Fostering pre-service mathematics teachers' technological pedagogical content knowledge (TPACK) through the learning community

IOP Conf. Series: Journal of Physics: Conf. Series **1097** (2018) 012094 doi:10.1088/1742-6596/1097/1/012094

Fostering pre-service mathematics teachers' technological pedagogical content knowledge (TPACK) through the learning community

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Abstract. Technological Pedagogical Content Knowledge (TPACK) is one of the major framework for assessing the knowledge of a teacher in integrating appropriate technology with pedagogy in the teaching content for fostering students' learning. This research aimed to study on pre-service mathematics teachers' level of TPACK after engaging in a learning community during their teaching practicum. The samples were three pre-service mathematics teachers who studied in Mathematics Education Program of Yala Rajabhat University, Thailand selected by purposive technique. Each pre-service mathematics teacher taught the students in different mathematics contents and involved in the learning community which were arranged by the researcher every Wednesday evening or as convenience regularly in order to share and reflect on their teaching. Qualitative data analysis using content analysis was employed to analyze TPACK level of the pre-service mathematics teachers based on TPACK Developmental Model from the data gathered in the focus group discussion during involving in the learning community. The result showed that there are two pre-service mathematics teachers whose TPACK were identified in level 4 (Exploring) and the other one was identified in level 5 (Advancing) which are considered as good level. These finding indicated the successfulness of the learning community in developing pre-service mathematics teachers' TPACK. The relevant suggestions are discussed.

1. Introduction

Teaching and learning of mathematics can benefit from further innovations and improvement. The challenge of the education in this era is to find out and develop the effective and valuable tools for teaching and learning. Especially in the 21st century, the use of technology in teaching and learning has a profound effect on students' learning due to the technology is an effective intellectual tool to pass on the way of teaching in the particular content. Therefore, technology facilitates the teaching of the teacher and supports the learning process of the learner. Additionally, the effective teaching and learning needs the capability of the technology in collecting, organizing and evaluating the data in order to be a guideline for solving problems in the actual situations in everyday life [1,2]. Nowadays technology has taken the important role in the human's life and lead to the educational change. Technology offers many opportunities for learning and can change the way of teaching and beliefs of teachers in teaching and learning [3]. Kay [4] mentioned that teaching and learning in 21st century must have well ordering process which allows students to effectively participate in the teaching and

learning. These will lead the students to be able in analyzing and integrating their knowledge with other subjects. For this reason, teachers in this era need to learn the skills in designing lessons which emphasizing the use of technology and use the designed lesson to meet the learning objectives of the learner in the curriculum [5]. Therefore, the integration of the technology in teaching and learning is important in conveying content through the appropriate teaching strategies.

Technological Pedagogical Content Knowledge or TPACK is a combination interacting between the notions of content, pedagogy and technology knowledge. TPACK is considered as a key basis to facilitate a successful teaching by using of technology. This integrated strategy enables to provide teachers with a better understanding on represented concepts which combine technology and pedagogical techniques together. With the use of TPACK in a constructive way, it is found to be useful to convey a variety of teaching contents and knowledge which lead to solving problems in different concepts with technology, comprehending students' knowledge in theories of epistemology, and realizing how to apply technology to expand existing knowledge, to develop new epistemologies as well as to strengthen the old ones [6].

The concept of integrating the knowledge of technology, pedagogy and teaching content has evolved from a theoretical framework of Shulman [7] on the knowledge of integrating pedagogy and teaching content (Pedagogical Content Knowledge) or PCK. But when technology comes and plays an important role in education, Mishra & Koehler [8] developed a new theoretical framework in the knowledge of integrating technology with pedagogy and teaching content called Technological Pedagogical Content Knowledge or TPACK. Mishra & Koehler [8] defined TPACK as the knowledge of a teacher in integrating technology with teaching methods and content by integrating three main knowledge which are Technological Knowledge, Pedagogical Knowledge, and Content Knowledge in order to make the teaching and learning more effective. Therefore, it is essential for teachers to have the knowledge and understand how to integrate these three aspects together. The TPACK framework is shown in Figure 1.

