DEVELOPMENT OF TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE THROUGH PROJECT-BASED LEARNING

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Abstract: *The aim of this case study was to better understand how TPCK can be developed through Project-based Learning (PjBL). Accordingly, a course was designed and a purposively sampled group was selected for collecting in-depth data. The findings of the study demonstrated that teachers' knowledge and conception of using technology for teaching developed in three levels. With each level, there was an improvement of teachers' TPCK and its components as a result of performing PjBL activities. First level was limited to using technology for exhibiting curriculum information. The participants used software and Internet facilities for exhibiting curriculum information corresponding to the content. In the second level, the participants focused on using technology to present content and materials. The results indicated that in this level although two components of the participants' TPCK, viz. TCK and PCK developed, considering technology as a learning tool (TPK) appeared to be missing. However, in the third level they developed the ability to use technology for enhancing teaching and learning.*

Keywords: *Instructional technology, Technology integration, Teacher education, Development of TPCK, and PjBL*

INTRODUCTION

Researchers have argued that teaching technology skills out of context and as separate skills is not adequate to prepare teachers for teaching with technology in their classroom (Vrasidas&McIsaac, 2001; Flick & Bell, 2000; Koehler, Mishra &Yahya, 2007). Thus, the integration of technology into curriculum for effective technology usage is suggested by many studies (Lee, 2002; Cradler, et al 2002; ISTE, 2000; Woodbridge, 2004; Vrasidas&McIsaac, 2001; White, Ringstaff, & Kelley, 2002; Willis, 2001), in order to prepare teachers for teaching with technology. Accordingly, the TPCK framework introduced by Mishra and Koehler (2006) is offering opportunities for teachers to learn how to integrate technology in curriculum. TPCK refers to the complex interrelationship between a teacher's technological knowledge, pedagogical knowledge, and content knowledge. TPCK refers to the complex interplay between a teacher's technology use, knowledge about teaching and learning process and understanding of the subject matter.Although the complexity of teacher knowledge makes it extremely difficult to represent, the TPCK framework seems promising in studying the development of teacher knowledge regarding integration of technology (Mishra & Koehler, 2006). Accordingly, the development of TPCK has received the attention of educators and researchers because it appears to be instrumental in enabling teachers

to effectively use technology in teaching. However, there is a need to understand more about how TPCK can be developed through different approaches and methods. As such, the current study focuses on exploring how teachers develop TPCK in a PjBL context. . The project-based learning (PjBL) approach was identified because a number of studies (Koehler, et al., 2004; Koehler, Mishra &Yahya, 2007; Cavin, 2007; Harrington, 2008; Suharwoto, 2006) have shown the potential of constructivist environments to develop TPCK.

METHODOLOGY

This study utilized the case study method (Merriam, 1998) because it intends to study "how" teachers develop TPCK

Research Context

Since the goal and the plan of learning activities corresponding to the "*Application of Computer Software in Elementary Education"*(ACSEE) course appeared to be in-line with this research, the ACSEE class held at Psychology and Education College was selected as the research setting. The class met at a technology lab for 4 hours once a week for 14 weeks. The technology resources available for these classes included 16 computers with Internet access with software such as Microsoft Office 2007, SPSS, Flash, Adobe and some other common software.

Sampling

Since the aim of the case study research is to develop an in-depth understanding and exploration of a central phenomenon, a sample needs to be selected based on the most relevant data. Therefore, the sample for the study is small, non-random, and purposeful (Merriam, 1998). Samples of this case study were selected in two levels. In the first level, participants who were already enrolled in the course for teaching with technology based on TPCK were assumed as a unit or a case. In the second level, group PRD as a sub-unit was purposefully selected within the case during the data collection.

Participants

The participants of the study included 30 pre-teachers enrolled for ACSEE course in the 2nd semester of the academic year 2010-2011.

Setting the Stage for Project-based Learning

The current study used a *constructivist environment* as the research setting and the activities were planned and conducted based on Project-based-Learning.Accordingly, the following criteria were considered to set the stage for the PjBL process.

a. PjBL provided a *learner-centric environment*. In this environment, the role of the instructor was not to prescribe which kind of technology a teacher should use for teaching, but to provide opportunities for helping the teachers to learn how to use technology and pedagogy for the particular content.

b. During the program, the participants worked on an actual *real-life problem* or issue as the topic for their project.
c. The participants worked *collaboratively* in small groups while carrying out the project.
d. The participants learned the technology through *design tasks*. The role of the participants in this course was as a designer and they experienced technology integration in teaching *by doing*.
e. They received *feedback* during the project from each other and the instructor.
f. As the outcome for PjBL activities, teachers were asked to *design the lesson* study with use of technology and created a *product* as an end result.

