Transforming Pre-service Teachers' Technological Pedagogical and Content Knowledge through a Case-based ICT module

Niwat SRISAWASDI
Faculty of Education, Khon Kaen University, Thailand
niwsri@kku.ac.th

Abstract: Recently, It is becoming a critical need in teacher education in order to educate student teachers, and prepare pre-service and beginning teachers for high quality of teaching competency. To promote the competency for 21st century teachers, the epistemology of technological pedagogical and content knowledge (TPACK) is currently considered as the essential qualities of knowledge for highly qualified teachers. The aim of this study is explore the effect of case-based learning approach on TPACK competency of pre-service teachers. In order to develop the pre-service teachers' competency regarding effective integration of technologies into teaching specific content areas, a case-based ICT module was presented to 43 of pre-service physics, chemistry, biology, mathematics, and computer teachers during a course of information and communication technology (ICT) in Education at Faculty of Education, Khon Kaen University, Thailand. The pre-service teachers were investigated instructional design competency of using ICT tools into classroom teaching practice in order to support student learning process of specific content area. The results showed that the pre-service teachers' TPACK has been transformed after participating with the case-based ICT module. In an effort to better serve the needs of high quality teachers, the results of this study illustrated that the competency of TPACK could be particularly considered as a core attributes for 21st century teachers. By the way, case-based approach can play an effective part in preparing and professing the TPACK competency for teachers.

Keywords: TPACK, ICT, Case-based, Pre-service, STEM education

Introduction

In an alarming trend that can have severe profound and accelerating changes in the 21st century society, the challenges for education of this century are to discover and develop tools that add efficiency and value to both teaching and learning. Technologies has profound and lasting impacts in school classroom as being a powerful cognitive tool that can transform the way core subject is taught by facilitating both teachers' instructional practices and students' learning processes and effective learning and teaching requires both teachers and students being able to use new technologies gathering, organizing and evaluating of information to solve problems and innovate practical ideas in real-world settings [5, 6]. To enhance teachers' instructional potentialities and students' active engagement and learning opportunities in subjects, not only all students need a more robust process of technology-enhanced subject learning, but teacher also are need to educate and prepare for gaining high quality of teaching competency by integrating technologies into classroom teaching practice [9].

To prepare and create a unique classroom environment for subject teaching and learning, there is a requirement for comprehensively use of technology in order to develop proficiency in 21st century skills for student, support innovative teaching and learning, and create robust education support system for both students and educators [11]. To promote, therefore, the competency for 21st century teachers, the epistemology of technological pedagogical and content knowledge (TPACK) is currently considered as the essential qualities of knowledge for highly qualified teachers. Furthermore, viewing of teachers' knowledge as including rich relationships between content, pedagogy, and technology also has significant implications for teacher education and teachers' professional development. The goal of this study was to explore impact of case-based approach in the context of pre-service teachers' preparation and development. The study focused on investigation the transformation of TPACK in the pre-service teachers through a case-based information and communication technology (ICT) module in a course of ICT in education.

2. Literature Review

2.1 Technological Pedagogical and Content Knowledge (TPACK)

The TPACK framework was built upon Shulman's [10] pedagogical content knowledge (PCK) work, idea of knowledge of pedagogy that is applicable to the teaching of specific content, and it has been embraced as a theoretical basis for structuring ICT curriculum in teacher education programs [1, 2, 6]. The TPACK was firstly proposed by Mishra and Koehler [8] to describe an integrated connection among content knowledge, pedagogical knowledge, and technological knowledge in order to aid the potential integration of ICT tools in classroom setting and school practices. They postulated seven constructs that capture the different types of teachers' professional expertise needed for effective technology integration including the knowledge about the processes and practices or methods of teaching and learning called pedagogical knowledge (PK); the knowledge about the actual subject matter that is to be learned or taught called content knowledge (CK); and the knowledge about standard technologies and the skills required to operate particular technologies called technological knowledge (TK); the knowledge about particular teaching practice that appropriately fit the nature of specific subject content called pedagogical content knowledge (PCK), the knowledge about the existence, components, and capabilities of standard technologies that could be appropriately used to particularly support in the processes and practices or methods of teaching and learning called technological pedagogical knowledge (TPK), the knowledge about the manner which knowledge of actual subject matter could be manipulated into appropriate representations by the application of standard technologies called technological content knowledge (TCK), and knowledge about the manner which the transactional relationship between knowledge about content (C), pedagogy (P), and technology (T) was dynamic in order to develop appropriate, context-specific, strategies, and representations for better learning of content knowledge called technological pedagogical content knowledge (TPACK). Figure 1 shows a diagram of TPACK framework.

