How Do Subject Specific Teacher Preparation Program that Integrate Technology Throughout the Courses Support the Development of Mathematics Preservice Teachers' TPCK (Technology Pedagogical Content Knowledge)?

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Abstract: The question in the study was "How did the mathematics preservice teachers develop their TPCK (Technology Pedagogy and Content Knowledge) in a subject-specific teacher preparation program that integrates technology throughout the program?" An exploratory case study design was used to gather the information about the components in the program that support the development of preservice teachers' TPCK. The study was a year long program included the description of the courses, faculty, university supervisors, notebook, cooperating teachers, school and real classroom setting. Three preservice teachers were purposefully selected for the study. The description of the program was discussed along with the rationale of the technology sequence course. The results were presented into case by case description and then compared the three cases to obtain a general depiction of how the program effected the preservice teachers' development of their TPCK. The conclusion and recommendations for future research were also discussed in the paper.

Introduction

Technology has transformed almost every segment of American society with different degrees of the transformation. However, teachers, students, classroom, and instruction remained less affected by this transformation. This assertion is supported by the fact reported by The US Department of Education reported that only about 20% of the teachers felt prepared enough to integrate technology into classroom instruction. Of these teachers, 99% have access to computers and the internet somewhere in their schools. However, only 39% reported frequent use of computers or the internet to create instructional materials; 34% used them for record-keeping; and less than 10% used them to access lesson plans, do research, or investigate best practices (Kent, 2001). In term of first-year teachers, only 40% of them felt adequately prepared to integrate technology into their classrooms meaningfully (Market Data Retrieval, 1999). The progress has been in the making in support of the use of technology in mathematics classrooms such as by the National Council of Teachers of Mathematics (NCTM, 2000) by stating that "technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances learning" (p. 24). In more specific to teacher education domain, International Society for Technology in Education [ISTE] suggests that schools and colleges of education coursework must consistently model exemplary pedagogy that integrates the use of technology for learning content with methods for working with PK-12 students" (ISTE, 2000).

To help the students develop a conceptual understanding in mathematics, students are required to construct their knowledge based on the context of their living. When technology has lived with the student in their 24 hours daily living, using hands-on materials combined with technology in a non-traditional classroom suggest a new solution about teaching in context. The contexts of high technology environment become eminent for the student life either at home or at school. That environment requires the teachers to have knowledge of content, pedagogy and technology that appropriate for the students learning. Therefore the integration of knowledge of technology, subject matter, and teaching and learning become an essential factor for mathematics preservice teachers to enabling them to teach mathematics with technology, known as Technology Pedagogical Content Knowledge (TPCK) (Pierson, 1999; Keating & Evans, 2001; Woodbridge, 2004; Niess, 2005).

Teachers also must be prepared to make decisions about various technologies, must be taught new skills for working with technologies in classrooms, and must be able to address many of the pedagogical

issues that arise when using technology in teaching such as the possibility of misunderstanding a concept being taught. Teacher preparation programs need to help preservice teachers to understand how technology can be used to teach content in rich and meaningful ways (Keating & Evans, 2001). Unfortunately the facts still show that teacher preparation programs do not currently provide preservice teachers with the kinds of experiences necessary to prepare them to use information technology effectively in their future classroom practice (Duran, 2000).

Problem Questions

The main question in the study was "How did the mathematics preservice teachers develop their TPCK (Technology Pedagogy and Content Knowledge) in a subject-specific teacher preparation program that integrates technology throughout the program?" The study also aimed to investigate on how an integrated model helps the preservice teachers develop their TPCK. What features or components of such a program were related to their TPCK development? What was the role of each component in supporting preservice teacher development of their TPCK? Important factors were identified based on some previous empirical studies on technology integration in teacher preparation program. But, which, if any, of these factors were influential in the development of TPCK in a subject specific model? Several components in the teacher preparation program have been identified in many researches as important feature that need to be implemented in order to help preservice teacher to teach with technology. Those components are technology coursework, peer teaching, worksample or e-portfolio, faculty/ instructor who model the use of technology, cooperating teachers in the classroom site, and university supervisor.

