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A Case Study of Secondary Pre-service Teachers' Technological Pedagogical and Content Knowledge Mastery Level

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Abstract

In recent years, researchers reported that effective ICT integration requires teachers to acquire knowledge of technology, content, pedagogy and the intersection of these, known as TPACK (Mishra & Koehler, 2006; Archambault, & Crippen, 2009). This study specifically sought to answer: 1) What are pre-service teachers' perceptions of their TPACK mastery level before and after field experience; and, 2) Is there a significant difference of TPACK after field experience in schools? The TPACK survey instrument was adapted from Schmidt et al. (2009) and Archambault and Crippen (2009) and administered before and after their field experience to 107 pre-service teachers in a research intensive university programme in New Zealand. In addition, three student teachers were interviewed before and after field experience. These pre-service teachers scored highest in Content Knowledge (CK) and lowest in Technology Knowledge (TK) domains within TPACK at both before and after field experience. Paired-sample t-tests showed significant increases in most TPACK domains, namely, TK, PK, PCK, TCK and TPACK. Interviews and observations of three students clarified complex changes in knowledge of TPACK that linked to their experience in schools. The study continues to support the need for field experience while also adding caution to the interpretation of TPACK survey evidence given the strength of the student teachers' perceived knowledge before field experience. Further research is underway with a comparative survey in a programme that prepares teachers for secondary schools in Malaysia.

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1. INTRODUCTION

The integration of information and communications technologies (ICT) in teaching and learning remain as key issue in most educational institutions (Jones, Harlow & Cowie, 2003; Choy, Wong & Gao, 2008). A study of ICT implementation across all schools in New Zealand showed that ICT is implemented across all school types with differences in implementation between the primary, middle and secondary school systems (Jones, Harlow & Cowie, 2003). Bolstad's (2011) more recent synthesis of the future focus in the New Zealand curriculum indicates the increasing challenges of integrating ICT.

Therefore the preparation of teachers for New Zealand schools and in many countries worldwide includes preparation to enhance learning and teaching with ICT (Davis, 2010). However, it is important to note that many student teachers have inaccurate perceptions of their competence to teach before they gain experience in schools and such beliefs must be challenged throughout their programme; field experience is a particularly relevant strategy (Howey & Zimpher 1996; Knowles & Cole, 1996). Most if not all pre-service teacher education programmes include field experience in schools to provide a hands-on opportunity for pre-service teachers to put what they have learned into classroom instructions (Darling-Hammond & Baratz-Snowden, 2007; Smith & Lev-Ari, 2005). Field experiences provide "the first formalized opportunity for pre-service teachers to verify, challenge, and modify their preconceptions" (Knowles & Cole, 1996, p. 654). Within such field experience student teachers in the 21st century are also likely to gain experience with ICT in classrooms that enhance their understanding of the complex interaction of digital technologies with content and pedagogical knowledge (Compton & Davis 2010). For this reason pre-service teachers' confidence to teach may drop in the process of becoming more competent. In other words, measures of pre-service teachers' perception of their competence to teach may drop as a result of all or part of their programme, particularly as they experience of the complexity of education during a field experience (Compton, Davis & Mackey 2009).

