Chapter 11
Prospective Teachers' Incorporation of Technology in Mathematics Lesson Plans

Karen Hollebrands
North Carolina State University, USA

Allison W. McCulloch
North Carolina State University, USA

Hollylynne S. Lee
North Carolina State University, USA

ABSTRACT

INTRODUCTION

Teachers' use of technology in mathematics classrooms is influenced by their knowledge of mathematics, technology, and pedagogy. Teachers need to have a deep understanding of the mathematics content they are teaching, technical knowledge and skill related to the tools they are using, and a broad understanding of instructional strategies and students' mathematical thinking to guide the design and implementation of a lesson (Niess, 2005). More importantly, teachers' use of technology relies on teachers' specialized knowledge about the ways in which technology influences the mathematics that is taught, the tasks and questions that can be posed, and the interactions with the tool that supports students' mathematical thinking. This latter type of knowledge has been characterized as Technological Pedagogical Content Knowledge (TPACK; Koehler & Mishra, 2008, 2009; Niess, 2005).

Niess (2005) adapted Grossman's (1989, 1990) components of PCK to construct four aspects of TPACK that include an overarching idea about how technology can be integrated in mathematics; knowledge of students' mathematical thinking with technology; knowledge of technology-intensive mathematics curricula; and knowledge of instructional strategies for teaching with technology. In the design of a lesson that incorporates technology, teachers need knowledge of mathematics and an understanding of how to integrate technology into the learning of mathematics. They are planning questions they may pose that

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are informed by their knowledge of students' thinking, and they are anticipating student responses to their questions. They may also utilize activities and examples from curricula that use technology. Finally, they include representations and strategies specific to technology. Thus, in the process of planning a lesson that incorporates technology, teachers are addressing all four of Niess' components of TPACK. For the current study, we focus on all four of these elements by examining lesson plans designed by prospective teachers that incorporate technology.

BACKGROUND

Several researchers have examined how practicing teachers design mathematical tasks using technology. Laborde (2002) studied four practicing high school mathematics teachers over a three-year period as they learned how to incorporate dynamic geometry (Cabri) in learning scenarios. A learning scenario consisted of an introduction, a sequence of tasks (i.e., activities within the lesson), and explicit discussion of definitions and theorems. Laborde (2002) found that all four teachers initially designed tasks for which the technology served as a visual aid or used the tool to do similar non-technology based activities in a more efficient manner. The use of technology in these cases could be characterized as an amplifier (Pea, 1985). In essence, the tasks themselves remain unchanged, but the technology enables one to do them more quickly or accurately. Over a three-year period, Laborde (2002) found that teachers began to develop tasks that could only exist in the technology-based environment. For example, a construction task that takes advantage of the dragging capabilities of the dynamic geometry tool cannot be accomplished with paper and pencil. Dragging requires one to think differently about properties of geometric objects. This use of technology might be characterized as a reorganizer (Pea, 1985).

Pea's amplifier/reorganizer metaphor has been extended and applied by other researchers. Ben-Zvi (2000) described how technology could be used as an amplifier and reorganizer in the context of teaching and learning statistics. As an amplifier, technology can be used to quickly perform calculations accurately. However, the power of technology in statistics (or mathematics) education is better captured by the ways it can be used as a reorganizer. Because students do not need to focus on performing computations, they can direct their attention to reasoning about representations of data, overlaying measures, and considering distributions and other important features of a data set. Ben-Zvi (2000) also argues, "working with a powerful technological tool may shift parts of the activity to a higher cognitive level" (p. 140).

Sherman (2014) applied the amplifier/reorganizer metaphor when considering the cognitive demand of technology-based mathematical tasks when they are set up and implemented. He used Stein, Grover, and Henningsen's (1996) definition of a task: "a classroom activity, the purpose of which is to focus students' attention on a particular mathematical idea" (p. 460). Four practicing middle and high school mathematics teachers were observed teaching for four to six weeks. Each teacher had three years of teaching experience, used technology in their mathematics instruction, and had taught the units that were observed at least once before. Sherman found that although teachers tended to implement more tasks that were of low cognitive demand, a greater percentage of tasks that utilized technology were of high cognitive demand (20% without technology versus 50% with technology). He also found that there was a relationship between teachers' use of technology-based tasks that demanded high cognition and their use of technology as a reorganizer. For example, in one case a teacher designed a GeoGebra task for students to explore the medians of a triangle and to discover that the centroid divides a median into two segments whose lengths maintain a ratio of 1:2. The technology served as a reorganizer by enabling