Liu, C.-C. et al. (Eds.) (2014). Proceedings of the 22nd International Conference on Computers in Education. Japan: Asia-Pacific Society for Computers in Education

Do They Keep Technology in Mind? An Implementation of TPACK-oriented Science Teacher Program for Science Degree-graduated Students

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Abstract: Science-based education in 21st century needs qualified and innovative science teachers who are expertise in using information and communication technology as pedagogical tool for their work and as cognitive tool for student learning. As such, a framework of Technological Pedagogical and Content Knowledge (TPACK) has been recognized as a theoretical basis for development of professional science teacher. This paper reported a pilot study result of implementing TPACK-focused preservice science teacher program for science degree-graduated students. The study participants were 54 preservice science teachers in a master degree of education at Khon Kaen University, Thailand. The alignment of 2-year courses has been particularly designed based on TPACK for students who graduated in 4-year bachelor degree of science. The results showed that the preservice science teachers have been cultivated their technological pedagogical knowledge (TPK) and technological content knowledge (TCK) during enrollment in the program. This could be implied that the TPACK-based approach should be used as a basis to create well-designed coursework in teacher education program.

Keywords: Technological Pedagogical Content Knowledge, preservice teacher, science education, teacher education

1. Introduction

In today's world, information and communication technology (ICT) have become commonplace in improving and advancing the practice of education because of its potential of bringing about change in ways of teaching and learning. In light of technological advancement, in science education community of practice, there is a wide range of efficient technological environments and applications that can serve science teaching and learning (e.g. animations, simulations and modeling tools, microcomputer-based laboratories (MBL), intelligent tutoring systems, web resources and environments, spreadsheets, scientific databases, etc.) for both students and teachers (Srisawasdi, 2014). According to its features, these tools could provide opportunities for active learning, enable students to perform at higher cognitive levels, support constructivist learning, and promote scientific inquiry and conceptual change (Jimoyiannis, 2010). As such, there is a worldwide call for professional science teachers who are able to comprehensive use of ICT, and the challenge for teacher education in this century is to discover effective ways to prepare literate preservice science teachers and also to professionally develop inservice science teachers.

Over the last decade, traditional educational practice in teacher education no longer provide prospective teachers with all the necessary skills for teaching student to cope with this current knowledge-based society, especially in the fast changing world of early 21st century (Srisawasdi, 2014). Currently, Technological Pedagogical and Content Knowledge (TPACK) is a theoretical basis for development of teachers' expertise with respect to the integration of information and communication tools (ICT) into teaching and learning activities for particular subject matter (Koh & Chai, 2011). TPACK illustrates essential knowledge of how teachers could integrate technological tools into their

teaching of specific content in their school practice (Jimoyiannis, 2010; Srisawasdi, 2012). Research indicated that the experienced teachers seem reluctant to incorporate educational technology in schools, while preservice teachers and newly qualified teachers are more confident users of educational technology in classroom and are more willing to learn and adapt educational technology in their classroom practices (Madden, Ford, Miller, & Levy, 2005; Sime & Priestley, 2005; Anderson, 2006). In science education, it is, however, still not clear how best to prepare science teachers who are competent in using and managing educational technologies to support their teaching practice and enhance students' understanding about science (Srisawasdi, 2014).

To address the above issue, a pilot study was conducted to explore a preliminary result of an implementation of TPACK-focused preservice science teacher program for science degree-graduated students. This study seeks to describe preservice science teachers' technological pedagogical knowledge and technological content knowledge after finishing one-year coursework in the program. Moreover, this paper aims to provide evidence of preservice science teachers' use of the TPACK framework resulting from the preservice science teacher education program. Finally, implications for the design of preservice science teacher program for science degree-graduated students then are discussed.

2. Technological Pedagogical and Content Knowledge (TPACK) and Teacher Education

TPACK is currently an important fundamental framework in community of research and practice for educational research, especially in teacher education (Chai, Koh, & Tsai, 2010; Jimoyiannis, 2010; Srisawasdi, 2014). According to the framework, many studies showed that teachers who demonstrate TPACK can effectively integrate their knowledge of technology with their pedagogical and content knowledge to promote student learning (Niess, 2008; Harris and Hofer, 2011; So and Kim, 2009). In this light for science teacher education, both preservice and inservice science teachers are targeted to improve teaching proficiency based on the implementation of TPACK in many kinds of instructional intervention i.e. coursework (e.g. Niess (2005), Jimoyiannis (2010), Jang & Chen (2010), Srisawasdi (2014)), training (e.g. Hennessy et al. (2007), Guzey & Roehring (2009), Alayyar et al. (2012), and workshop (e.g. Annetta et al. (2013)). As such, it is clearly that the development of science teacher education program based on TPACK framework is important in order to prepare and cultivate science teacher for gaining high quality teaching competencies by integrating technologies into their science teaching practice.

