the transformation factor. The table also shows the means (with Standard Deviations) for the subjects in this study for each of these ICT integration examples, as well as the percentage of participants who perceived themselves as having no or limited confidence to support students using ICT for each of the TPACK examples.



Table 6: *Perceived confidence to integrate ICT into student learning - TPACK*

	In my class, I could support students' use of ICT to:	Mean (SD)	% No / Limited Confidence
1.1	acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change.	2.48 (.99)	38.8
1.2	develop functional competencies in a specified curriculum area.	2.57 (.97)	34.8
1.3	synthesize their knowledge.	2.58 (.98)	32.2
1.4	actively construct their own knowledge in collaboration with their peers and others.	2.61 (1.00)	30.8
1.5	actively construct knowledge that integrates curriculum areas.	2.58 (.99)	35.4
1.6	develop deep understanding about a topic of interest relevant to the curriculum area(s) being studied.	2.68 (.99)	27.8
1.7	develop a scientific understanding of the world.	2.50 (.99)	35.9
1.8	provide motivation for curriculum tasks.	2.74 (.97)	23.2
1.9	plan and/or manage curriculum projects.	2.59 (.99)	31.3
1.10	integrate different media to create appropriate products.	2.47 (1.05)	39.1
1.11	engage in sustained involvement with curriculum activities.	2.53 (.98)	35
1.12	support elements of the learning process.	2.70 (.97)	25.2
1.13	demonstrate what they have learned.	2.75 (.99)	22.3
1.14	undertake formative and/or summative assessment.	2.68 (.99)	28.4
2.1	acquire awareness of the global implications of ICT-based technologies on society.	2.43 (1.02)	41.7
2.2	gain intercultural understanding.	2.55 (1.00)	33.6
2.3	critically evaluate their own and society's values.	2.50 (.99)	38.2
2.4	communicate with others locally and globally.	2.84 (1.04)	20.8
2.5	engage in independent learning through access to education at a time, place, and pace of their own choosing.	2.65 (.95)	30.4
2.6	understand and participate in the changing knowledge economy.	2.42 (.96)	41.8

Again, the Pearson Chi-square test of significance was not significant for university for each of the 20 items. A MANOVA comparing the means of the two universities for each of the two factors measured by the instrument was also not significant. Table 7 displays the means for each factor (with Standard Error) for each university.

Table 7: *A comparison of means (with Standard Error) for each university for the two TPACK factors of ICT use by students (N = 345)*

University	Factor 1: Enhancing Student Learning Outcomes	Factor 2: Transforming Student Learning Outcomes
Metropolitan	2.59 (.06)	2.55 (.06)
Regional	2.62 (.08)	2.58 (.07)

* indicates significance at $p < .05$



In view of the impact of gender on the confidence of the pre-service teachers in this study described earlier, as well as the significant mean differences between males and females for each of the two dimensions of ICT student use measured in all previous studies by these researchers, a MANOVA was conducted to determine if gender was a determining factor in their confidence to integrate ICT into their future students' learning, which is hypothesised by this study to be a measure of their TPACK. The MANOVA was significant for gender, Pillai's Trace = .02, $F = 3.14$, $df = (2,342)$, $p = .000$, indicating different levels of confidence to support student ICT use for male and female teachers. However, this statistical main effect is of no significance as the univariate F tests showed no significant difference between males and females for either dimension. Table 8 presents the means (with Standard Error) for each factor by gender.

Table 8: A comparison of means (with Standard Error) for male and female teachers for the two dimensions of ICT use by students ($N = 345$)

Gender	Factor 1: Enhancing Student Learning Outcomes	Factor 2: Transforming Student Learning Outcomes
Female	2.64 (.06)	2.58 (.05)
Male	2.48 (.11)	2.50 (.11)

* indicates significance at $p < .05$

This non-significant difference is in itself significant as, unlike all previous studies conducted with this instrument, with several thousand teachers and pre-service teachers over the past 5 years, this 2009 cohort of pre-service teachers have not expressed a gender-based difference in their confidence to either enhance or transform the curriculum, teaching and learning with ICT. It might be concluded therefore, that there is no difference in the TPACK of male and female pre-service teachers from the two universities studied in 2009.

