Assembling the Pieces Together: What are the most Influential Components in Mathematics Preservice Teachers' Development of Technology Pedagogical Content Knowledge (TPCK)?

GOGOT SUHARWOTO AND KWANG HO LEE
Oregon State University
Corvallis, OR USA
suharwog@onid.orst.edu and leekw@onid.orst.edu

Abstract: The integration of knowledge of technology, content, and pedagogy is a model to prepare preservice teachers to integrate technology in teaching mathematics, known as Technology Pedagogical Content Knowledge (TPCK) (Pierson, 1999; Niess, in press). The question in the study is "What components in program that integrate technology throughout the program are related to the development of preservice teachers' TPCK? Technology coursework, microteaching, worksample are combined to help preservice teachers develop their TPCK. Journal, questionnaires, and observations from eight mathematics preservice teachers participated in the study reported that coursework was valued as main source of knowledge of technology, content, and pedagogy followed by the work sample, and microteaching. Cooperating teacher was considered as important source of knowledge of pedagogy and content. While faculty was considered as main source of technology, university supervisor was as source of knowledge of pedagogy. *

Introduction

Technology has transformed almost every segment of American society except education (Dyrli & Kinnaman, 1994). This assertion is supported by the fact that only about 20% of the teachers felt prepared enough to integrate technology into classroom instruction (Lewis, et. al., 1999; Archer, 1999). 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

* Paper presented at SITE conference March 1-5, 2005 Phoenix, AZ and Oregon State University Graduate conference April 13, 2005 (by first author alone)

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).

The fact is that when the technology is adopted in the school, technology becomes a significant force that helps students to learn in a different environment. To help the students develop a conceptual understanding in mathematics, students are required to construct their knowledge based on the context of their living. Using hands-on materials combined with technology in a non-traditional classroom suggest an answer to that concern. That environment requires the teachers to have knowledge of content, pedagogy and technology. Therefore the integration of knowledge of technology, subject matter, and teaching and learning become an eminent 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; Moursund & Bielefeldt, 1999).

Problem Questions

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. The question being investigated in this study is”What roles of those components of such a program are related to the secondary mathematics preservice teachers’ development of TPCK?

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 components in term of technology in teaching provide direction to an outline of the teacher preparation program : (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). The method of selecting the program model in the study is represented in the Table 1.

Model of Integration	Aiming at TPCK (Niess, in press; Pierson, 1999)	Form of Teachers’ Knowledge (Shulman, 1986)	Evolution of Thought & Practice (Sandholtz, Ringstaff, & Dwyer, 1997)	NETS-T (ISTE, 2000)
Single Course	Low	Propositional Case	Adoption Adaptation	1,2,5,6
Component of Courses	Medium	Propositional Case Strategic	Adoption Adaptation Appropriation	1,2,3,5,6
Integrated Throughout the Program	High	Propositional Case Strategic	Adoption Adaptation Appropriation Innovation	1,2,3,4,5,6

Table 1. Method of selecting the model on technology integration in PTE

Teacher Preparation Program Model

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

The participants of study were ten preservice teachers enrolled in the mathematics preservice teacher program in the Northwest during 2004-2005 school-years. Research had identified that preservice and beginning 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 teach with technology. At the winter term, nine students enrolled for the term. From those nine, 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.

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

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.

Data Analysis

To investigate which factor influence the development of TPCK, all data sources were arranged as described in table 2. 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 2. Data sources arrangement for questionnaire two.

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 teacehrs 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.

Conclusion

Looking at data, in term of knowledge of technology, the role of the coursework has the highest level of significance followed by the worksample 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.

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 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.

References

Archer, J. (1998). The link to higher scores. *Education Week on the Web.* [On-line] Available: http://www.edweek.org/sreports/tc/tc98/ets/ets-n.htm

Duran, M. (2000). Preparing technology-proficient teachers. In D. A. Willis, J. D. Price, and J. Willis (Eds.), *Proceedings of SITE 2000* (pp. 1343-1348). Charlottesville, VA: Association for the Advancement of Computing in Education.

Dyrli, O. & Kinnaman, D. (1995). What every teacher needs to know, part 1:Technology in education: getting the upper hand. *Technology and Learning*, 15, 38-43

Grossman, P. L. (1989). A Study in Contrast: Sources of Pedagogical Content Knowledge for Secondary English, *Journal of Teacher Education, 40* (5), pp. 24–31.

International Society for Technology in Education [ISTE]. (2000). *National educational technology standards for teachers: Connecting curriculum and technology.* Eugene, OR.

Keating, T. M., & Evans, E. (April 2001). *Three computers in the back of the classroom: Pre-service teachers' conceptions of technology integration*. Paper presented at the Annual Meeting of the American Educational Research Association, Seattle, WA.

Lewis, L., Parsad, B., Carey, N., Bartfai, N., Farris, E., & Smerdon, B. (1999). *Teacher quality: A report on the preparation and qualifications of public school teachers* (NCES 1999-080). Washington, DC: National Center for Education Statistics. [On-line] Available : http://nces.ed.gov/pubs99/1999080.pdf

Market Data Retrieval (1999). *New teachers and technology: Examining perceptions, habits, and professional development experiences*. Shelton, CT: Author.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: A focus on pedagogical content knowledge. *Journal of Teacher Education.*

Pierson, M. (2001). Technology practice as a function of pedagogical expertise. *Journal of Research on Computing on Education*, 33(4), 413-430.

Putnam, R. & Borko, H., (1996). Learning to teach. In D. Berliner & R. Calfee (Eds.), *Handbook of educational psychology* (pp. 673-708). New York: Macmillian.

Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1997). *Teaching with technology: Creating student-centered classrooms.* New York: Teachers College Press.

Woodbridge, J. (2004). *Technology Integration as a Teaching Strategy*. Paper presented at the National Educational Computing Conference, New Orleans, LA.