Data Collection

In qualitative research, data are in the form of words and are collected from people about their experiences; options, feeling, and knowledge obtain through interviews, detailed descriptions of people activities, behaviors, actions record in observation and document (Merriam, 1998). In this study, the collected data provided opportunities to obtain a clear picture of the development of the teacher's thinking and belief systems regarding technology integration while carrying out the project including observations, interviews, artifacts and documents.

Data Analysis

In this study the data was gathered along with some notes and comments. Subsequently, data was coded based on two sets of factors. At first, collected data was coded and categorized based on the strategies, conditions and also teachers' behavior, activity, actions, feeling and experience in order to find the patterns which are helping teachers in the development of their TPCK. Every category was considered as a conceptual element that covers many individual examples to find the patterns that help in the development of TPCK. In addition, the collected data was coded based on the seven categories defined by the TPCK framework, namely, C, P, T, CP, CT, PT and CPT (Koehler et al., 2004; Mishra & Koehler, 2006; Koehler et al., 2007). These coded data led the researcher to determine in which way participants made the relationship between their knowledge about pedagogy, technology and content and how their TPCK develops.

DISCUSSION OF FINDING

To answer the research question of how teachers' TPCK developed in Project-based Learning setting, the results of the study demonstrated that teachers' knowledge improved in three levels. With each level, there was a development of teachers' TPCK and its components as a result of performing PjBL activities.

First Level: Using Technology for Exhibiting Curriculum Information

The participants' initial perception of use of technology for teaching was limited to using software and the Internet facilities for exhibiting curriculum information corresponding to the content. However, the PjBL environment developed some basic knowledge of TPCK in the participants at this level through *general guidance*

from the instructor, interaction and *learning by doing*. The course started with about 30 minutes of introductory explanation by the instructor. The introductory talk was as to alert the participants to be aware about TPCK. Although the instructor did not directly mention about the TPCK framework, the participants were receiving some basic concepts of TPCK by: 1) Observing the instructor's method of teaching and how he was using technology tools for instructional purpose, 2) Reviewing some information about tools and software that were designed exactly for teaching a particular content on Zoho wiki., and 3) The theoretical explanation of the instructor about how technology can be used to enhance learning. In the first step of the project, the group started *learning by doing* to get new experiences in computer skills in the class, without any focus on a particular topic or technology tool. For example, the PRD group was practicing with different software which were introduced by one distance learning website. They installed many of those software to find which program was suitable to their topic. One of the candidates in this group expressed:

> *I really didn't know computer program can be used for facilitating or enhancing learning. Before this session, I didn't notice any software or tools for learning.* [Farbod (1st session)]

Since making the project was a team effort, the groups started *defining the roles* in the group and *sharing experiences*. To scaffold the group, the members interacted and got familiar with each other's background, abilities and interests. Most of the groups accepted at least one experienced teacher and also one member who had sufficient technology skills. These two roles were basic in the groups and the leader of each group was holding one of these roles. When the group members became more familiar with each other's abilities, they shared their general knowledge and experiences about Technology, Content and Pedagogy and defined their roles in the group activities (Mishra and Koehler, 2004). As the previous studies (Guzey&Roehrig, 2009, Riales, 2011 and Cavin, 2008) have illustrated, although the participants did not "receive" any new knowledge about Content and Pedagogy from the instructor during the course, sharing their experiences developed their knowledge in CK and PK. They discussed about different subjects to select the topic of the project and the way in which each topic is usually taught. In this way, their Pedagogical Content Knowledge (PCK) progressed through *intra group interaction*. The thick description of the data from the analysis of the artifacts in this level of development of TPCK indicated that although the participants promoted their TK through *learning by doing* and developed their knowledge of CK, PK, TK and PCK by *knowledge sharing*, the firstdreaft of the project was a result of *cooperation* of only two of the four participants rather than collaboration similar to the result of Cavin's (2008) study. However, the first draft of the project was incomplete and showed that the conception of the participants was doing technology rather than using technology, similar to the findings described by Harrington (2008).

Second Level: Using Technology to Present Content and Materials

In this level of development of TPCK, the participants began to change their views on using technology for presenting after receiving feedback from the instructor. They started to seek for more objective materials such as images, videos and games related to the content area. For this purpose, they had to identify and analyse important concepts of the content and find material related to those concepts. In fact, the process of the development of their knowledge continued after *receiving feedback from the instructor*. When the instructor observed how participants were going in wrong directions, he provided them *feedback* to lead them to recognize the use of technology for making the particular content easier to understand rather than finding information which happens to be available. At this level, the instructor was more specific to offer feedback by asking some questions like:

-Do you think that your project can be implemented in a real class?