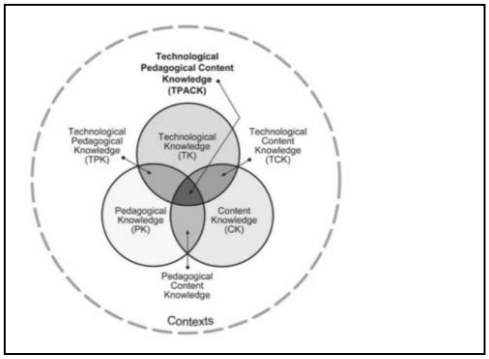


Figure 1. TPACK Framework [8].

In addition, Niess et al. [9] proposed a model for the development of TPACK called TPACK developmental model which mathematics teachers should develop their knowledge in integrating technology with pedagogy and teaching content through the 5 hierarchical steps starting from Pedagogical Content Knowledge or PCK. When technology is used in teaching and learning, teacher will develop a level of integration of technology into pedagogy and teaching content from level 1 (Recognizing), level 2 (Accepting), level 3 (Adapting), level 4 (Exploring) and level 5 (Advancing). The last level will show the successfulness of integrating technology with pedagogy and teaching content or the TPACK level of the teacher [9] as shown in Figure 2.

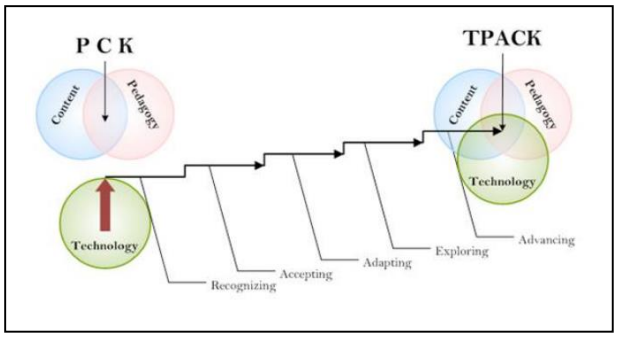


Figure 2. TPACK Developmental Model [9].

Despite the availability of hardware and software in the technology-rich secondary school and the importance of integrating technology in the teaching and learning, teachers rarely use computers in their teaching because they believe in their existing pedagogy, they concerned about time constraint and their preference towards some particular text resources. Moreover, some teachers had restricted images of the potential of computer in the teaching and learning because they have absorbed images of teacher-centered and content-focus pedagogy [10,11,12]. In addition, a research on measuring mathematics teachers' TPACK in three southernmost provinces, Thailand found that The level of knowledge in integrating technology with pedagogy and teaching content of the teachers still be in the medium level [13]. This might because of the teachers have not been fostered the use of technology in teaching and learning from some courses in the curriculum during they were in the university. It was found that the bachelor degree students in education who were cultivated the use of technology in teaching and learning will realize the importance of technology in organizing effective teaching and learning in particular subjects [14]. Moreover, the training programs in integrating technology in teaching and learning for the bachelor degree students affect the knowledge of integrating technology with pedagogy and teaching content [14]. Therefore, it is essential that the university with the mission of producing teachers must cultivate the knowledge of integrating technology with pedagogy and content to the students in education program through the courses in the curriculum. Especially for students in mathematics education program, they should be involved in some courses on how to use technology such as mathematical software in teaching the particular concepts of mathematics because mathematics is one of the abstract subject which is difficult for learners to understand and technology will lead students to create the instructional media for making the learner have better understanding in the particular mathematical concepts.

One of the method using in teacher preparation program is "the learning community". In this method, a group of people come in a setting community for sharing common academic interests and goals in teaching and learning in order to improve each other's knowledge, skills, and attitudes through exchanging, participative learning, and mutual encouraging [15]. They share a concern or a desire for the particular thing they do and learn how to do it better [16]. It is claimed that a sense of learning community using in some teacher preparation programs can foster learning and dissuade the intellectual and professional isolation of teachers [17]. Additionally, through the use of learning communities, more ideas can be inspired, theory can be connected with practice, and the community experience can continue at a later stage of practicum [17].

Yala Rajabhat University, Thailand provides the bachelor degree in Mathematics Education Program, this program encourage students to develop their knowledge in integrating technology with pedagogy and teaching content (TPACK) through the course of Technology Innovation for Mathematics Teacher for the fourth year students as identified in the study plan of the curriculum in order to lead the student learn about the various and appropriate technologies and also the methods in

integrating technology in teaching particular mathematics concepts for creating an effective teaching and learning for learners before going for the teaching practicum in the final year of the program.

