Tan, S. C. et al. (Eds.) (2013). Workshop Proceedings of the 21st International Conference on Computers in Education. Indonesia: Asia-Pacific Society for Computers in Education

Exploring the Changes in In-service Teachers' Perceptions of Technological Pedagogical Content Knowledge and Efficacy for ICT Design Thinking

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Abstract: The present study explores the changes in teachers' perceptions of technological pedagogical content knowledge (TPACK), and their efficacy for ICT design thinking. The TPACK survey and the Technological Pedagogical Content Design survey (TPCD) were administered to 100 Singaporean in-service teachers who participated in a three-day professional development session for ICT mentors. The TPACK-MLS has seven scales, including content knowledge (CK), pedagogical knowledge (PK), Pedagogical content knowledge (PCK), technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). The TPCD has two scales, including design practice (DP), and design disposition (DD). The results shows that through the workshop activities, the teachers had significant positive change in their perceptions of pedagogical knowledge (PK), technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), technological pedagogical content knowledge (TPACK). The professional development sessions also enhanced the teachers' perception about their design practice (DP) and design disposition (DD).

Keywords: Technological pedagogical content knowledge (TPACK), design thinking, design practice, design disposition

1. Introduction

The technological pedagogical content knowledge (TPACK) framework (Mishra & Koehler, 2006) has been utilized in many studies to explore the teachers' knowledge for the integration of information and communications technology (ICT). For example, Schmidt, Baran, Thompson, Mishra, Koehler, and Shin (2009) have employed this framework to explore pre-service teachers' knowledge about pedagogy, content, and technology. The TPACK framework has seven components, comprising three main knowledge sources (i.e. content knowledge, pedagogical knowledge, technological knowledge) and four advanced components that are derived from the interactions among these three basic knowledge sources (i.e. pedagogical content knowledge, technological pedagogical knowledge, technological content knowledge, and technological pedagogical content knowledge).

Recently, many surveys based on the TPACK framework to explore teachers' self-efficacy about TPACK. Examples of such studies are Asian pre-service teachers' perceptions of technological pedagogical content knowledge (Chai, Ng, Li, Hong, Koh, 2013), K-12 online teachers' TPACK (Archambault, & Crippen, 2009), and teachers' perception about the integration of web-based resources (Lee & Tsai, 2010). These surveys provide educators a way to explore the factors influencing teachers' integration of ICT and to measure if the teachers' efficacies have improved after professional development activities.

More recently, Chai, Koh, and Tsai (2013) theorized that teachers' general efficacies for design practices (DP) and their design disposition (DD) are associated with teachers' TPACK efficacy and

therefore could influence teachers' TPACK development. Teachers' general efficacy for DP is related to how teachers deal with design problems while their DD is related to their propensity to engage in the resolution of design problems. That is, teachers' confidence for engaging in ICT design thinking may influence how they enact their TPACK in ICT-based classrooms. Koh, Chai, Hong, and Tsai (2013) developed the Technological Pedagogical Content Design survey (TPCD) to investigate the relationship between teachers' perceptions of TPACK, DP and DD. They found that these constructs are significantly correlated. Hence, the enhancements of teachers' perceptions of TPACK could also change teachers design practice and design disposition. As current literature has not discussed how teachers' design practice and disposition could be enhanced, this study attempts to contribute to TPACK research by investigating these new factors associated with teachers' TPACK development.

Many studies indicated that the effective of professional development course can support teachers to improve their TPACK perceptions (Lee, Chai, & Koh, 2012; Nadelson, Callahan, Pyke, Hay, Dance, & Pfiester, 2013). For example, Lee et al. (2012) found that the effectiveness of an ICT course can support teachers to improve their technology-related ability more than non technology-related ability. Thus, this study attempts to examine the impact of a professional development activity for Singapore teachers' changes in TPACK, DP and DD. Our research question is: Were there any changes in the teachers' perceptions of TPACK, design practices and design disposition after the professional development activity for ICT mentors?

2. Method

2.1 Participants and Program

The participants of this study were 100 in-service teachers (including 34 males and 66 females). Their average teaching experience is 6.40 years. All of them were enrolled in the ICT mentors' program which is conducted by an educational institution in Singapore to develop teachers who can serve as mentors of ICT initiatives in Singapore schools. The program pedagogy emphasizes teacher engagement in design work. Throughout the three days, teachers worked in groups according to their content specialization to critique ICT lesson plans, explore ICT tools for supporting 21st century learning, design ICT lesson ideas to support 21st century learning, as well as to engage in peer critique and refinement of these lesson ideas. The survey was conducted before and after the workshop to explore the changes in teachers' perceptions about content knowledge, knowledge about teaching methods, knowledge about technology integration and design efficacy. Participation was voluntary.

2.2 Instrument and procedure

The TPACK survey developed by Chai et al. (2013) was adopted in this study to explore teachers' perceptions about content knowledge, knowledge about teaching methods, and knowledge about technology integration. The TPACK survey consisted of seven scales, including content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). According to Chai et al. (2013), the survey had been verified by both exploratory factor analysis and confirmatory factor analysis, indicating the survey had acceptable reliability and validity. The definition of each TPACK scale is as follows:

- Content knowledge (CK): Teachers' knowledge of subject matter, e.g., I can think about the content of my main teaching subject like a subject matter expert.
- Pedagogical knowledge (PK): Teachers' knowledge of teaching methods, e.g., I am able to help my students to reflect on their learning strategies.
- Pedagogical content knowledge (PCK): Teachers' knowledge of teaching methods with respect to subject matter content, e.g., Without using technology, I can help my students to understand the content knowledge of my main teaching subject through various ways.
- Technological knowledge (TK): Teachers' knowledge of technology tools, e.g., I know how to solve my own technical problems when using technology.

