Tasks Analysis of Teacher Training Programs: Focused on Technology

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The modern society is rapidly changing because of Information Technology. In particular, recently the trend has gotten faster and faster with the advent and development of smart devices. This wave is also influencing mathematics education and many research studies have demonstrated that technological tools can be used in teaching and learning mathematics. Cuoco and Goldenberg (1996) argued that computers may help students develop mathematical properties and construct mathematical ideas. Moreover, mathematics and science standards point toward a scientifically and mathematically rich curriculum where technology is an essential component of the learning environment, not only in the curriculum but also in the instruction (NCTM, 2000).

Challenges and a Suggested Approach of Technology Integration into Teaching

Although the use of technological tools in schools is widespread, actual outcomes of using such tools have been disappointing. Technologies, especially computer tools, are purported to enhance the learning experience and to bring learners to higher levels of understanding, motivation, engagement and self-esteem. These technology tools are often marginalized, however, within existing classroom practices, or used only for repetitive, delimited activities, rather than to promote complex learning (Reed, Drijvers, & Kirschner, 2010). Koehler and Mishra (2009) describe that teaching with technology is a complicated practice with many challenges. They say that modern digital technologies, such as computers, handheld devices, and software applications, are "protean (usable in many different ways); unstable (rapidly changing); and opaque (the inner workings are hidden from users)" (p. 61). These characteristics of new technologies present new challenges to teachers who are struggling to use more technology in their teaching. In addition, if the use of technology is inconsistent with their existing pedagogical beliefs, the teachers are unlikely to use technological tool in their classroom practice (Ertmer,

2005). The teachers may need to see how technology is a part of their own mathematics and ways of doing mathematics.

Faced with these challenges, Koehler and Mishra suggest that an approach for teachers to integrate technology into their teaching is "to treat teaching as an interaction between what teachers know and how they apply what they know in the unique circumstances or contexts within their classrooms" (p. 62). So educators are required to develop new ways of understanding and accommodating complexity. They claim that teaching with technology should focus on three key components: content, pedagogy, and technology, as well as the relationships among and between them. In this respect, they suggest a framework, called the technology, pedagogy, and content knowledge (TPACK) framework (Koehler & Mishra, 2009).

The TPACK Framework

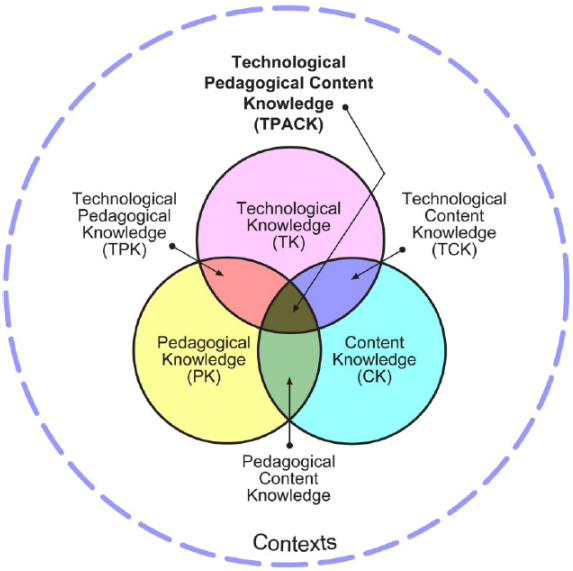

Figure 1. The TPACK framework and its knowledge components

The TPACK framework builds on Shulman's (1986) descriptions of PCK (Pedagogical Content Knowledge) to describe how teachers' understanding of educational technologies and

PCK interact with one another to produce effective teaching with technology. Seven components are included in the TPACK framework (see Figure 1). They are defined as (Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009, p.125):

1. Technology knowledge (TK): Technology knowledge refers to the knowledge about various technologies, ranging from low-tech technologies such as pencil and paper to digital technologies such as the Internet, digital video, interactive whiteboards, and software programs.

2. Content knowledge (CK): Content knowledge is the "knowledge about actual subject matter that is to be learned or taught" (Mishra & Koehler, 2006, p. 1026). Teachers must know about the content they are going to teach and how the nature of knowledge is different for various content areas.

3. Pedagogical knowledge (PK): Pedagogical knowledge refers to the methods and processes of teaching and includes knowledge in classroom management, assessment, lesson plan development, and student learning.

4. Pedagogical content knowledge (PCK): Pedagogical content knowledge refers to the content knowledge that deals with the teaching process (Shulman, 1986). Pedagogical content knowledge is different for various content areas, as it blends both content and pedagogy with the goal being to develop better teaching practices in the content areas.

5. Technological content knowledge (TCK): Technological content knowledge refers to the knowledge of how technology can create new representations for specific content. It suggests that teachers understand that, by using a specific technology, they can change the way learners practice and understand concepts in a specific content area.

6. Technological pedagogical knowledge (TPK): Technological pedagogical knowledge refers to the knowledge of how various technologies can be used in teaching, and to understanding that using technology may change the way teachers teach.

7. Technological pedagogical content knowledge (TPACK): Technological pedagogical content knowledge refers to the knowledge required by teachers for integrating technology into their teaching in any content area. Teachers have an intuitive understanding of the complex interplay between the three basic components of knowledge (CK, PK, TK) by teaching content using appropriate pedagogical methods and technologies.