The TPACK framework may provide new directions for teacher educators in solving the problems associated with infusing ICT into classroom teaching practice and learning process [2]. Researches on teacher education reported that the TPACK model can be used as a potentially fruitful framework to prepare and develop teacher competencies in school teaching [3, 7, 12].

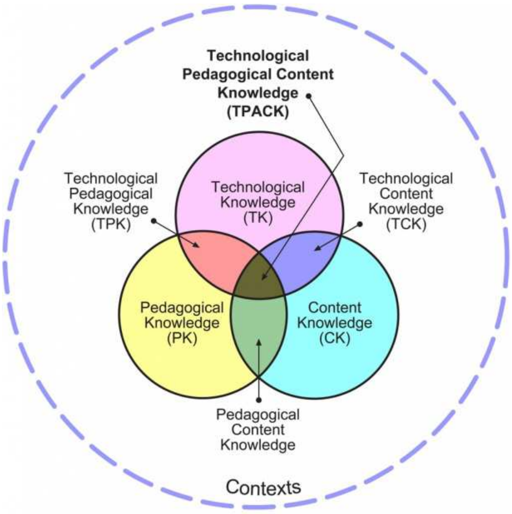


Figure 1. Technological Pedagogical and Content Knowledge (TPACK) framework (http://tpack.org)

3. Method

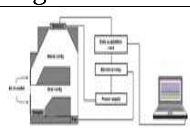
3.1 Study Participants

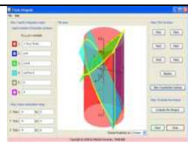
The participants for this study included 43 pre-service teachers in Graduate Diploma Program in Teaching Profession at Faculty of Education, Khon Kaen University, Thailand, and they were 5 physics major, 11 chemistry major, 8 biology major, 9 mathematics major and 10 computer science major. They were attending a course of information communication technology (ICT) in Education and they were invited to participate in this research. The participants were aged 21 to 24 years, and about 63% were women. The participants have basic computer and ICT skills and most of them never have any direct experience with using ICT tools for teaching before.

3.2 The Case-based ICT Module

The case-based ICT module consisted of six three-hour weekly lectures and the module included six case studies on integrating ICT for science, mathematics, and computer education. Table 1 presents the cases and its details of technology, pedagogy, and content used, which used in this study.

Table 1. Details of the case-based ICT module

Case	Lesson name	Technology	Pedagogy	Content	Figure
1	computer-based laboratory environment for authentic-inquiry science	Computer-based laboratory	Inquiry-based learning	Nanoscience and technology of smell (Nanotechnology)	
2	Virtual computer-based laboratory environment for chemistry learning	Computer simulation	Inquiry-based learning	Water contact angle (Chemistry)	

3	Symbolic tool set for integral problem solving in mathematics learning	Maple software	Problem-based learning	Calculus (Mathematics)	
4	Constructivist web-based learning environment for physics learning	Web-based learning environment	Constructivist learning	Force and laws of motion (Physics)	
5	Testing and diagnostic learning problem – an educational application from computer science	Web-based Artificial intelligence	Web-based learning	System of linear equation (Mathematics)	
6	Geographic information system tool for teaching biology	Geographic information system (GIS)	Inquiry-based learning	Mollusk diversity and distribution (Biology)	

After finishing each case presentation, the participants were encouraged into a forum of critical open discussion by considering the potential impact of the case on students' learning and the TPACK framework. The case discussion is aligned into critical issues of using ICT tool to enhance student learning in classroom comprising: identification of suitable topic to be taught with technology; identification of appropriate representations to transform content; identification of teaching strategies difficult to be implemented by traditional mean; selection of appropriate tools and appropriate pedagogical uses of their affordances; and identification of appropriate integration strategies. After the discussion each participant was assigned to conclude their own feedback on the case into a case study report.