Effective ICT integration requires teachers to acquire knowledge of technology, content, pedagogy and the intersection of those (Neiss, 2005; Mishra & Koehler, 2006; Archambault, & Crippen, 2009). Therefore Technological Pedagogical and Content Knowledge (TPACK) model provides a useful theoretical framework for this study. The TPACK model was developed by Mishra and Koehler (2006), derived from Shulman's Pedagogical Content Knowledge (PCK) model. According to Shulman (1986) pedagogical content knowledge (PCK) is a "specific category of knowledge which goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching". As for TPACK model, Technology Knowledge (TK) covers pre-service teachers' knowledge of technology tools to be used in teaching (Koehler et al., 2007). Pedagogy Knowledge (PK) is defined as knowledge in applying strategies to deliver the instruction which includes teaching approaches for assessing individual's learning needs, performance and strategies to present the content (Koehler et al., 2007). Content Knowledge (CK) is a subject matter knowledge in which teachers specialize. The intersection between three domains of knowledge produces Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK) and Technological Content Knowledge (TCK). The PCK domain refers to knowledge of integrating effective teaching strategies with the content knowledge (Mishra & Koehler, 2006). TPK involves pre-service teachers' understanding of using technology with suitable teaching strategies. The heart of the suggested model is Technological Pedagogical and Content Knowledge (TPACK), which is described as knowing how to integrate technology within the subject matter in pedagogically sound ways (Mishra & Koehler, 2006). The TPACK model lays out the core knowledge; TK, CK and PK, and their intersections; PCK, TCK, TPK and TPACK to enhance teaching with technology (Mishra & Koehler, 2006). Pre-service teachers' perceptions of TPACK may be used to ensure effective integration of ICT in classroom

instructions (Mishra, & Koehler, 2006; Schmidt, Baran, Thompson, Mishra, Koehler & Shin, 2010; Lux, Bangert, & Whittier, 2011). Studies have been conducted to measure teachers' TPACK development (Koehler & Mishra, 2005; Graham, Burgoyne, Cantrell, Smith, St. Clair, & Harris, 2009; Jimoyiannis, 2010), in-service teachers' TPACK (Archambault, & Crippen, 2009; Lee & Tsai, 2010; Jang & Tsai, 2012) and pre-service teachers' TPACK (Schmidt, et al., 2010; Lux, Bangert, & Whittier, 2011; Yurdakul, Odabasi, Kilicer, Coklar, Birinci, & Kurt, 2012). However, the majority of the TPACK survey studies were administered with teachers in the USA (e.g. Schmidt, et al., 2010; Lux, Bangert, & Whittier, 2011) and very few studies have been conducted outside the country (e.g. Jimoyiannis, 2010; Yurdakul et. al., 2012) and now in New Zealand. Therefore, there is a need for measuring pre-service teachers' level of TPACK in New Zealand to effectively integrate ICT in teaching. A reliable measure of TPACK could benefit the field by enabling a better understanding of the ICT in pre-service teacher education. This is very relevant with the planned increased access to ICT introduced above.

2. PURPOSES

The study reported in this paper is part of an ongoing research project examining pre-service teachers' use of ICT during field experience and their development of Technological Pedagogical and Content Knowledge (TPACK) mastery before and after completing the field experience in New Zealand and in Malaysia. In this paper, we limit our findings to one programme in New Zealand and seek to answer: 1) What are pre-service teachers' perceptions of their TPACK mastery level; and, 2) Is there any significant difference in pre-service teachers' perceptions of their TPACK mastery level before and after field experience.

3. METHODOLOGY

3.1. Research Design

This study used a mixed methods design which combined both quantitative and qualitative approaches for data collection and data analysis (Creswell & Clark, 2011). Methods of gathering data included: survey of a large sample. In addition to the surveys, three student teachers were interviewed during their field experience in different secondary schools; two majored in ICT and one in Social Studies. These three students were interviewed before starting field experience and after completing field experience and also observed during the field experience by the first author.

3.2. Instrumentation

In order to survey the students' perception of their mastery level of TPACK before and after field experience, TPACK instruments developed by Schmidt et al. (2009) and adapted by Archambault and Crippen (2009) were further adapted to the New Zealand context. The final version of the New Zealand TPACK survey consists of 36 items that measure pre-service teachers' perceptions of TPACK with a five-point Likert-type scale: (1) strongly disagree; (2) disagree; (3) neutral; (4) agree and (5) strongly agree. A pilot study was conducted with pre-service teachers (N = 33) in New Zealand to test the reliability of the TPACK instrument.