3. General Description of Science Teacher Education in Thailand

In Thailand, there are two main pre-service science teacher education programmes. The 5-year undergraduate degree programme known as the Bachelor of Education (B.Ed.) programme is the programme which offer candidates the choice of teaching at either the primary or secondary levels of science education. The 5-year preservice science teachers have to enroll in all compulsory coursework for four years and then complete one year of school internship. The another preservice programme is 2-year Postgraduate Master of Education (M.Ed.) for teaching at the upper secondary education level for those who already possess at least a Bachelor's Degree of Science (B.Sc.), called The Promotion of Science and Mathematics Talented Teachers (PMST) program. For this programme, the preservice teacher have to enroll in all compulsory coursework in three semesters for one year and then complete one year of school internship and conduct their Master's degree theses at the same time.

4. Research Methodology

4.1 Study Participants

A total of 54 PMST preservice science teachers enrolled in Master Degree of Education in Science and Technology Education programme at Faculty of Education, Khon Kaen University, Thailand,

were the study participants. These teachers were in the third semester of their M.Ed. programme in academic year 2013. They were 14 preservice physics teachers, 20 preservice chemistry teachers, and 20 preservice biology teachers. They were 43 females and 11 males and they age between 23-25 years old. About twenty-five percent of the preservice teachers had a job before attending this programme and another just finished a Bachelor's degree of Science. About fifty percent had experience working with children in a classroom setting or in a tutoring situation.

4.2 Details of the Course Arrangement

In order to cultivate TPACK for the preservice science teachers, a series of coursework in M.Ed. Science and Technology Education at Faculty of Education, Khon Kaen University was particularly designed for science degree-graduated student. At the faculty, preservice science teachers completed a sequence of five science education method courses across three semesters. The program faculty for science education teacher preparation had infused research-based strategies as well as student-centered approaches into the program. Thus, a commitment to modeling student-centered approaches and learning from authentic and up-to-date researches were evidence in the instructor's values for these method courses. For example, the courses of technology-enhanced learning in science education was conducted in a manner that the instructor minimized content delivery via lecture and engaged students in many active learning activities, such as small group discussions, panel presentations, and team planning workshops, as well as the professional laboratory practice in science education. Also, scenarios, examples and problems that are important both in workplace and in society in general were crucial in these course. However, they also undertook four general methods courses in the first two semesters.

4.3 Data Collection and Analysis

The researchers collected data by considering the preservice science teachers' poster presentation during an intensive seminar organized in the last three weeks of the third semester. All the preservice science teachers were presenters and they were assigned to create a poster and present their science teaching ideas and research in science education to science educators in ten minutes. After each poster presentation, they were asked by four science educators to clarify their thought for 5 minutes. The researcher performed the content analysis of the preservice science teachers' TPACK based on their poster contents and presentations, and the question-answer session. Inter-rater agreement was conducted by two raters and the reliability was, finally, established a completed agreement. For this pilot study, the majority of the study was on the preservice science teachers' technological knowledge (TK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK) only. Each knowledge type was coded into three types of knowledge related technology in TPACK framework. Moreover, characteristics of TK-PK interaction and TK-CK interaction also were investigated in order to describe their thought about using technology in science teaching and learning. For TK-PK interactions, T-disassociated PK extents to which instructor uses technology separately from teaching strategy selected. T-assisted PK extents to which instructor uses technology as a supporting tool to teach following the selected strategy. T-enhanced PK extents to which instructor pedagogically involves technology into the process of learning by its nature, as a part of learning process. Finally, T-transformed PK extents to which instructor pedagogically use technology to transform regular learning process following a specific learning model or teaching strategy.

5. Results and Discussions

Results showed that about a half of the preservice science teachers (51.85%) thought about the use of technology in their own research and teaching ideas. From the content analysis, the preservice science teachers' research and teaching ideas on the poster presentation were coded inductively and then identified their teaching idea on the use of technology. The results of technology used for their research and teaching ideas was presented in Figure 1.