3.3 Data Collection

For investigating the TPACK transformation of the participants in this study, the two design tasks of using ICT tools into their teaching practice and student learning process constituted the unit of analysis. For the design task, an open-ended question towards designing the use of ICT tools into their classroom teaching practice of any specific content topic was administrated to the participants. The first design task was assigned to the participants in the first week of the case-based ICT module, before the presentation of the first case study. At the end of the module, the participants were assigned to complete the second design task of using ICT into their teaching, and three of them were not administered the task by their absence.

3.4 Data Analysis

For the analysis of the transformation of TPACK for the participated pre-service teachers, the content analysis was primarily used for writing protocol of their design tasks. A coding system for writing protocols consistent with the TPACK framework was developed and then the design tasks were coded based on the seven categories defined by the TPACK framework, including Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological

Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical and Content Knowledge (TPACK). Descriptive statistics was used to quantify number of the knowledge within the framework.

4. Results

In order to present the TPACK transformation of the pre-service teachers, this paper reports quantity of the transformation on each TPACK components. Moreover, only an example of a qualitative content analysis on the transformation of the pre-service teachers is reported in this paper to provide more in-depth details for representing the TPACK transformation. Further in-depth qualitative data analysis of the pre-service teachers' TPACK transformation for this present research will be performed and reported in the near future.

4.1 Quantity of Pre-service Teachers' TPACK

In Table 2 that follows, it presents the percentage of coded segments over the first and second design tasks for each of seven categories, as abovementioned. The statistical analyses of the data suggest that there are some differences between the first and the second design tasks that the percentage of CK, TK, PCK, TCK, TPK, and TPACK for the first design task is greater than the second design task, except for the percentage of P.

Table 2. Percentage of pre-service teachers on each TPACK category for both design tasks

Design task	Category of TPACK framework						
1st task (N=43)							
2nd task (N=40)	70.00	100.00	100.00	70.00	67.50	97.50	65.00
Percent difference	39.77	0.00	2.33	53.73	39.6	6.83	51.05

A graphical representation of the Table 2 is provided in Figure 1, which allows us to see some interesting transformation of TPACK for pre-service teachers.

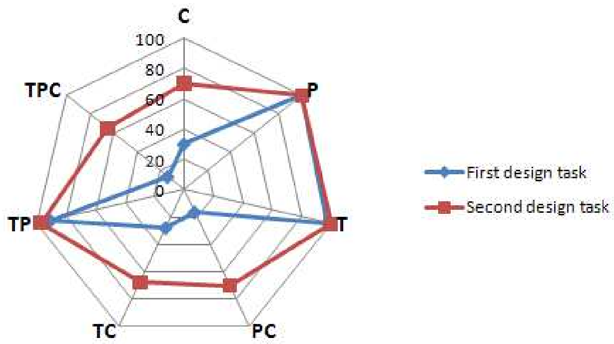


Figure 1. The transformation of percentage for pre-service teachers' TPACK

4.2 A Qualitative Example of Pre-service Teachers' TPACK Transformation

A qualitative result of an in-depth content analysis with a male participant who age 24 years old is showed as a case analysis in this part. The case finished Bachelor of Science degree in Physics from Faculty of Science, Khon Kaen University, Thailand. The case had no school teaching and no tutor experience but he had two years working experience in computer programming after finishing the degree. The case selected a physics topic of projectile motion, and speed of sound for planning learning activities of the first and the second design tasks, respectively. The design tasks could be summarized with TPACK framework as display in Table 3.