3.3. Participants

The participants in the New Zealand study were enrolled in a Graduate Diploma in Teaching and Learning (Secondary) from a research intensive New Zealand university. A total of 107 respondents participated both in the pre-survey and post-survey. As summarised in Table 1 the sample comprised 62 females and 45 males. In terms of age 53 were between 21-24 years, 26 were between 25-29 years, 13 were between 30-39 years, and 15

were above 40 years. As for the major subject taken by the pre-service teachers in the teacher education program, the majority of the respondents took English or another language as their major (n=29); 16 pre-service teachers majored in Social Studies, while pre-service teachers majored in Science Education (n=14), Physical Education (n=24), Arts Education (n=12), Mathematics Education (n=7), or Technology Education (n=5). The Technology Education group included the two pre-service teachers with ICT major who volunteered for closer study.

Table 1. Profile of respondents based on gender, age and major

Profile		Respondents (N=107)
Gender		
	Female	62
	Male	45
Age		
	21-24	53
	25-29	26
	30-39	13
	>40	15
Major		
	Technology	5
	Arts Education	12
	Science Education	14
	English or Other Language	29
	Physical Education	24
	Social Studies	16
	Mathematics Education	7

3.4. Procedure for Analysis

Each TPACK knowledge domain subscale was assessed for internal consistency using Cronbach's alpha reliability technique. The difference between pre- and post- survey scores was analyzed using a paired-samples t-test via SPSS version 19.0. For qualitative data, case study analysis (Yin, 2009) was employed to examine pre-service teachers' development of TPACK mastery level. To analyze the interview data, the first step was to become familiar with the data; this was achieved by reading and re-reading the interview transcripts. Before a list was made of what were felt to be significant phrases, these phrases were examined for inter-rater reliability to identify patterns or themes that emerged from the data. One researcher coded the data and devised a clearly described coding system, which was then given to the two independent researchers. After initial coding, all interviews were independently examined by the principal researcher. The themes emerged were then reviewed and discrepancies were discussed and resolved. All data are reported anonymously where possible and the three pre-service teachers were given fictitious names of Vanessa, Paige and Melinda. Both data sets were analyzed and merged during data interpretation for data triangulation to provide more information (Creswell & Clark, 2011).

4. FINDINGS

4.1. Quantitative Findings

Findings from pre-survey analysis showed the reliability coefficients of the constructs range from α=.70 to α=.87, as shown in Table 2. Based on the results, the alpha values of all TPACK scales indicated good reliability of the instrument, α>.60, (Hair et al., 2010). Results also indicated that all mean scores ranged from 3.44 to 4.31 as illustrated in Table 2. From the pre-survey analysis, the highest mean (M) of TPACK for the respondents in this study was for content knowledge (M = 4.22, SD = .46), whereas the lowest was for technology knowledge (M = 3.44, SD = .70). Similarly, for post-survey findings, the highest mean scores of pre-service teachers' perceptions towards their TPACK mastery level was for content knowledge (M = 4.31, SD = .48), whereas the lowest mean score was for technological knowledge (M = 3.61, SD = .68). However, the mean scores for all TPACK domains indicated an overall positive response to the scales. In other words, generally, pre-service teachers agreed that their level of TPACK before and after were above average. Although the mean score for technology knowledge was the lowest mean score among the seven domains of perceptions of TPACK, it was observed that pre-service teachers perceived that they had the necessary technology knowledge, sufficient enough for them to be able to apply TK during field experience.

Table 2. Reliability, mean scores, standard deviations, t-value and effect size of TPACK domains (n = 107)

Domains Subscales	Reliability	Pre-survey		Post-survey		t	Effect Size (Cohen's d)
		Mean	SD	Mean	SD		
TK	.87	3.44	.70	3.61	.68	2.25*	0.25 (small
CK	.80	4.22	.46	4.31	.48		
PK	.76	3.82	.45	4.11	.60	4.97*	0.55 (medium)
PCK	.70	3.86	.41	4.02	.52	2.46*	0.34 (small)
TCK	.85	3.78	.59	3.97	.61	2.61*	0.32 (small
TPK	.75	3.80	.51	3.92	.63		
TPACK	.82	3.64	.53	4.00	.61	5.16*	0.63 (medium)