- Technological pedagogical knowledge (TPK): Teachers' knowledge of using technology to implement teaching methods, e.g., I am able to facilitate my students to collaborate with each other using technology.
- Technological content knowledge (TCK): Teachers' knowledge of subject matter representation with technology, e.g., I can use appropriate technologies (e.g. multimedia resources, simulation) to represent the content of my main teaching subject.
- Technological pedagogical content knowledge (TPACK): Teachers' knowledge of integrating technology to teach in specific pedagogical approach for specific subject matter, e.g., I can formulate in-depth discussion topics about the content knowledge and facilitate students' online collaboration with appropriate tools. (e.g. Google Sites, CoveritLive).

The Technological Pedagogical Content Design survey (TPCD) developed by Koh et al.'s (2013) was also implemented is this study to investigate these aspects of teachers' design efficacy. The TPCD consisted of two scales, including design practice (DP), and design disposition (DD). According to Koh et al. (2013), the TPCD items were verified by exploratory factor analysis, and the survey had acceptable reliability and validity. The definition of each TPCD scale is as below:

- Design practice (DP): How teachers deal with design problems, e.g., When designing an ICT lesson, I allow conflicting lesson ideas to coexist until I feel that I have adequately understood the learning problems.
- Design disposition (DD): Teachers' propensity to engage in the resolution of design problems, e.g., I am comfortable to deviate from established practices.

In order to explore the changes of teachers' perceptions of TPCK and design efficacy before and after the professional development activity, the participants were asked to indicate their agreement with these two online surveys before and after the activity. Their responses were scored by using a 7-point Likert scale (i.e. 1 for strongly disagree and 7 for strongly agree). The reliability coefficients of the teachers' perceptions before activity were from 0.90 to 0.96, and those of the teachers' perceptions after activity were from 0.95 to 0.98, indicating that the TPACK and TPCD surveys had satisfactory reliability to measure teachers' view of content knowledge, knowledge about teaching methods, knowledge about technology integration, and design efficacy. This study further utilized paired-samples *t* tests to find out the changes of teachers' perceptions before and after the activity.

3. Results

Table 1 shows the teachers' average scores and standard deviations on the seven scales for each of the pre-test and post-test of the TPACK and on the two scales for each of those of the TPCD. The results of paired-samples *t*-tests are also shown in Table 1. Except for the scales of content knowledge (CK) and pedagogical content knowledge (PCK), there were significant differences found for the other seven scales. For the scales of pedagogical knowledge (PK), technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), technological pedagogical content knowledge (TPACK), design practice (DP), design disposition (DD), the teachers' scores after the professional development program were significantly higher than those before the activity. It implies that through the design activities they participated in, the teachers held stronger self-efficacy perceptions of pedagogical knowledge (PK), technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), technological pedagogical content knowledge (TPACK), design practice (DP), and design disposition (DD). Notably, the increase in ratings TPK, TCK, TPACK, and DP were the largest.

Table 1: Descriptive data and results of paired-samples *t*-test.

Surveys	Factors	Pre-test		Post-test		*t*-value
		Mean	SD	Mean	SD	
TPACK	CK	5.75	0.74	5.79	0.84	0.77
	PK	5.36	0.77	5.58	0.84	3.58**

	PCK	5.21	1.05	5.24	1.07	0.42
	TK	5.17	1.10	5.52	1.01	4.78***
	TPK	4.74	1.13	5.53	0.91	8.11***
	TCK	4.75	1.12	5.48	0.97	8.15***
	TPACK	4.34	1.20	5.35	0.86	9.23***
TPCD	DP	5.07	0.98	5.64	0.92	6.43***
	DD	5.33	0.98	5.62	0.94	3.89***

** $p < 0.01$; *** $p < 0.001$

4. Discussion and conclusions

TPACK is a kind of knowledge that emerges through design activities (Koehler, Mishra, & Yahya, 2007), Teachers' capacity for design is inextricably linked with their capacities for fostering TPACK. This study examines the impact of a professional development activity on changes in teachers' perceptions of technological pedagogical content know ledge (TPACK), and their efficacy for ICT design thinking. The results revealed that through activity design-intensive pedagogy and multiple design opportunities, the teachers held stronger perceptions of pedagogical knowledge (PK), technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). Similar findings are shown in the study of Lee et al. (2012) that the effectiveness of an ICT course can support teachers to improve perceptions of their technology-related ability more than non-technology-related ability. With regards to design practice (DP), and design disposition (DD), the results suggest that teachers' design practice and disposition can be developed along with their TPACK through design activities. Professional developments in these areas are important because they attest to the teachers' capacities to deal with emerging technologies. The more comfortable teachers are when they are confronted with emerging technologies, the more likely they are to engage in productive design activities to create new forms of TPACK. On the other hand, if teachers are apprehensive about the design problems posed by emerging technologies and shy away from design activities, their professional development will be hampered. Future research is suggested to explore how the teachers' self-reported professional developments can be further supported by their performances in addressing design problems. This can be achieved through analyzing and scoring the designed artifacts (lesson plans or lesson packages).

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