CONCLUSION

This paper has explored some aspects of an audit of the ICT knowledge bases of students in their final year in pre-service teacher education programs at two Queensland universities. It found that the 345 pre-service teachers had high levels of ICT ownership and broadband Internet availability, but perhaps less than optimum mobile computing access for the 21st century. They also generally expressed high levels of interest in and use of ICT for both personal and professional purposes, but they believe that they use ICT for teaching and learning purposes less in comparison to their strong belief in the value of ICT to improve student learning outcomes.

The participants' self-perception of their competence with digital technologies, a measure of technology knowledge (TK), indicated that overall they did not have a high level (mean >3) of perceived competence or TK. More than 10% also expressed no competence at all with keeping informed about new digital technologies or about being able to solve their own technical problems; both of which might be considered important competencies for teachers in today's classrooms.

Another measure of TK in the survey was the participants' self-perceived competence with a list of ICT software applications. This study found little change in graduating students' perceived competence when compared with findings from a similar study conducted in 2003 at the metropolitan university involved in this study. Both studies found high levels (mean >3) of competence with word processing, presentation software, email, web browsers and web searching; and very low levels (mean <2) of competence for multimedia development and authoring, visual thinking software, digital video editing, and web page development. Of concern in this study is the finding that students generally did not express a high level of competence (mean >3) for any of the Web 2.0 applications that have evolved in the past few years, as well as digital learning object repositories. Since 2003, significant funding has been injected into the development of learning object repositories, for example the Learning Federation repository (see <http://tlf.edu.au>). Given the access available to pre-service and



practising teachers to these digital learning objects, this result deserves further investigation to determine what is needed to ensure that graduating teachers access and use these valuable teaching and learning resources.

This study, along with all previous studies conducted by these researchers, also found a difference between male and female teachers with respect to their reported confidence to use ICT with school students for teaching and learning. However, this study's result also indicates that there is a positive trend with a reported increase in the proportion of female pre-service teachers becoming more confident, though they are still in general proportionately less confident than males. In parallel with the results of the 2003 student audit conducted at the metropolitan university, students in the Bachelor of Education (Primary) were more confident than students in any of the other cohorts. In comparison, the regional university exhibited no such differences in confidence between programs of study. By closely examining the differences in program structures within and between each university, this result might be explained due to limited opportunities for students to engage with ICT during their degree which would build their TK and TPACK capabilities.

Finally, this study measured the pre-service teachers' TPACK using a statistically valid, reliable instrument that asked them to rate how confident they would be to use ICT with their students to both enhance and transform student learning outcomes across the curriculum. While its development preceded the TPACK conceptualisation, the researchers contend that this instrument is a measure of the pre-service teachers' TPACK as it describes how their students use and experience ICT for learning, *as a direct result* of how confident the pre-service teachers are with integrating ICT into the curriculum. In all previous studies, the researchers have found a significant gender-based difference in both dimensions measured by the instrument. Male teachers have repeatedly demonstrated greater confidence to integrate ICT for teaching and learning, to both enhance and transform the learning outcomes of students. This study found no such difference.

In general, this paper has drawn attention to the need to regularly audit the ICT experiences of students in undergraduate teacher preparation programs to ensure that all graduates have the necessary knowledge bases (TK and TPACK) and confidence to integrate ICT into the curriculum, especially in light of the rapidity with which those knowledge bases change in relation to digital technologies. Further, as there appears to be a less than optimal acceptance of ICT curriculum integration by graduating pre-service teachers in the past decade, based on a comparison of the results from two audits conducted 6 years apart, we contend that teacher education programs on the whole are designed using Pedagogical Content Knowledge (PCK) (Shulman, 1986, 1987) as a core philosophy and this will prove to be increasingly more and more problematic as TPACK capabilities are needed by teachers in the 21st century.

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