Table 3. Summary of TPACK component transformation of a pre-service physics teacher

Design task	TPACK component																	
	CK		PK		TK		PCK			TPK			TCK			TPACK		
	Pn	Cn	Pn	Cn	Pn	Cn	Pn	Cn	An	Pn	Cn	An	Pn	Cn	An	Pn	Cn	An
1st design task		√	√		√		√			√			√			√		
2nd design task		√	√		√			√*				√*		√*				√*

Note: Pn = perception level, Cn = conception level, An = action level, Nn = no perception, * = transformation of knowledge, ** = generation of knowledge

In the details of the first design task, the case identified the physics content knowledge of projectile motion was difficult-to-realize phenomena which may lead students to misinterpretation of the knowledge and cause student to held alternative conceptions of the phenomena (CK-Cn). Thus, slow motion video (TK-Pn) of falling objects has been planned to introduce the phenomena and help them realizing the difficulty (TCK-Pn). The case mentioned that student have collaboratively participated (PCK-Pn), after watching the slow motion video, in hands-on experiment (PK-Pn) of falling object. Finally, the case detailed the use of slow motion video at the end of classroom time to comparatively discuss phenomena of falling objects with all students (TPK-Pn). These evidences implicitly indicated a summative evaluation that this participant had a perceptual status of the technological pedagogical content knowledge (TPACK-Pn) because the case was able to identify difficulty of content and perceive the need for transformation of the content. Also, the participant was able to identify most of TPACK components but not describe the "how to" of each component and reason why the participant has to use.

In the details of the second design task, the case indicated a conceptualization in the specific characteristics of physics content knowledge (CK-Cn) of speed of sound that the CK is an abstract concept which causes students to held alternative conceptions of the concept such as different temperature has no effect on speed of sound. Therefore, the case has planned to use discrepant events to puzzle student's prior knowledge and stimulate disequilibrium state of exist cognitive structure (PCK-Cn) in the teaching practice of interactive lecture demonstration (PK-Pn). The integration between microcomputer-based laboratory and computer simulation (TK-Pn) has been mentioned and explained the sequence of using microcomputer-based laboratory, to represent speed of sound phenomena at macroscopic level, and computer simulation, to represent microscopic level of speed of sound phenomena, (TCK-Cn) in the interactive lecture demonstration method (TPK-An). In according to the transactional relationship between knowledge about content, pedagogy, and technology, this evidence indicated that the case had an actionable mission statement of teaching practice and learning process based on the technological pedagogical content knowledge (TPACK-An) because the case revealed a conceptual link between CK, PK, and TK and also provided mission statement that was actionable in science classroom.

5. Discussion

Both quantitative and qualitative results were consistent in order to provide evidence that pre-service teachers' TPACK has been transformed through the case-based ICT module. The quantitative result reflects that a greater number of the pre-service teachers can present their knowledge of content (CK), pedagogical content (PCK), technological content (TCK), and technological pedagogical content (TPACK), and a few more number of them on technological knowledge (TK) and technological pedagogical knowledge (TPK) after attending the module, except pedagogical knowledge (PK). The qualitative result clearly provides empirical evidences that a sample case of pre-service teachers' TPACK on the second design task were higher level of competency than the first design task. There could be argued the case has been transformed their own TPACK after attending the case-based ICT module. This finding could be argued that the case-based ICT module play an important role to foster pre-service students knowing about using technological tool for teaching specific subject content knowledge. This finding is consistent with research findings that case-based teaching for teacher professional development induced a significant change in their abilities high-quality learning activities [4]. Moreover, Chai et al. [2] reported the use of the core ICT module to model pre-service teachers' TPACK that the pre-service teachers' perceived relations between content knowledge and TPACK changes form insignificant to significant.

6. Conclusion

This paper reported on the use of case-based approach to foster pre-service teachers' TPACK competency. In a case-based ICT module, the pre-service teachers have been transformed their TAPCK in specific subject teaching. In an effort to better serve the needs of high quality teachers, the results of this study illustrated that a potential of TPACK framework could be particularly considered as a core attributes for future 21st century teachers. By the way, case-based approach can play an effective part in preparing and professing the TPACK competency for pre-service teachers, maybe even in-service teachers.

Acknowledgements

This work was financially supported by the National Research Council of Thailand (NRCT).

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