Therefore this research aimed to study on the level of knowledge in integrating technology with pedagogy and teaching content (TPACK) of the pre-service mathematics teachers through the learning community setting by the researcher for fostering the TPACK level of the pre-service mathematics teachers based on TPACK developmental model during their teaching practicum. This will be a guideline for developing and promoting knowledge in integrating technology with pedagogy and teaching contents through the use of the learning community of the pre-service mathematics teacher which will lead to an effective teaching and learning in the future.

2. Methodology

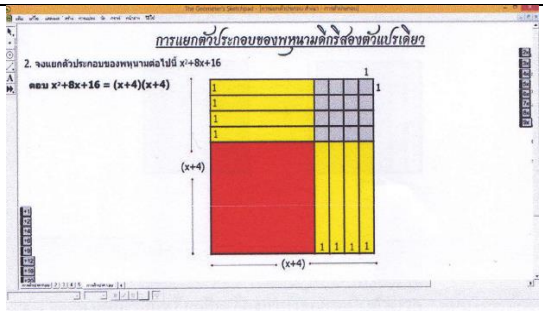
2.1. Research Design

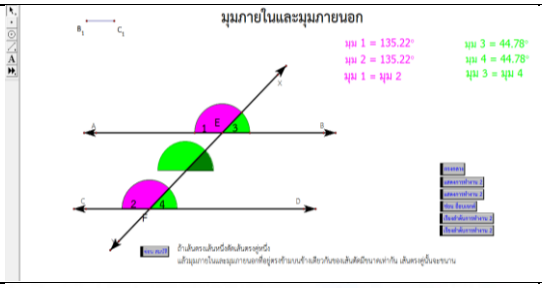
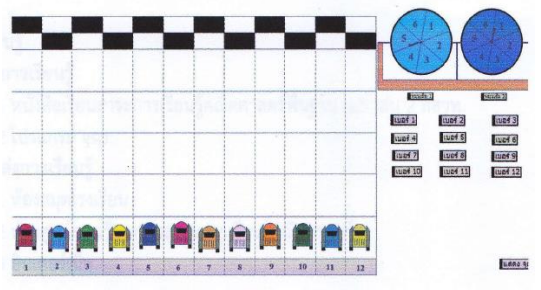
The qualitative research method using multicase studies for the three pre-service mathematics teachers in Mathematics Education program were employed in this study.

2.2. Participant

The participants in this study were three pre-service mathematics teachers in the final year of mathematics education program of Yala Rajabhat University who already passed the subject of Technology Innovation for Mathematics Teacher provided by the curriculum. The first two students went for their teaching practicum in the 2015 academic year and the other one student went for the teaching practicum in 2016 academic year in the different schools. These three participants were selected by the purposive technique from the students who were under the supervision of the researcher because these three students Gun, Nut, and Prin (pseudonyms) interested and decided to employ technology in their teaching during the teaching practicum. Table 1 shows the detail of the mathematics content which the participants were assigned to teach during their teaching practicum.

Table 1. The detail of the mathematics content which the participants were assigned to teach during the teaching practicum.

Pre-Service Mathematics Teacher	Teaching Content	Technology Used	Number of students in the classroom	Example of the Created Lesson by Integrating Technology (GSP Program)
Gun	Factoring polynomials of degree two of one variable (Grade 8)	GSP program	32 students (Grade 8)	

Nut	Parallel Lines (Grade 8)	GSP program	30 students (Grade 8)	
Prin	Probability (Grade 9)	GSP program	32 students (Grade 9)	

2.3. Instrument

The instrument using in this study were the questions for focus group discussion which the researcher set it as the learning community for fostering pre-service mathematics teachers' TPACK during their teaching practicum. The questions were;

- Can you identify the problems and the goals of the content which you are assigned to teach in the school?
- Can you explain the causes of the problems in the content which you are assigned to teach? Do you think technology can help in supporting the understanding of the learners in that content? What kind of the appropriate technology?
- How can you design the lesson by integrating technology that you have chosen for solving the problems or supporting the goals of learning?
- How does the technology in the designed lesson help in supporting the understanding of the learners in the actual class?
- Do you think the way of integrating technology in your designed lesson is appropriate? If not. How should the lesson be improved to make students have better understanding in that concept?