Note: *. t-value is significant at $p < .05$; Cohen's d values were presented for TPACK domains with the significant difference

There was a small improvement between pre and post mean scores on all seven TPACK constructs (Table 2). In order to measure the significant differences between the two times of data collection, a paired-samples t-test was conducted to evaluate the differences in the mean of the pre-service teachers' TPACK mastery level before and after field experience with a total of 107 respondents. There was a statistically significant increase in the mean scores between the pre- and post-survey for TK, $t(106) = 2.25$, $p < .05$, $d = 0.25$; PK, $t(106) = 4.97$, $p < .05$, $d = 0.55$; PCK, $t(106) = 2.46$, $p < .05$, $d = 0.34$; TCK, $t(106) = 2.61$, $p < .05$, $d = 0.32$ and TPACK, $t(106) = 5.16$, $p < .05$, $d = 0.63$. Cohen (1988) defines effect sizes as small, d = .2, medium, d = .5, and large, d = .8. Therefore, the findings reported that the Cohen's d for TK, PCK and TCK indicated a small effect size and a medium effect size for PK and TPACK.

4.2. Qualitative Findings

The three female students who volunteered to be interviewed and observed were given pseudonyms: Melinda and Vanessa were ICT majors, while Paige was social studies major. All three perceived themselves as having good mastery levels of TPACK both before and after field experience. Vanessa with a major in ICT and minor in

Economics, had more advanced uses of ICT because of her advanced knowledge of ICT and her participation as a volunteer in an ICT project led by New Zealand Association for Computing, Digital and Information Technology Teachers. During the period of field experience, Vanessa was assigned to three associate teachers: 1 Economic and 2 ICT. Vanessa rated agree in all TPACK domains. However, after field experience, whilst TK, PK, PCK, TPK and TPACK remained at the same level, she rated a negative change in her CK and a positive change of her TCK. The negative change of her CK in the survey was supported in the third interview session after field experience. "[M]y economics part was quite old, and when I was teaching my year 13 economics…I was learning two or three steps ahead of the students and it was coming back… but because I don't use economics every day its quite rusty" Thus Vanessa needed to revise the work before continuing her teaching. Furthermore, "my economics associate [teacher]… was never around". In contrast, her ICT subject, "all of the content is not a problem for me at all, but in saying that there is still so much more - especially in my area that needs to be maintained and upgraded and so on". Vanessa stated that this knowledge developed throughout her field experience. She noted that her understanding of TPACK concepts was "getting there" and that her "…PK is improving all the time"; she further added that "we can't chop one of them out as we need them all", (Vanessa, 3rd interview, 2011).

Melinda was majoring in ICT and taking a minor in Mathematics and she was guided by three associate teachers: two Mathematics and one ICT. Melinda rated 'agree' for all TPACK domains before and after field experience. She further described that there was not much teaching involved during her field experience as the students had a group discussion on the project they were working on. Thus, "ICT use was not really there" which suggested her TK remaining at the same level as rated in the pre-survey. However, in the third interview session after field experience, Melinda agreed that she had improved more of her CK when they discussed the students' projects and during their revision period. She added that she was not able to enhance her content knowledge during her studies perhaps because the "student teachers have already done a degree (in most cases) on the subject they taught, thus they knew a lot about the content of that subject and they may just pick up new bits and pieces during field experience" (Melinda, 3rd interview, 2012). Additionally, she stated that there was a significant increase in PCK as she was able to solve students' misunderstanding of the concepts taught previously.

