Chapter 12
Supporting Mathematical Communication through Technology

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ABSTRACT

Technology has the potential to support the creation and use of mathematical representations for exploring, reasoning about, and modeling cognitively demanding mathematical tasks. In this chapter, the authors argue that one of the key affordances of these dynamic representations is the synergistic relationship they can play with communication in the mathematics classroom. The authors highlight the ways in which technology-based representations can support mathematical communication in the classroom through a series of vignettes. They conclude with a discussion of the development of teachers' Technological Pedagogical and Content Knowledge (TPACK) for supporting the implementation of dynamic representations.

INTRODUCTION

Communication and representation play prominent roles in modern mathematics education. They are incorporated as goals in standards documents from the mathematics education community (NCTM, 2000, 2006) and policymakers (National Governor's Association/Chief Council of State School Officers, 2010; U.S. Department of Education, 2008). Specifically, the new Common Core State Standards for Mathematics (Common Core; NGA/CCSSO, 2010), adopted by 45 states, includes *Standards for Mathematical Practice*, that embody processes all K-12 teachers are expected to consistently enact in their classroom. One avenue for addressing communication and representation in the mathematics classroom involves the use of cognitively-demanding mathematical tasks that benefit from students' interactions with digital mathematical representations as a medium for fostering communication (Henningsen & Stein, 1997; Huferd-Ackles, Fuson, & Sherin, 2004; Orill & Polly, 2012).

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Digital technologies have potential to support teachers' enactment of mathematical practices by supporting students' creation of mathematical representations, their modeling of mathematical situations, and their computation within the context of exploring cognitively-demanding mathematical tasks (Battista & Clements, 2007; Clements & Battista, 2001; Wenglinsky, 1998; Zbiek, Heid, Blume, & Dick, 2007). Technologies, such as Geometer's Sketchpad (Johnson, 2002; Leong & Lim-Teo, 2003), spreadsheets (Erbas, Ledford, Orrill, & Polly, 2005), and virtual manipulatives (Polly, 2011; Steen, Brooks, & Lyon, 2006) allow students to create dynamic representations, which they can construct and manipulate to deeply explore mathematical concepts in ways that are impractical or impossible outside of the digital environment. Further, the use of these technologies has been empirically linked to gains in students' mathematical understanding (e.g. Polly, 2008; Bitter & Hatfield, 1994; Leong & Lim-Teo, 2003; Roberts, 1980; Steen, Brooks, & Lyon, 2006; Wenglinsky, 1998).

In this chapter, we examine the synergistic relationship between digital, dynamic representations and the communication they support. To do this, we provide snapshots of classroom learning in which dynamic representations support meaningful communication. Through these snapshots, we provide insight into four different ways that dynamic representation can support meaningful conversations about mathematics and students' development of related Standards for Mathematical Practice from the Common Core State Standards for Mathematics. We conclude by exploring the interplay between communication, technology, representation, and cognitive demand of mathematical tasks. We also consider the implications for teacher knowledge if creating communication-rich, technology-enhanced, representationally-rich classrooms is our goal.

BACKGROUND

In this section, we explain how technology-based representations and communication are interconnected in the mathematics classroom. In order to situate this view, we present a brief overview of the literature on the importance of communication in the mathematics classroom followed by a discussion of the role of representations in promoting mathematical learning. We work from a position that mathematical learning is best achieved through the use of high cognitively demanding tasks (Stein, Grover, & Henningsen, 1996), therefore we also discuss representations in these contexts. We end the section by examining the promise of dynamic representations to support communication in mathematics classrooms.

Communication

Communication in mathematics classrooms is done through verbal, drawn, and written means. Naturally, discussion is a critical component of communication. The role of discussion in supporting student learning is prevalent and persuasive in the mathematics education literature (e.g., Franke, Kazemi, & Battey, 2007). The *Principles and Standards for School Mathematics* (PSSM; NCTM, 2000), the Common Core State Standards (Common Core) and findings from a variety of research (e.g., Boston & Smith, 2009; Cobb, Yackel, & McClain, 2000; Hufferd-Ackles, Fuson, & Sherin, 2004; Ryve, 2006; van Es & Sherin, 2008) confirm the importance of communication in the mathematics classroom. For example, the Common Core outlines two important Standards of Practice that specifically require mathematical sharing among students in the classroom. First, the Common Core asserts that students at all grades should engage in constructing viable arguments about mathematics as well as critiquing