Chapter 21
Re-Thinking Pre-Service Mathematics Teachers Preparation:
Developing Technological, Pedagogical, and Content Knowledge (TPACK)

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ABSTRACT

Powerful and modern digital technologies have significantly impacted mathematics teaching – both what is to be learned and how it should be learned. Technology, pedagogy, and content knowledge (TPACK) is the knowledge that teachers rely on for teaching content with appropriate digital technologies. What preparation do mathematics teachers need in order to develop this knowledge needed for integrating appropriate digital technologies as teaching and learning tools? The challenges of understanding TPACK and identifying appropriate educational programs for pre-service mathematics teachers call for thoughtful attention toward the development of the knowledge, skills, and dispositions that support the dynamic nature embedded within the TPACK construct. The design of appropriate pre-service teacher learning trajectories for developing a rigorous TPACK emphasizes that both how and where they learn to teach mathematics are fundamental to what is learned about teaching and learning mathematics. Redesign ideas and models support re-thinking and re-designing pre-service mathematics teacher preparation programs.

INTRODUCTION

Mathematics as a body of knowledge evokes many different descriptions. Some view mathematics as a study of patterns while still others envision mathematics as an art. Some suggest that mathematics is the language of science. Others describe mathematics as a way of thinking that results in organizing, analyzing, and synthesizing data. Irrespective of the various descriptions, the mathematics discipline has been significantly impacted by the use of digital technologies with advanced computational, graphical, and symbolic

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capabilities. These advanced capabilities have changed how mathematicians are able to think about and do mathematics. Has this change shifted how students today are learning mathematics? Are they using today's technologies for learning mathematical ideas? If students learn mathematics with the tools of the 20th century, will they be able to compete mathematically in the society and culture of the 21st century?

In 2000, the National Council for School Mathematics (NCTM) declared that *the existence, versatility, and power of technology make it possible and necessary to reexamine what mathematics students should learn as well as how they can best learn it* (NCTM, 2000, p. 25). Many digital technologies are promoted as useful tools for students learning mathematics: graphing calculators, applets or virtual manipulatives, spreadsheets, dynamic geometry tools, computer algebra systems and a host of Web 2.0 technologies. These digital technologies offer advanced capabilities for visual representations to engage students in dynamic explorations and communicating their understandings while learning mathematics. NCTM further reinforced this view through its Technology Principle: *Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning* (2000, p. 24). The Association of Mathematics Teacher Educators (AMTE) expanded on this call for integrating appropriate technologies in mathematics programs through its Technology Position. *Mathematics teacher preparation programs must ensure that all mathematics teachers and teacher candidates have opportunities to acquire the knowledge and experiences needed to incorporate technology in the context of teaching and learning mathematics* (AMTE, 2006, p. 1).

Three key questions arise with the challenge of adequately preparing teachers for meeting the challenges and demands for teaching mathematics with appropriate 21st century digital technologies: What knowledge do teachers need to effectively teach mathematics with current and emerging digital technologies? What preparation adequately develops this knowledge for teaching mathematics? How should pre-service teachers' preparation programs be re-designed to describe appropriate learning trajectories for learning to teach mathematics in the 21st century? The purpose of this chapter is to respond to these questions within an emerging framework for teacher knowledge – technology, pedagogy, and content knowledge or TPACK (Niess, 2008b; Thompson & Mishra, 2007). Since the TPACK construct stems from a cognitive constructivist view of individual learning, the responses to the questions additionally attend to the importance of the social context and how the pre-service teachers' participation in that context impacts their personal understanding and learning. Thus, the responses to the questions emphasize the importance of *how* and *where* they learn mathematics and how to teach mathematics as being fundamental to *what* is learned about teaching and learning mathematics (Greeno, Collins, & Resnick, 1996).

KNOWLEDGE FOR TEACHING MATHEMATICS WITH TECHNOLOGY

While teacher preparation programs have been struggling with preparing teachers to teach mathematics in the 21st century, a new framework for thinking about the knowledge teachers need for teaching with technology has emerged. In recognition of a broader perspective with respect to the knowledge needed for teaching with appropriate digital technologies, numerous researchers have proposed thinking about the integration of technology, pedagogy, and content in much the same way that Shulman (1986, 1987) did in describing pedagogical content knowledge (PCK). Technological pedagogical content knowledge (TPCK) was envisioned as the interconnection and intersection of content, pedagogy (teaching and student learning), and technology (Margerum-Leys & Marx, 2002;