Significance of the study

For preservice teachers, this study helped them to be more prepared in teaching with technology during students teaching and future career. Identification of the important components in the program that contribute to the development of preservice teachers' TPCK also helped the Preservice Teacher Education (PTE) programs to reflect and improve the quality of their programs and take the necessary steps in updating and modifying the courses, projects, and specific features needed in teacher preparation programs.

Theoretical framework

Transforming the following four components in term of technology in teaching mathematics will provide direction to an outline of the teacher preparation program in helping the preservice teachers in developing their TPCK: (1) an overarching conception of what it means to teach mathematics with technology; (2) knowledge of instructional strategies and representation for teaching mathematics with technology; (3) knowledge of students' understanding, thinking, and learning with technology in mathematics; (4) knowledge of curriculum and curriculum materials that integrate technology with learning mathematics (Niess, 2005).

Teacher Preparation Program Model

The method of selecting the program model was based on the three research studies framework; Aiming at TPCK (Niess, 2005), Form of Teachers' Knowledge (Shulman, 1986), and Evolution of Thought & Practice (Sandholtz, Ringstaff, & Dwyer, 1997). Niess (2005) outlined the idea of looking at the teacher preparation program in helping the preservice teachers develop their TPCK into four categories, as mentioned above. Shulman (1986) described the three forms of teachers' knowledge; Proportional, Case, and Strategic knowledge. The program was analyzed in term of its support to those three forms of knowledge. Sandholtz, Ringstaff, & Dwyer (1997) categorized the process of teachers' stages in adopting technology in their classroom. Those stages are Adoption, Adaptation, Appropriation, and Innovation. Based on these frameworks, the teacher preparation program selected in the study was considered as the closest program in delineating their program to those three concepts.

The teacher preparation program in the study is a one year, graduate level content-specific teacher preparation program, mathematics and science. The program integrates learning about and teaching with electronic technologies as an integral component in teaching and learning science and mathematics, grades

3-12. The emphasis of the program is on the development of a teacher's ability to transform what he or she knows into teaching strategies that make that knowledge accessible to learners. Even though the program has science and mathematics majors, the focus of this study is only on the mathematics majors. The program begins with technology summer coursework to provide the foundation for the program and preparation for the internship experiences integrated throughout the following terms.

The program integrates school-based internships with the on-campus coursework during the program. The fulltime internship (student teaching) is situated during the final term of the program, spring term. Student teachers are required to teach a sequence of lessons with technology designed and planned during the previous terms. A sequence of three of those lessons must integrate technology in teaching of mathematical concept. During the student teaching experience, student teachers are expected to provide evidences in writing lesson reflections and video tape lessons demonstrating their ability to teach with technology and complete their work sample.

Important components in the model

Six important components in the model were identified as factors that affect preservice teachers' development of their TPCK. Those components can be classified into two types of sources, the element being done in the program and the people who involved in the program. The elements or pieces in the program consist of course work, micro-teaching, and e-portfolio. The second source consists of faculty or course instructor, university supervisor, and cooperating teachers. These components are practical and operational features in the programs that involve and interact with the preservice teachers. They all are inter-related. The course instructor and the course are related, but the categorization is made in order to identify specific support from the research as how each of those specific components affects the preservice teachers' TPCK as they participate in the program.

Participants

Three participants of study, Mia, Kelly, and Joshua (all names are pseudonyms) were purposefully selected from ten preservice teachers enrolled in the mathematics preservice teacher program in the Northwest during 2004-2005 school-years. Research had identified that preservice teachers often focus their concerns on controlling the class rather than on specific tasks of teaching (Fuller, 1969; Hawley & Rosenholtz, 1985). Based on this notion, the observations of the classroom during the student teaching was to ensure that the preservice teachers who were selected in the study had less problem in controlling their students or classroom management. This way made the study more focus on preservice teachers' teaching with technology. At the winter and spring term, nine students enrolled and eight responded the questionnaires.

Method

Yin (1994) suggested that using multiple sources of evidence was one way to ensure construct validity. The preservice teachers' knowledge development of technology, teaching and learning, and content were collected from a questionnaire, observations, and courses attendance. The researcher recorded the nuances and richness of the context of the program, the courses and preservice teachers during the one year program through research journal and field notes. Three preservice teachers were closely observed during fulltime student teaching. The fulltime student teaching observations and interviews were recorded and analyzed along with the student notebooks, classroom artifacts and researcher journal.