-How does it help teachers or students to teach or learn better?

According to the received feedback, the group engaged in finding or creating materials about the selected content. Therefore, the groups continued *learning by doing* with attention to the received feedback. They decided to find and use different materials like pictures, videos, games, student activities, theoretical documents etc. suitable for the selected topic to enhance learning of students. These activities which involved gathering materials from different sources increased the TK of the participants. Further, in this level the participants significantly developed their knowledge towards appropriate technology for the selected topic (TCK) through these activities. At this level of development of TPCK, the participants performed the second versionof the project which was made ready by *collaboration* of group members. However, the analysis of the artefact and also discussion in the group indicated that although TCK and PCK of the participants developed, considering technology as a learning tool (TPK) appeared to be missing. This version of project included gathered materials related to the topic. Therefore, the project that was implemented in the class had many gaps.

Third Level: Using Technology to Enhance Teaching and Learning

Teaching with technology as using a combination of technology, pedagogy and content knowledge formed only after the participants received feedback on the second version of their project implemented in the class which gave the opportunity to the groups to experience *implementing their teaching with technology* in a real classroom. In line with the findings of Riales's (2011) research, implementation of the project in the class caused the participants in other groups to experience the role of learners instead of teachers and evaluate the teaching from the student's perspective. Also, it allowed the participants to predict student's thinking through this activity. In addition, by implementing the project in the class, some defects and gaps in the project appeared to the group members. This finding is consistent with earlier research (Tee and Lee, 2011) which revealed that implementing the project in the class and receiving feedback from other groups created an opportunity for participants to interact with the real-world problem and explore new ideas. This challenge led the participants to revise their project by *identifying and eliminating*

gaps .For example, after PRD group presented their work, participants from other groups in the class offered some important comments and questions that helped to improve their project such as:

> - *Your students are in the first level. Why did you use some words when they are still not able to read? Is it for teachers or students? It appears you changed your audience in the middle of your content (PCK)*
>
> - *You showed some slides with empty spaces in some places as if you want students to fill it up after your teaching. It can be written down on paper. I think both the teacher and students would be more comfortable that way. (TPK)*
>
> - *One or two slides that you made could have been presented using paper without any difference in effect. Do we really need to use them? (TPK)*

Similar to the findings of Riales (2011), most of the needed changes after the implementation were related to pedagogy rather than technology. Therefore, the participants returned to continue working on their project with new knowledge and experiences which they had gained with regard to strengthening relationship between content, pedagogy and technology. The data emerged from observation showed that after presenting the projects, the participants felt more comfortable *exchanging their knowledge* across groups to improve their respective projects. Although the topics of projects were different across groups, some techniques used in the projects were similar. By *interacting* with other groups the participants experienced how technology tools could be used for instructional goals regardless of content area (TPK). However, evidence of development of TPCK occurred when the participants completed their work with a critical view during *collaboration*. In this respect, the group evaluated the project through discussions. As noted above, since most of the deficiencies in the projects related to the technology used for enhancing learning, groups started to review their respective projects, step by step, considering relationship between Pedagogy and Technology (TPK). In this regard, the participants tried to find new ideas to integrate technology in their pedagogical content knowledge. For example, in one group the experienced teacher was describing how she usually taught in her classroom, step by step, and other members were trying to accommodate it with their technology knowledge:

> *Giti: When I want to teach about BIRDS, first I ask my students to recall names of animals that they already know and have seen. (PCK)*
>
> *Zeynab: Hmm...for this question we can show the pictures of different animals. Then what do you do? (TCK)*

Giti: Then I ask them to tell me which of them are flying and direct the topic to BIRDS. (PCK)

Zeynab: Don't you think it is better if we start from the BIRDS from the beginning? (PCK)

Samane: I think we can do everything as she teaches here on PC. We can show many animals and then create some emphasis on the pictures of birds. Then we introduce the main topic as BIRDS. (TPCK) [9th session]

Finally, in the last step, the participants formed an interrelationship between technology, pedagogy and content and as a result developed their TPCK. They understood that every decision about selecting one of technology, pedagogy and content, should consider all those components. In concurrence with previous findings (Harrington, 2008 and Riales, 2011), the comment from the instructor in the interview after the last session revealed that there was a change in the participants' perceptions and their feeling about their knowledge:

I think there wasn't just a change in the knowledge and skills of the participants. There was a change in their beliefs of using technology for teaching. In the initial weeks, everything appeared like a great challenge for the groups and even me. There was a huge difference between my view/expectations and the views/ expectations of the participants with regard to use of technology in teaching. We should have destroyed their previous perception about using technology for teaching to build a new one. But gradually they improved and even enabled themselves to evaluate their work within the group before I commented on them. [The instructor (14th session)]

Analysis of the project created by the group indicated development of participants' TPCK. While the initial versions of the project included some technology affordances using different colours and motions, which were used merely because it was attractive, in the last version, most of the clip-arts, images and motions were selected based on enhancing teaching and learning and in light of the learning goal.