The TPACK framework emphasizes new types of knowledge. It is not easy for teachers to internalize knew kinds of knowledge into their classroom practice because when teachers experience unfamiliar ideas, they tend to not explore the nature of the ideas. In order to use the new knowledge or ideas in teaching practice, Silver, Clark, Ghousseini, Charalambous, and Sealy (2007) claim that using professional learning tasks (PLT) allows teachers to render their mathematical knowledge more useful because it can provide opportunities for them to rethink and reorganize the mathematics they teach. In other words, teachers can acquire knowledge that is possible to use in classroom practice in the process of solving the tasks suggested in teacher education. In this respect, Hollebrands and Lee (2012) have published teacher education materials in the fields of geometry, statistics, and algebra to help teachers teach mathematics with technology. Moreover, the Melbourne University in Australia executed a research project (RITEMATHS) to use real life problem situations and technology in order to strengthen mathematics (https://extranet.education.unimelb.edu.au/DSME/RITEMATHS). Not only that, in South Korea, much teacher training is also being executed, providing books and information to support mathematics teaching and learning with technology. Therefore, it can be a meaningful

work to analyze a variety of tasks used in teacher education to develop knowledge related to technology for teachers and teacher educators. Furthermore, this analysis can be used in more effective and systematic teacher education.

The tasks in mathematics teacher education

Mathematical tasks and cognitive demand

The definition of the mathematical tasks has been made by many researchers. Stein and Smith (1998) defined a mathematical task as a segment of classroom activity that is devoted to the development of a particular mathematical idea. Standard 1 in NCTM's (1991) *Professional standards for teaching school mathematics*, entitled "Worthwhile Mathematical Tasks," says that the teacher of mathematics should pose tasks that engage students in mathematical activity and develop students' mathematical thinking, understanding, and skills.

To make a framework for good tasks, Stein and Smith classified mathematical tasks as lower-level demands and higher-level demands in terms of cognitive complexity. This model further delineates four levels of cognitive demand for tasks: lower-level demands of "memorization" and "procedures without connections", and higher-level demands of "procedures with connections" and "doing mathematics." They argued that it is important to examine the cognitive demand required by tasks because of their influence on student learning. Based on the Stein and Smith's framework for analyzing the cognitive demand of mathematical tasks, Schultz (2009) studied that the relationship between cognitive demand and the use of instructional technology in tasks teachers select and use in instruction and suggested a technology-oriented addendum to the framework for analyzing the cognitive demand of mathematical tasks. The research findings of Schultz can be applied to not only students but also teachers. In other words,

we can consider the relationship between cognitive demand and the tasks related to technology in mathematics teacher education.

The tasks of mathematics teacher education

Ball and Cohen (1999) studied what it would take to reconstruct professional education in ways to improve teachers' capacity to encourage deeper and more complex learning in their students. Many changes are required to reconstruct teacher education: First, teachers need to fully understand the subject matter they teach. It is not enough to know the procedures and information. They need to know meanings and connections of concepts and principles. In addition, teachers need to know about their students. This involves in the students' interests, difficulties, and ideas in particular domains. Furthermore, teachers need to develop and expand their ideas about what it means to learn, what helps students learn, and how to understand what students are thinking in learning. Lastly, teachers need to know pedagogy to connect students with content in effective ways, including the capacity to adapt and shift modes in response to students.

We can expand the ideas of Ball and Cohen at the secondary level mathematics students and teachers and reinterpret their work in terms of teacher education with technology. First, teachers would need to understand the mathematics they teach, in ways to use technologies to promote learning. Second, in addition to knowing the mathematics they are teaching and the use of technology, teachers would need to know about children's attitude and tendency about technology—what children are like, what technology factors they are likely to find interesting and to have trouble with, in particular domains. Third, teachers would need to know what it means to learn about technology and what helps children learn through technology. Lastly,

Teachers also would need to know technological pedagogy in order to connect students with content in effective ways by using technology. These four views generally emphasize that teachers would need to know the understanding of learning and learners, in addition to content and technology knowledge. Thus, in teacher education with technology, it is important to assign tasks to improve not only content knowledge (CK) and technology knowledge (TK) but also learning through technology and the characteristics of learners who use technology.

As the learning of teachers can be achieved by the tasks, the effect of well-organized learning tasks can be applied to pre- and in-service teacher education. That is, teachers can think of specific concepts, procedure, and connection between other mathematical ideas through the tasks. In addition, good tasks help teachers develop mathematically and pedagogically useful techniques and promote the development of teachers' general ideas of teaching mathematics. Ferrini, Burrill, and Schmidt (2007) also claim that mathematics teacher learning tasks may impact the ways teachers organize mathematics they teach in the classroom practice. In other words, the tasks provided in teacher education have an important impact on teacher professional development.

Necessity of analysis on mathematics tasks

Although many researches and curriculums emphasize the use of technology in mathematics, mathematics teachers find difficult with integrating technology in their classroom. We may need to investigate mathematics teacher education with technology focusing on mathematical tasks the teachers are given. Mathematical tasks now using in the mathematics teacher education and technology program can be collected and classified in terms of technological component knowledge-TK, TCK, and TPACK- in TPACK framework. We should investigate whether most

technology-related tasks in teacher training program is more focused on TK or TCK than TPACK. With such investigations, teacher educators should focus and develop mathematics tasks related to TPACK and so help teachers integrate technology into their mathematics classroom practice.

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