Chapter 52

Developing Teachers' TPACK for Mathematics Through Professional Development:
The Case of InterMath

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ABSTRACT

In this chapter, InterMath is introduced as a learner-centered professional development environment that supports the development of Technological Pedagogical Content Knowledge (TPACK). Evidence will be presented from the research and evaluation on InterMath to highlight some of the ways in which InterMath has been successful. Vignettes provide examples of a typical conversation in a TPACK professional development environment. An analysis of findings indicates that the InterMath project contributed to teachers' TPACK development, with a focus on teachers' knowledge of technology and content (TCK). The knowledge and skills of the professional development facilitator was a key factor in the teachers' development. Implications for the design of professional development include simultaneously developing teachers' integrated knowledge of technology, pedagogy, and content.

INTRODUCTION

Mathematics teachers need to be able to integrate technology into their instruction in ways that support communication and sense making (e.g., Association of Mathematics Teacher Educators (AMTE), 2009; National Council of Teachers of Mathematics (NCTM), 2000, 2014; National Governor's Association Center for Best Practices and Council of Chief State School Officers (NGA & CCSSO, 2010)). Throughout, the technology to be used is less important than the learning opportunities that it provides (NCTM, 2014). In mathematics, technology is more powerful when it is used beyond drill and practice activities

(Polly, 2008; Wenglinsky, 1998). For example, technology should foster creativity and communication, promote reflection, and encourage the development of mathematical understanding (AMTE, 2009; NCTM, 2014; Orrill & Polly, 2013).

This chapter focuses on how to best support teachers' learning of skills and knowledge related to using technology. Many teachers have not had opportunities to learn about or with technology in the ways suggested. Further, many teachers have not had the opportunity to learn mathematics in an exploratory way, influencing their beliefs about teaching (NCTM, 2014; Polly, McGee, Wang, Lambert, Pugalee, & Johnson, 2013). Yet, teachers are expected to create rich learning environments for their students (NGA & CCSSO, 2010; NCTM, 2000). In other words, creating innovative professional development that can support teachers in developing Technological Pedagogical Content Knowledge (TPACK; AMTE, 2009; Mishra & Koehler, 2006; Niess, 2005; Polly & Orrill, 2012) for mathematics is an important goal.

In this chapter, we examine what TPACK development looks like in one professional development program aimed at supporting teachers' use of technology and exploration-based mathematics in their mathematics classroom. The program, InterMath, allows teachers to work alone or in groups on mathematics tasks using digital technologies, such as graphing calculators, spreadsheets, and dynamic geometry software. In this way, the technology serves as a tool for teachers to test conjectures, explore patterns, and engage in other inquiry-oriented practices important for mathematics learning (NGA & CCSSO, 2010; NCTM, 2000). These uses of technology align to best practice recommendations in the fields of mathematics education (NCTM, 2000, 2014; Zbiek, Heid, Blume, & Dick, 2007) and educational technology (New Media Consortium, 2014; Niess, 2005). Further, these uses of technology are also the ones teachers are least likely to have experienced in their educational preparation.

What does professional development that promotes the development of TPACK look like and what features seem important for supporting teacher learning? This question is examined through this chapter. To situate the reader, we provide the background and design framework from InterMath. Then, we present a description of the program and the data that support the claims of its effectiveness, including pre/posttest studies from some implementations of InterMath (Bleich, Ledford, Orrill, & Polly, 2006; Izsák, Jacobson, de Araujo, & Orrill, 2012; Orrill & Brown, 2012; Orrill & Kittleson, 2015; Orrill & the InterMath Team, 2006; Polly 2006; Polly & Orrill, 2012). Vignettes of an InterMath experience highlight the ways in which it supports the development of different aspects of TPACK. The chapter concludes with a discussion of the TPACK framework in which we critically examine ways in which the InterMath program develops TPACK as well as the ways in which it falls short in meeting the needs for aligning to all of the knowledge elements in TPACK. Finally, we propose implications and future directions for professional development programs like InterMath to more robustly develop teachers' TPACK for mathematics.

BACKGROUND

InterMath, in many ways, grew from a musing, "How can teachers teach a mathematics that they never have learned, in ways that they never experienced?" (Cohen & Ball, 1990, p. 233). At that point in time, the mathematics teachers had not experienced school mathematics that embodied the principles and standards outlined in the original NCTM standards (NCTM, 1989). A long history of failed reforms, including " the new math" (e.g., Walmsley, 2003) and the "California math wars" (e.g., Wilson, 2003) had shown that simply providing teachers with standards or new curriculum was inadequate for promot-

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