In contrast, Paige, who was majoring in Social Studies with a minor in Geography, rated 'agree' in all TPACK domains before field experience and remained 'agree' in all domains except for TCK and TPK which were rated as 'strongly agree' in the post-survey. The reason for this was clarified when she said that "We won't be an effective teacher if we were lacking in one of those areas". Furthermore, those three domains of knowledge were important and "I don't think there is one more important than the other", (Paige, 3rd interview, 2011). Paige continued that "I guess you could teach without technology if you had the other two, but the lessons would be probably more boring". She further commented that "[A]ll the feedback from students that I've received says that using technology in class makes it much more interesting". Paige noted that "if you have learnt what they [TPACK] are, then, you can develop it during teaching practice". Though Paige found that most of the time during her field experience she was unfamiliar with the topic, she tried to find out what was taught in school in the different year levels in that subject and to make sure that she learnt the topic before she got to teach the class. She was then able to teach the topic. She stated in relation to TK that "I have been exposed to ICT tools, and then I need to just have some time actually working on them and learning them practically".

5. DISCUSSION

The mean level of each TPACK domain was similar to that of previous studies (Koh, Chai and Tsai, 2010; Schmidt, et al. 2009). Contrary to the findings of Graham, et al., (2009), but consistent with those of Archambault and Crippen (2009), participants in New Zealand showed lower levels of TK before and after field experience than other domains of knowledge. Although the mean score for technology knowledge was the lowest mean score among the seven domains of perceptions of TPACK mastery level, results still indicated that the pre-service teachers in New Zealand perceived that they do have a certain level of technology knowledge. For example, they can keep up with the important new technologies and they can learn to use new software easily, -- technology knowledge they thought would be adequate enough to enable them to use ICT during their field experience. In spite of this, participants in New Zealand showed significant differences in their TK mastery level which indicates that they have developed their TK mastery level after completing field experience.

The small effect size of significant differences in TK within the New Zealand context aligned with the findings of Koh, Chai and Tsai (2010), who found that the participants indicated that they have the confidence in integrating technology into their lesson plans, however, when it comes to the actual implementation, they faced issues, such as a lack of time and difficulties in reserving technology for their class. While pre-service teachers perceived that their CK were good in comparison with other domains, they showed no significant improvement of CK after field experience. In support of this finding, the contexts of the students interviewed provided evidence of the lack of opportunity to develop content knowledge while in the field. For example, Melinda noted that "student teachers have already done a degree (in most cases) on the subject they taught, thus they knew a lot about the content of that subject and they may just pick up new bits and pieces during field experience" (Melinda, 3rd interview, 2012). Having rated their initial CK the highest among all domains, it became less likely that the trainees would show significant development of their CK during their field experience, as compared to the significant pre- and post- field experience differences observed in most of the other domains of TPACK. The significant increase in technology-related domains; TK, TCK and TPACK within New Zealand context provide support for the recommendation of Archambault and Crippen (2009) to integrate technology throughout content courses including field experiences where the use of technology can be contextualized.

Understanding of TPACK components was not an easy task, nor developing the knowledge bases among pre-service teachers. It requires a comprehensive understanding of the core knowledge and interaction of the knowledge within the teaching context (Mishra & Koehler, 2006; Niess, 2005). Although pre-service teachers were confident about the complementary knowledge bases before field experience, their use of ICT during field experience was limited. However, the requirement to complete two teaching practices during this teacher education program is likely to have contributed to the significant improvement in many of the TPACK domains, namely, TK, PK, PCK, TCK and TPACK.

6. CONCLUSION

In conclusion, pre-service teachers in New Zealand rated their CK as the highest and TK as the lowest mean score in both surveys, indicating little change in their knowledge. However, as noted in the introduction, pre-service teachers often have inaccurate preconceptions of their knowledge and skill of teaching and this can explain the puzzling findings on the TPACK survey of New Zealand pre-service teachers. There was medium effect size in PK and TPACK and small effect size in TK, PCK and TCK. The interviews and observations of three students enhanced our view of changes in the pre-service teachers' perceptions of TPACK mastery level. Although the TPACK provides a model to guide effective integration of ICT into teaching, the implementation of these intersecting knowledge bases is a complex process that includes challenging students' preconceptions.

Therefore, the survey findings and the three students interviewed suggest further research of TPACK development during field experience to build up students' knowledge of the three components and their interactions. Further research is underway with a comparative sample of pre-service students in a Malaysian teacher education programme.

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