CONCLUSION AND RECOMMENDATION

The findings demonstrated the potential of PjBL setting for the development of TPCK. The findings showed how intra and *inter group interaction* and also *receiving feedback* from the instructor (Oster-Levinz and Klieger, 2010) and from other groups (Tee and Lee, 2011; Cavin, 2008) helped the participants to develop TPCK. Further, similar to previous studies on the development of TPCK, the results suggests the crucial role of *collaboration* in the development of TPCK (Niess, 2008; Kocoglu, 2009; Suhawoto, 2006 Mishra & Koehler, 2006, 2007; Cavin, 2008; Kim, 2009; Guzey and Roehrig, 2009; Harrington, 2008; Riales, 2011). Intra group

collaboration along with inter group interactions created a fruitful ground for the development of TPCK and changed the perception of pre-service teachers' use of technology for teaching by making the relationship between technology, pedagogy and content knowledge. Furthermore, *learning by doing* helped in the development of TK.. Also, doing PjBL activities provided the opportunities to make artifacts and develop TPCK (Rodriguez, 2006). In brief, the study revealed strong evidence that PjBL can help facilitate the development of TPCK. However, with emphasis on effective use of technology, further researchis needed to track the participants to know how they transfer TPCK into practice in the actual classroom.

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RAPTOR: PERSEKITARAN PENGATURCARAAN CARTA ALIR SECARA VISUAL BAGI TEKNIK PENYELESAIAN MASALAH DALAM BAHASA PENGATURCARAAN

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Abstrak: *Pembelajaran bahasa pengaturcaraan adalah sukar dan mencabar bagi kebanyakan pelajar. Kebiasaannya, pelajar memperuntukkan masa yang lebih untuk menguruskan sintaks yang kompleks. Situasi ini menjejaskan peluang untuk pelajar mempelajari teknik penyelesaian masalah yang merupakan antara objektif pembelajaran bahasa pengaturcaraan. RAPTOR (Rapid Algorithms Prototyping Tool Of Reasoning) adalah persekitaran pengaturcaraan ikonik yang direka bentuk untuk membantu pelajar melakukan visualisasi kelas serta mengurangkan kompleksiti pembelajaran bahasa pengaturcaraan. Kajian ini bertujuan untuk menilai kebolehgunaan dan keberkesanan teknik penyelesaian masalah dalam bahasa pengaturcaraan secara visual dengan perisian RAPTOR. Seramai 57 orang pelajar sarjana muda telah dipilih secara rawak daripada program teknologi maklumat dari salah sebuah institut pengajian tinggi awam di Malaysia. Dapatan kajian Kebolehgunaan mendapati sebanyak 60% responden bersetuju untuk menggunakan RAPTOR sebagai teknik penyelesaian masalah, manakala 70% berpendapat RAPTOR mudah dipelajari. Kajian pra eksperimental jenis satu kumpulan ujian pos digunakan dalam kajian ini bagi menilai keberkesanan pelbagai teknik penyelesaian masalah. Dapatan menunjukkan RAPTOR dapat membantu meningkatkan penguasaan dan kepuasan pelajar bagi penyelesaian masalah dalam subjek bahasa pengaturcaraan. Oleh demikian, penggunaan RAPTOR disaran untuk diperluaskan penggunaan dalam pembelajaran subjek bahasa pengaturcaraan di peringkat universiti.*

Keywords: *Teknik penyelesaian masalah, pengaturcaraan visual, RAPTOR, carta alir, bahasa pengaturcaraan dan logik.*

PENGENALAN

Pelbagai teknik penyelesaian secara konvesional yang telah diperkenalkan seperti pseudo code, algoritma dan carta alir sejak dahulu lagi. Setiap satunya mempunyai kekuatan masing-masing. Secara umumnya teknik penyelesaian masalah merupakan satu set arahan langkah-demi langkah untuk menyelesaikan sesuatu tugas atau masalah. Kita sentiasa menggunakannya dalam seharian tanpa disedari.Namun begitu, teknik penyelesaian masalah merupakan pengukuran kepada keupayaan seseorang untuk memahami, melaksanakan, menilai dan menyelesaikan sesuatu masalah. Keupayaan seseorang untuk memahami dan melaksanakan adalah penting