Chapter 3
Developing TPACK in Elementary Mathematics Education:
A Framework to Design Activities With Pre-Service Teachers

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ABSTRACT

Two case stories are given of how technological pedagogical content knowledge (TPACK) is developed in a first semester undergraduate pre-service elementary mathematics education course. The theoretical frameworks that guided the design and implementation of technology-based mathematics lessons are discussed, including both TPACK and the substitution, augmentation, modification, redefinition (SAMR) framework. Then the authors describe specific activities intended to develop TPACK, the motivation and implementation for these activities, and excerpts of pre-service teachers’ survey results, comments, and reflections about learning elementary mathematics in these courses. The contrast between the courses is focused technology use during one unit with opportunity to teach elementary lessons with the same technology, and pervasive use of technology throughout the other but no opportunity to use the technology with elementary learners. The chapter concludes with a discussion of the implications and issues that have presented themselves in this action research experience.

INTRODUCTION

In 2000 when the National Council of Teachers of Mathematics (NCTM) released their Principles and Standards for School Mathematics, technology was cited as one of the six principles to guide mathematics teaching in the new millennium. The pervasive access to technology has made the fundamental tenets of NCTM’s Technology Principle (NCTM, 2000) a conceptual mooring in the current and future eras.

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of teaching mathematics. In particular, the following two points of the NCTM technology principle: (1) technology influences which mathematics is taught, and; (2) the teacher must make prudent decisions about when and how to use technology to enhance students’ mathematical thinking and understanding. Furthermore, one of the Common Core Standards for Mathematical Practice (Common Core Standards Initiative, 2010) relates strongly to the NCTM Technology Principle: Mathematically proficient students consider the available tools when solving a mathematical problem.

In consideration of the variety of digital and electronic technological tools available for learning mathematics, and to delineate how these technologies may be used in the mathematics classroom, the following four categories are used in this chapter: (1) cultural technology; (2) educational technology; (3) content specific technology, and; (4) pedagogical content specific technology. A particular technology may be found in multiple categories, determined by teacher or student use. Cultural technology refers to those forms of technology that are widely used in everyday life and are recognizable by most students. Hardware like smartphones and computers, and applications like Facebook are some current examples. An example of cultural technology in the pre-service mathematics education course would be the use of cloud storage, like Google Drive for file sharing or co-editing, or social media, like Twitter (hashtag communities such as #mtbos or #elemmathchat) to connect to mathematics specific professional education communities. Educational technology refers to those forms of technology that are found primarily in an educational environment. Interactive whiteboards or digital document cameras, software like Blackboard or Google Classroom, while not content specific, may be used in the mathematics classroom. Content specific technology refers to those forms of technology that are specific to the content field of study. In the K-16 (including undergraduate) mathematics classroom this category includes hardware like graphing calculators, spreadsheets, computer algebra systems (Mathematica or CoCalc), and interactive algebra and geometry software (Desmos or GeoGebra). Pedagogical content specific technology refers to those forms of technology that have been designed specifically for the teaching and learning in a specific content area. Some examples include Shape Makers (Battista, 2003), Desmos activities (Desmos, 2014), or applets created with GeoGebra (Hohenwarter, 2002).

With the breadth of technology available across the four categories discussed, and the breadth of mathematical content at the elementary level, it has become an exceptionally daunting task to teach pre-service elementary teachers how to effectively teach mathematics in the K-6 classroom. Most universities have only two or three mathematics courses for pre-service teachers to learn the mathematics content and pedagogy, so adding technology into the curricular mix compresses the courses even more. In order to attend to this issue, the authors of this chapter sought to integrate technology into a first semester mathematics elementary education course to teach challenging content with novel and meaningful uses of the most current forms of technology in education and address directly the pedagogy of technology.

In this chapter two case stories are shared to reflect the uses of technology as important tools to explore and deepen pre-service teachers’ understanding of learning and teaching mathematics. Two essential questions considered in this chapter are:

1. How can pre-service teachers’ knowledge for teaching with technologies be developed and transformed through learning experiences in collegiate elementary mathematics education courses?
2. What experiences support pre-service teachers in engaging in learning about technologies while also learning mathematics content and pedagogy with the technologies?