2.4. Data collection

The researcher collected the data of pre-service mathematics teachers' TPACK through the focus group discussion which was used as the learning community for fostering the pre-service mathematics teachers' TPACK based on TPACK developmental model defined by Niess et al. [9]. The learning community was conducted in every Wednesday evening or as the convenience regularly during teaching practicum. The interview for the school supervision teachers and the classroom observation were employed for triangulating the data to identify the TPACK level of the three pre-service mathematics teachers.

2.4.1. Focus group discussion as the learning community for fostering pre-service mathematics teachers' TPACK

The focus group discussion was employed in the learning community which arranged by the researcher for the group of pre-service mathematics teachers who were under the supervision of the researcher. There are one learning community in 2015 academic year which included six people consisting of five pre-service mathematics teachers and I as the researcher and another one learning community in 2016 academic year which also included six people consisting of five pre-service

mathematics teachers and I. There are two pre-service mathematics teachers in 2015 and one pre-service mathematics teacher in 2016 academic year who decided to use technology in their teaching during the teaching practicum. However, the other pre-service mathematics teachers who did not integrate technology in their teaching still also be in the group of the learning community. In the learning community, the researcher use five questions as mentioned in the previous section to lead student share, reflect and discuss based on what they were doing and experiencing. The focus group discussion sessions under the learning community were conducted in every Wednesday evening or as convenience regularly for fostering the development of the three pre-service mathematics teachers TPACK through the hierarchical steps of TPACK developmental model as defined by Niess et al. [9].

3. Data analysis

The qualitative data analysis using content analysis by employing TPACK developmental model adapted from Niess et al. [9] which has five level descriptors as a rubric score were employed in this study in order to identified the pre-service mathematics teachers' level of TPACK. Five level descriptors are as follows:

- Level 1 Recognizing: it is the level which the pre-service mathematics teacher is able to use and recognize the capability of technology in teaching. However, it has not been unwilling yet to integrate technology in their teaching.
- Level 2 Accepting: it is the level that pre-service mathematics teacher will form the positive or negative attitude in integrating technology in teaching mathematics at their specific grade level. The pre-service mathematics teacher may attend some professional development training about technology. Then they try to use the ideas from the training to the learners in their classroom and practice content ideas with technology but technology is not a consistent thought when they think about teaching the content.
- Level 3 Adapting: it is the level that pre-service mathematics teacher engage with the activities which will lead them to decide that they will adopt or reject the technology in teaching. Therefore, pre-service mathematics teacher will start to experiment with integrating technology as a teaching tool in their classroom (only in the low level cognitive activities such as drill and practice) to see whether they should adopt or reject the technology. They manage the classroom by using prepared worksheet to guide student in teaching the content.
- Level 4 Exploring: it is the level that those pre-service mathematics teacher eagerly integrate technology in their teaching contents. Therefore pre-service mathematics teacher who decide to use technology start to design lesson aligning with the curriculum which integrated technology as a learning tool for students that will build learners' understanding in particular mathematics concept. In this level, the pre-service mathematics teacher show an attempt to examine the different ways of teaching and willing to express their new ways of thinking regarding the content with technology as a learning tool.
- Level 5 Advancing: it is the level that pre-service mathematics teacher evaluate the results of integrating technology in teaching content and make changes in the curriculum to take advantages of technology affordances. By the capability of technology, they develop their lesson plan effectively by using technology in a variety of ways to help learners enhance their understanding of the content.

4. Results and discussion

4.1. Results on pre-service mathematics teachers' TPACK

The research found that, from the three pre-service mathematics teachers, Gun and Nut who taught the topic of Factoring Polynomials of Degree Two of One Variable and Parallel Lines in grade 8 respectively were identified the TACK level at level 4 (Exploring). This because of both of them eagerly integrated technology in their teaching contents. They decided to use technology in their designed lesson plan aligning with the contents in the curriculum in order to attract the interest and

build the learners' understanding in the content they taught. The excerpts below are the examples of what they said during engaging in the group learning community;

• Gun: "there is a problem occurred in teaching Factoring Polynomials of Degree Two of One Variable .From my classroom observation in another teachers' class, I found that some teachers used inappropriate instructional teaching media and some teachers did not have any instructional teaching media. These may make the learners have difficulties in learning. So, I intend to design activities using the GSP program by focusing on the area of the rectangle to represent the given variable for better understanding and put color in the pictures for more interesting."

