Chapter 37
Adding a New Dimension to Teaching Mathematics Educators

Anna Wan
University of Southern Mississippi, USA

Jessica Ivy
Bellarmine University, USA

ABSTRACT

Technology has the potential to transform the classroom, build access to new mathematical content, and provide access to students through unique representations. For this study, the authors considered the transformational promise of digital fabrication technology, specifically 3D printing, in a setting comprised of pre-service teachers. An introduction to digital fabrication session was implemented in a secondary mathematics methods course. Participants were assessed both prior to the experience and after, using an adapted TPACK developmental self-report survey to consider TPACK themes and subthemes. In this chapter, the authors describe ideas that emerged from narratives provided by participants, patterns of change noted from pre- to post-assessment, and three cases that emerged representing students who experienced the most positive changes, most negative changes, and least amount of change on self-perceived levels.

INTRODUCTION

The integration of technology to teach mathematics has the potential to transform the classroom, build access to new mathematical content, and provide access to students through unique representations (*National Council of Teachers of Mathematics* (NCTM), 2000; 2014). The National Research Council (2001) noted that quality use of technology does not suggest a replacement of paper-and-pencil calculations, but rather the technology used can offer complimentary opportunities for students to make more generalizations, engage in symbolic transformations, and more accurately examine graphical representations.

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The identified potential for enhancing student learning has led to widespread access to instructional technology in the mathematics classroom (Cuban, Kirkpatrick, & Peck, 2001). Though these technologies have typically included graphing calculators, dynamic geometry software, or computer algebra systems, the list is growing to include digital fabrication tools. Affordability of digital fabrication tools and advances in ways to share creative processes helped fuel this movement (Blikstein, 2013; Halverson, & Sheridan, 2014). Tools of digital fabrication include 3D printers, computer numerical controlled (CNC) mills, and laser cutters. Teachers are entering classrooms with technology that was not available when they were students. In response, mathematics teacher educators must engage pre-service teachers with these tools in ways that embrace the NCTM Technology Principle (NCTM, 2000). The implications for integrating 3D printing technology into teaching in these communities is profound (Kreiger, Anzalone, Mulder, Glover, & Pearce, 2013).

Through this study, the authors sought to provide pre-service teachers with experience as learners and teachers in the integration of digital fabrication tools for teaching mathematics. This study focused on the following question: How do pre-service teachers' self-perceptions of their Technological Pedagogical Content Knowledge (TPACK) evolve through experiences in the integration of digital fabrication for teaching mathematics? This question was explored considering each of the TPACK Developmental Model Themes (Niess, Ronau, Shafer, Driskell, Harper, Johnston, Browning, Özgün-Koca, & Kersaint, 2009).

BACKGROUND

It has long been acknowledged that neither pedagogical knowledge nor content knowledge alone is sufficient for effective teaching (Shulman, 1986). The overlaps of knowledge domains have been widely studied over the past two decades and have come to integrate technology as more tools are available and necessary for teaching and learning mathematics. Technological pedagogical content knowledge, or TPACK is the knowledge that encompasses the overlaps of technological knowledge, pedagogical knowledge, and content knowledge. This model recognizes the complexity of a variety of knowledge domains: technological knowledge, pedagogical knowledge, content knowledge, technological pedagogical knowledge, technological content knowledge, pedagogical content knowledge, and technological pedagogical content knowledge (Niess, Ronau, Shafer, Driskell, Harper, Johnston, Browning, Özgün-Koca, & Kersaint, 2009).

The work of Niess and her colleagues (2009) establishes a developmental model with four major themes: curriculum and assessment, learning, teaching, and access. For each theme, sub-themes were established to further describe the teacher knowledge components. The TPACK Developmental Model establishes levels and descriptors to allow each theme to function independently. The levels progress from recognizing to accepting, then to adapting, followed by exploring, and finally advancing, as shown in Figure 1 (Niess, Ronau, Shafer, Driskell, Harper, Johnston, Browning, Özgün-Koca, & Kersaint, 2009).

The TPACK Developmental Model can be used to consider teacher knowledge with regard to a specific tool for teaching mathematics. With the evolving nature of technological tools, many TPACK-related surveys are considered tool-specific. For the purpose of this study, the authors utilized a technology tool that is relatively new to the consumer and education market, the 3D printer. When used by mathematics teachers and students, the 3D printer can help students and teachers create and modify manipulatives as well as produce representations of mathematical concepts. This use is part of the larger movement known as the Maker Movement (Martin, 2015).