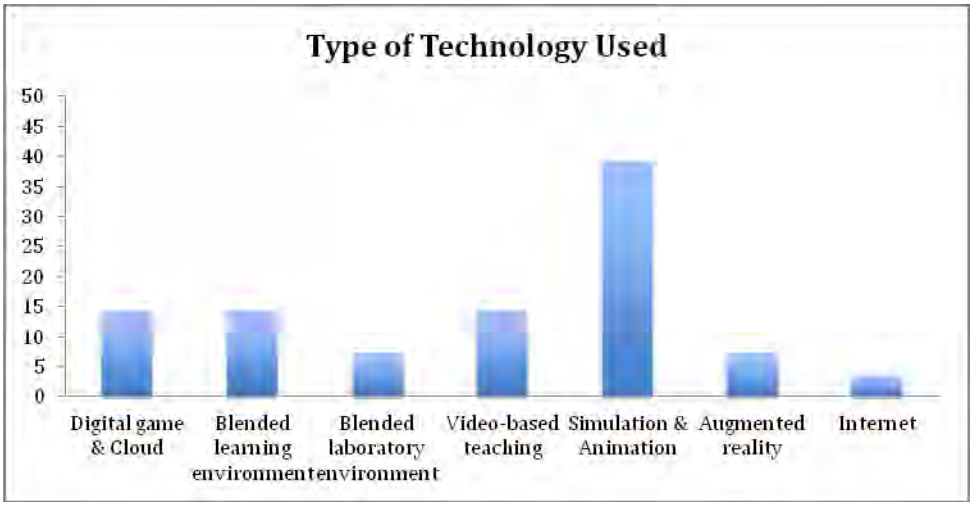

Figure 1. Percentage of type of technology used for the preservice science teachers's research and teaching ideas

A graphical representation of Figure 1 showed that the preservcie science teachers favor to use digital technology in science lesson. Most of them (39.29%) recognized that scientific visualization technology such as simulation and animation was a pedagogic tool for science teaching and learning. About 14.29% of them who selected to use digital game & cloud technology, blended learning environment by microcomputer-based laboratory (face-to-face) and web-based inquiry science environment (online), and video-based teaching, respectively. In additions, they decided to use blended laboratory environment by microcomputer-based laboratory (actual lab) and computer simulation (virtual lab), and augmented reality technology in 7.14% each type. Only one of them (3.57%) decided to employ internet for student's inquiry in science class.

In Figure 2 and 3 that follows, it presents the percentage of coded segments over the poster presentation for each of four categories of TK-PK interaction, and TK-CK interaction, respectively.

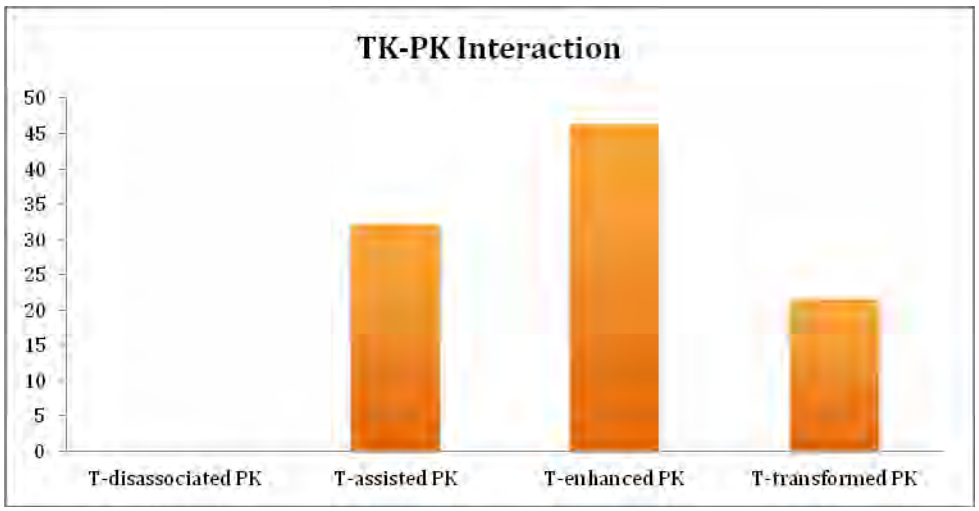

Figure 2. Percentage of characteristics of TK-PK interaction on the use of technology for science teaching and learning

According to the TK-PK interaction result, it showed that all of the preservice science teachers who decided to use technology in science lesson could identify how to pedagogically use technology for science teaching and learning. There were 46.43%, 32.14%, and 21.43% of them who could use technological tools to enhance (T-enhanced PK), assist (T-assisted PK), and transform (T-transformed PK) pedagogy of science teaching and learning, respectively, in their research and teaching ideas, as seen in Figure 2.

