

## Chapter 24

# Web-Based Simulations for the Training of Mathematics Teachers

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### ABSTRACT

*A crucial step in learning to fly an airplane is to use a simulator, where the risks are minimized or even eliminated, and similar problems and hazards can be replayed and reflected upon time after time. A key aspect of this case study is to exploit such techniques by adopting the latest technological developments in simulating teaching practice to give pre-service teachers more “teaching” experience than would otherwise be practical or possible in typical student teaching placements. The case study explores the affordances offered by digital simulations for contextualizing pre-service teachers’ learning of mathematics content and its pedagogy. Using the simulated classroom SimSchool as a virtual field experience, the authors seek to bridge the classic gap between teacher preparation and practice by creating reality-based learning contexts that strengthen pre-service teachers’ appreciation of how to implement standard-based mathematics instruction in complex classrooms.*

### BACKGROUND TO THE CASE STUDY

Mathematical literacy is a core literacy that serves as one of the foundational areas of knowledge that drives scientific and technological advancement in knowledge-based economies (European Commission, 2004). Cross-national studies of student

achievement (e.g. Trends in International Mathematics and Science Study (TIMSS), Programme for International Student Assessment (PISA)) indicate lack of mathematical competence for a considerable proportion of the student population around Europe and internationally. There is also well-documented evidence of declining interest in key science and mathematics topics, as well as

DOI: 10.4018/978-1-4666-7363-2.ch024

in science careers (e.g. European Commission, 2007; U.S. Department of Education, 2000; Osborne & Collins, 2001; Adleman, 2004; Jenkins & Nelson, 2005; Sjøberg & Schreiner, 2006; OECD, 2006). Students' low achievement and declining interest in mathematics is of concern given that mathematical literacy provides the foundations for more advanced or specialized training either in higher education or through lifelong learning, and functions as a critical gatekeeper for participation in many aspects of modern society. Research suggests that students' mathematics identity—their attitudes towards mathematics and self-perceptions of their mathematics ability—is formed in the elementary grades and predicts their mathematics achievement in later years (Tate & Rousseau, 2002; Tate, 2005), and that pupils with poor quantitative skills are likely to have fallen behind by the age of ten (DfES, 2003). Thus, learning substantial mathematics is critical for young children, since the early years of schooling are especially important for children's mathematical development (Sarama & Clements, 2009).

The direct relationship between improving the quality of teaching and improving students' learning in mathematics is a common thread emerging from educational research (Stigler & Hiebert, 1999). Although many factors affect a teacher's effectiveness, teacher knowledge is one of the biggest influences on student achievement (Fennema & Franke, 1992). For it is what a teacher knows and can do that influences how he/she organizes and conducts lessons, and it is the nature of these lessons that ultimately determines what students learn. Recognizing that the blend of mathematical content knowledge and pedagogical content knowledge is most critical for effective instruction, leaders in mathematics education have highlighted the need for improving teachers' pedagogical content knowledge of the subject (Ball, Lubienski, & Mewborn, 2001; Schwartz & Lederman, 2002). Pedagogical content knowledge refers to the ability of teachers to

transform formal subject matter knowledge into pedagogically powerful forms that are appropriate for a particular group of students (Shulman, 1986). This ability lies at the intersection of subject matter knowledge, knowledge about students' learning, and knowledge about mathematical instruction (Even & Tirosh, 1995). It includes knowledge of students' typical conceptions and preconceptions regarding main mathematical ideas, understanding of what makes the learning of specific topics easy or difficult, knowledge of effective strategies for helping students re-organize their understanding, as well as the ability to be adaptive to the variations in ability, prior knowledge, and individual characteristics presented by students (Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996).

In recent years, teacher preparation programs have come under attack for failing to equip their graduates with the knowledge and skills required to teach quality mathematics. Research indicates that the majority of teachers entering the profession lack substantial mathematics content knowledge, knowledge of what to teach, and of how to effectively represent the subject matter to learners (e.g. Chonjo, Osaki, Possi, & Mrutu, 1996; Parker & Heywood, 2000). Moreover, the research literature suggests that some of the pre-service teachers at the primary school level have negative attitudes towards mathematics (e.g. Ball, 1990; Haylock, 1995). A chief criticism of teacher education programs is that they are disconnected from the school system (Beck & Kosnik, 2006; Kirby, McCombs, Barney, & Naftel, 2006), overly theoretical (Darling-Hammond, Hammerness, Grossman, Rust, & Shulman, 2005) and not as relevant as practitioners demand (Crocker & Dibbon, 2008). Methods courses tend to predominantly deal with the visible parts of knowledge—the “know-what” of teaching mathematics—and not with the tacit knowledge—the “know-how” (Zibit & Gibson, 2005). Unlike “know-that,” which is explicit knowledge that can be transferred to apprentices by means of writing it down or verbalizing it,

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