

# Chapter 22

## Technology Integration in Mathematics: A Model for Integrating Technology through Content Development<sup>1</sup>

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### ABSTRACT

*This chapter describes Technology Integration in Mathematics (TIM), an iterative professional development model that focused on integrating technology into elementary school mathematics instruction. Grounded in the American Psychological Association's Learner-Centered Principles, the program provided teachers with ownership of their own learning and situated teachers' learning of technology in the context of learning mathematics. The authors provide design principles, a description of the project, examples, and challenges from their work.*

### INTRODUCTION

The Technology Integration in Mathematics (TIM) project was a technology integration-oriented professional development (PD) effort focused on elementary school mathematics. The project featured an iterative design approach

that allowed us to revisit and refine our model of professional development through a series of one and two year projects in four school districts over the course of five years. TIM emerged out of the first author's interest in school change and a hypothesis that supporting elementary teachers' use of learner-centered, constructivist pedagogies could be accomplished through supporting the integration of technology in their teaching (e.g.,

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Sandholtz, Ringstaff, & Dwyer, 1997; Roschelle, Pea, Hoadley, Gordin, & Means, 2001). Since teachers generally have not had the opportunity to develop a personally meaningful definition or model for teaching with technology and have had few opportunities to teach content in ways that integrate technology, they have not formed approaches and patterns to effectively integrate technology (Penuel et al., 2007; Schrum, 1999). Therefore, PD has the potential to substantially shape their initial interactions with technology to support content learning (Author, 1999; Lawless & Pellegrino, 2007). Based on the literature and our own experiences, we posited that if we could influence the ways teachers taught mathematics when they had access to computers and calculators and if teachers could see benefits in using those new pedagogies, then they would start using some of these pedagogies in other mathematics lessons—and, eventually, other subject areas.

The iterations of the TIM project, which embodied our theory of teacher change, focused on elementary mathematics. Specifically, we sought to support teachers in developing richer content knowledge as they developed pedagogical knowledge necessary for integrating technology into their classrooms. Numerous educational technology researchers have found that teachers' simultaneously develop technological, pedagogical and content knowledge (TPACK) while learning about technology integration (Polly, 2011; Mishra & Koehler, 2006; Niess, 2005).

Throughout the lifespan of the project, the TIM staff worked to build each teachers' dispositions toward technology and mathematical knowledge. This dedication to finding ways to meet the teachers' needs paid off as evidenced in teacher self-reports. On five of the six individual projects that comprised the TIM effort<sup>2</sup>, at least 89% of the participating teachers reported the project being a positive experience with up to 100% of the teachers in one project noting that the project had taught them some "great new ways to teach mathematics; and up to 85% of teachers

in another project agreeing that the project had "taught me a lot about using computers with my math students."

Over the course of the five-year lifespan of the TIM efforts, we had the opportunity to try a number of variations on this approach. However, specific aspects of the professional learning model either became central through our successive attempts to meet our goals or they proved from the beginning to be critical to the success of the professional development efforts. We present these aspects of the TIM approach as design principles and discuss them in detail following the introduction of our PD model. We will conclude the chapter with a discussion of the challenges we were unable to overcome in our own efforts.

### The TIM Professional Development Model

The goal connecting all of the TIM projects was to promote the creation and implementation of learning opportunities for students that were consistent with the *Principles and Standards for School Mathematics* (NCTM, 2000). As pointed out in the *Standards' Technology Principle* (NCTM, 2000), technology can help connect skills and procedures to mathematical understandings and technology can limit the necessity of particular skills once critical to mathematical success. This opens up opportunities for teachers to engage students in working at higher cognitive levels and focusing on generalizing and problem solving in ways that were not feasible without modern classroom technologies. As a concrete example of the power of technology in the elementary mathematics classroom, a dynamic geometry package can be used by the teacher to construct two-dimensional shapes. Students can then be given opportunities to manipulate those shapes by resizing (dilating), rotating, flipping (reflecting), and moving (translating) them to see what stays the same about the shapes and what changes. This is an activity that cannot be replicated in the "real" world. In the

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