Data Sources

Questionnaire

Two questionnaires were distributed during this study. The first questionnaire was developed based on the National Educational Technology Standards for Teachers. This questionnaire was divided into two parts. The first part of the questionnaire had five categories, Technology operations and concepts, Planning and designing learning environments and experiences, Teaching, Learning and the curriculum, Assessment and Evaluation, and Productivity and professional practice. The purpose of this section was to gather the information about the effect of instructional technology courses offered in the program toward the NETS-T standards. The second part of the questionnaire was designed to gain the demographic data

about the background of the participants in terms of their knowledge on teaching and learning, mathematics, and technology. The second open ended questionnaire was structured based on the six important components in the program. The preservice teachers were asked to identify those components in term of their roles in helping them to teach mathematics with technology.

Program Academic Courses Attendance

The researcher attended the courses in the program to gather data about the goals, design, and expectation of the courses. In addition, the class' artifacts were gathered including courses syllabi, assignments, projects, and e-portfolio to understand the context of preservice teacher's program. All courses in the program were tied together with the student teaching experience as a complete and well-planned sequence package in the program that needs to be understood as one integral program. The main purpose of the academic course attendance was to have a better understanding about the program as the main context of study.

Student Teaching Observation and Interviews

Part time student teaching was required for preservice teachers at the second term of the program to teach at least 8 lessons in one month period. Preservice teachers were placed at middle school and high school around the state. Observation was conducted to five preservice teachers as the representative of the population based on the demographic questionnaire. The purpose of observation was to look closely the context of the school, culture, and seeing the first hand of how preservice teachers communicate with the students in real classroom setting. Four observations, non technology and technology lessons, and interviews were conducted to each three preservice teachers in three different locations, middle and high school setting.

Data Analysis

To investigate which factor influence the development of TPCK, all data sources were arranged as described in table 1. The purposes of the table were to organize the themes, pattern, and focus of the data to the question being asked in this study and to keep track source of the evidence. The students respond were analyzed and interpreted by two researchers collaboratively to determine the role of each component from the perspective of the preservice teachers.

	Technology		**Subject Matter**		**Teaching and Learning**	
Component	Support	Evidence	Support	Evidence	Support	Evidence
Courses						
E-portfolio/ Worksample						
Microteaching/Peer Teaching						
Faculty						
University Supervisor						
Cooperating Teacher						

Table 1. Data analysis arrangement.

Preservice teachers respond to the questionnaires were triangulated with observations journal, interviews on the reflection on their teaching, and classroom documents such as lesson plans, activity worksheet and homework. In addition to the table above, notes and journal from the observations and interviews were looked intently to find the supporting evidence related to the themes mentioned or indicated in the table. The supporting evidences could be from the classroom documents, interviews responds, or observation of the preservice teachers' practice in the classroom. Maintaining the chain of evidence was watched closely in order to draw the finding of the study.

Result of the Study

The responds from the two questionnaires, notes from observations and researcher journal were brought together to describe the role of each components in the program to the preservice teachers' TPCK.

From the first questionnaire revealed that the majority of preservice teachers felt that the technology courses taken in the program have aligned with the NETS-T standards. Eight of the participants consist of 3 females and 5 males with the age average between 22-29 years. The majorities had undergraduate degree in mathematics, only two were engineering.

The first questionnaire resulted that in term of technology operation and concept about 70 % of them felt that they could explain, operate, demonstrate, and confident about using and presenting the basic computer operation and software. About 75% of preservice teachers were very confidence and able to design a lesson plan with technology, identify and locate the online resources and believe that knowing how utilize technology is important for mathematics teachers. The responds about the teaching, learning, and curriculum as well as the productivity and professional practice on using technology were high, about 74%. The only low responds was on the assessment and evaluation on the use of technology in mathematics classroom, evaluate appropriateness of students use of technology, and applying variety of effective assessment, about 60%.