• Nut: "Students will be able to understand this topic when they can prove the properties of parallel lines. So, I think creating the instructional teaching media by using GSP program to show the proof of the properties of the parallel lines will make them understand shortly. Because GSP can measure angles to determine properties and the translation of the figure in GSP lead them to prove on the equally of the angle. I intend to design activities on GSP program for proving the properties of parallel lines and make it colorful. During the teaching I found that students are interested and excited to see the proof of the properties through the GSP program. After teaching, I evaluate that the use of GSP program makes student understand and remember the properties of parallel lines faster.

The other pre-service mathematics teacher, Prin, who taught in the topic of Probability for grade 9 students was identified the TACK level at level 5 (Advancing). This because of not only he eagerly integrated technology in his teaching contents by deciding to use technology in his designed lesson plan for make lesson more easily to understand and more interesting, he also evaluated that the integration of technology into teaching content he taught is very valuable. Moreover, He tried to develop many of the effective activities by using the capability of GSP in various ways to make students have better understanding in the teaching content. The excerpt below is the example of what Prin said during engaging the group learning community;

• Prin: "The probability is usually taught by using real media such as dices or darts, but I think GSP can help. I will design the instructional media for teaching and learning probability by using GSP. The challenge is on how to make it realistic such as creating the spin wheel for the darts on GSP, creating the animation for representing tossing dice. These are great. In this topic, I added the designing of game activity by creating the car racing game on GSP program in which the students need to use the knowledge of probability for playing this game on GSP program. During teaching I found that the students were very interested in involving in the activities. The classroom become a very lively classroom especially in the game activities, voice and laugh reverberated over the classroom. GSP activities make me found the understating of the students.

4.2. Discussion

The TPACK level of three pre-service mathematics teacher after the teaching practicum as indicated in result of this study were considered as in the high level. This indicated that the curriculum for Mathematics Education Program fostering and promoting the pre-service mathematics teachers to learn the use of integrating technology with the pedagogy and teaching content and also enhancing the level of their TPACK through the course of Technology Innovation for Mathematics Teacher provided in the curriculum for 4^{th} year students. This course started from introducing the various technology such as mathematical software for making pre-service mathematics teachers familiar and realize the benefits of technology then allow them to design the instructional media through the technology using by following the given example. After that, pre-service mathematics teachers need to create their own activity by using appropriate technology for making the abstract mathematics contents to be more concrete. This consistent with the hierarchical step of TPACK Developmental Model defined by Niess et al. [9]. And when they need to go for their teaching practicum as a pre-service mathematics teacher in the final year, they will be able to apply the TPACK knowledge in creating mathematics teaching and learning activities. This consistent with the study of Groff & Mouza [14] which mentioned that the pre-service teacher who passed the course which emphasizing technology usage have the development of the TPACK level and be able to applied the TPACK knowledge in practice. Moreover, the learning

community which lead the pre-service mathematics teachers to share, reflect and discuss on integrating technology in crating the effective teaching makes them enhance their level of TPACK. This consistent with the study of Chang, Hsu, & Ciou [16] which highlighted that the use of learning communities can improve pre-service teacher's TPACK.

5. Conclusion

This research highlighted the importance of the technology training courses which provided in the curriculum for Mathematics Education Program students and also the learning community which allow students to share, reflect and discuss in integrating technology for crating the effective teaching. These lead pre-service mathematics teachers to realize on the usefulness and be able to integrate technology when they go for their teaching practicum. The effective teaching by integrating technology of the pre-service mathematics teacher will help the learners to have a meaningful learning and understand the contents accurately, easily, and lead to the effective teaching and learning in the classroom.

It can be noticed that the three pre-service mathematics teachers used only GSP program for creating the activities in the designed lesson plan. This might because of the contents in the secondary level are necessary to make it more concrete according to the young age of the learners. Therefore, GSP should be the appropriate tool for creating the teaching and learning activities in this level. The researcher recommended to do a further study on the pre-service mathematics teachers' TPACK who teach in the high school level because there are many appropriate and interesting technology in term of mathematical software such as Maple, Mathematica, or MATLAB in which pre-service mathematics teachers can choose for their effective teaching and learning in the high school level.

Acknowledgements

The researcher would like to thank the school administrators in facilitating the pre-service mathematics teachers for developing their teaching profession in the school and also the school supervision teachers who facilitated and provided the good advice to the pre-service mathematics teachers during the coaching period. Additionally, thanks to three experts who are university lecturers specialized in teaching mathematics and teaching by using technology for validating the quality of the instruments and give recommendations for this research.

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