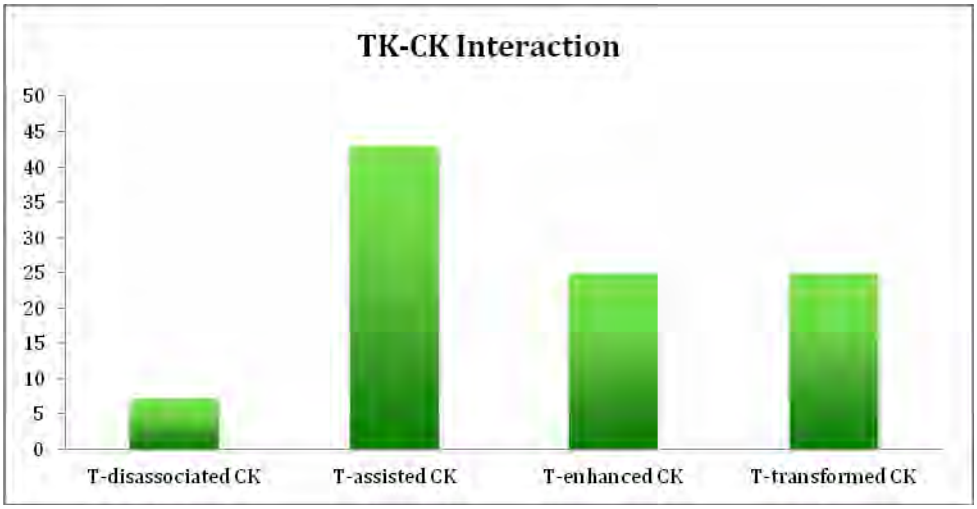

Figure 3. Percentage of characteristics of TK-CK interaction on the use of technology for science teaching and learning

According to Figure 3, the result on TK-CK interaction revealed that 93.86% of them understood the ways to use technology to simplify scientific knowledge. In the other words, there was 42.86% of them could use technological tools to assist (T-assisted CK) the presentation of scientific knowledge to student. Another, they proposed to use technological tools in a manner of enhancement (T-enhanced CK) and transformation (T-transformed CK) of scientific knowledge in 25.00% each characteristics.

In a summary, the results of this pilot study provided evidences that the preservice science teachers' TPK and TCK has been cultivated during their enrollment in the TPACK-oriented science teacher program for science degree-graduated student. This finding is consistent with Jimoyiannis (2010), Jang & Chen (2010), and Srisawasdi (2014) that implementation of well-designed coursework could foster preservice or inservice science teachers' essential knowledge of TPACK. As the measure of the TPK and TCK, the results indicated that the preservice science teachers' perceptual understanding on the ways to use technological tools to enhance pedagogy of science teaching (T-enhanced PK) is higher than others, compared to the use of technology to assist (T-assisted PK) and transform (T-transformed PK) the teaching of science. According to their TPK and TCK development, the preservice science teachers' TPK was more prevalent than growth in their TCK. This finding is consistent with Graham, Cox, & Velasquez (2009) who have reported that science teachers significantly increased their TK, TPK, TCK, and TPCK after attending a university-based professional development focused upon content, inquiry-oriented pedagogy, and educational technologies, and the TCK had the lowest mean score for their development. However, the findings of this study clearly showed the need for further classes or coursework in order to complete preservice science teacher's TPACK.

6. Conclusion and Implication

This paper reported a pilot study result of an implementation of TPACK-oriented science teacher program in context of two-year Master degree of Education in Science and Technology Education for graduate student who finished four-year bachelor's degree of science. In TPACK-oriented science teacher program, the preservice science teachers have been fostered their TPK and TCK in science teaching and learning. In an effort to better serve the needs of high quality science teachers, the results of this pilot study illustrated that the TPACK-oriented program for science teacher could be particular considered as a potential attribute for development of science teacher education in future. Therefore, an implication of this is the possibility that TPACK-based approach for professional development should be implemented into courses of teacher education program in a long time in order to effect any lasting changes and completion in preservice science teacher's TPACK.

Acknowledgement

The author wishes to gratefully acknowledge the financial support by Faculty of Education, Khon Kaen University, Thailand.

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