The second open ended questionnaire reported that the coursework was rated as the most helpful components in the program by 7 out of 8 participants in term of helping them to gain the knowledge of technology, content and pedagogy. Among the responds about the role of the course in term of their knowledge of technology, they reported that the course gave them the idea to integrate technology in mathematics classroom, get acquainted or familiar with new technology such as spreadsheet, geometer sketchpad, Imovie, and webpage software. They also reported that the course help them on gaining more content of mathematics, thinking and solving problem in different ways, and ideas for assessment on teaching mathematics with technology. Worksample or e-portfolio is more helpful in term of knowledge of teaching and learning by helping them to be more focus on student learning, step by step completing the work, forced to design lesson in more structure way, focus on objectives and organize the lesson plan. Peer teaching or microteaching component was seen more helpful for them to do reflection on their ability of teaching, strengths and weaknesses about certain methods, and expose to various approach of mathematics topic in teaching with technology.

The faculty or instructor was rated as less helpful in helping them to gain the knowledge of technology as well as content and pedagogy, by 3 out of 8 participants. Cooperating teachers helped them in many different ways such as providing new materials and timeframe of the lesson, suggesting about accommodating student with learning disability, giving good idea about seating arrangement and teaching style, giving some instruction model and how to manage the class, and helping with classroom management. Besides cooperating teacher was rated as very helpful in acquiring the knowledge of pedagogy and content, none of the eight participants responded about the role of cooperating teacher in helping them to gain the knowledge of technology. The university supervisor was rated very helpful only in term of helping them to gain the knowledge of pedagogy by 7 out of 8 participants. They responded that university supervisor helped their ability to assess their own lesson and focus on lesson, improved the quality of teaching, and helped them with classroom management and integrating different idea into teaching mathematics.

From interviews and observations during the student teaching resulted that Mia, Kelly and Joshua had the same perception about technology, the important of technology integration in teaching mathematics, and the role of technology in helping students understanding of mathematics. However, the different practices among the three preservice teachers while teaching with technology were obvious. Mia was placed in a high school with block schedule, 120 minutes length, in algebra II class. She found a very hard time to successfully integrated technology, calculator, into her class. Even though she had experience of using the calculator while taking courses and micro teaching practices in the program, the lesson was still far from success. The main problem that she faced was organizing the class in a different setting when technology is being used. Joshua seemed to have the same problem as Mia in integrating technology in his classroom. On the other hand, Kelly was very successful in her classroom when she taught probability in her class on 8^{th} grade. When Kelly was asked how she planned the lesson and preparing the class, she noted that the key issue by stating that" You had to really go through into every detail that you going to do in your classroom, it's not just the matter of putting words in the lesson plans, but it more to contemplating the class before you teach in your mind so that you feel that you were in real class with your students." Her class was amazing in term of how technology was seen as a tool to help student to have a better understanding of theoretical and experimental probability.

Conclusion

Looking at data, in term of knowledge of technology, the role of the coursework has the highest level of significance followed by the work sample or e-portfolio and faculty or instructor. The level of importance on helping preservice teachers in term of knowledge of content, the course was rated as the most importance followed by the cooperating teachers and microteaching. The responds in term of gaining the knowledge of pedagogy, cooperating teacher is the most influential components in the program. Implication of this study suggests that since the coursework was the only main source that the preservice teachers rely on when they teach mathematics with technology, the coursework in the program are required to be designed in a very careful way to meet the need of preservice teachers on teaching mathematics with technology. The coursework must consider the balance and appropriateness of technology, pedagogy and content with the level of student and topic being taught.

Even though the knowledge of content, pedagogy, and technology among the three preservice teachers during the course work began to develop, but it did not assure that they would be successful in their teaching mathematics with technology unless they practice, contemplate, and prepare it very well in advance. So, the question that could follow the next research would be how preservice teachers encounter their problem managing the classroom when technology is around. It is not just the matter of designing technology lesson, but it more to preparing to teach mathematics with technology.

The responds to the questionnaire might be more detail and elaborate if the preservice teachers were given more time to analyze the open ended questionnaire a head of time. The future research should be also more focus on more complex analysis of each component from different sources and perspectives, not only from the preservice teachers but also from the faculty, cooperating teachers and university supervisors.

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