

Chapter 11

A Theoretical Framework for Implementing Technology for Mathematics Learning

Travis K. Miller

Millersville University of Pennsylvania, USA

ABSTRACT

This chapter details a theoretical framework for effective implementation and study of technology when used in mathematics education. Based on phenomenography and the variation theory of learning, the framework considers the influence of the learning context, students' perceptions of the learning opportunity, and their approaches to using it upon measured educational outcomes. Elements of the TPACK framework and the CTFK model of teacher knowledge are also addressed. The process of meeting learning objectives is viewed as leading students to awareness of possible variation on different aspects, or dimensions, of an object of mathematical learning.

INTRODUCTION

Implementation and study of technology within the mathematics curriculum must consider an appropriate theoretical framework. Leading theories of mathematical learning tend to focus upon one particular aspect of learning: cognition, social interaction, or context. Further, technology use

and educational research based upon these theories limit focus to the primary considerations of the chosen theory, with limited scrutiny or examination of alternatives. The view of learning taken by the phenomenographic research approach and its associated variation theory (Bowden & Marton, 1998; Marton & Booth, 1997; Prosser & Trigwell, 1997; Runesson, 2005) avoids these limitations. Phenomenography and variation theory share a unique relationship; the fundamental assumptions

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of the phenomenographic view of learning are detailed in the recently developed variation theory, which itself evolved from the findings of empirical phenomenographic research studies (Bowden & Marton, 1998; Marton & Booth, 1997; Runesson, 2005). As an approach to research, phenomenography searches for the qualitatively different ways of experiencing an educational phenomenon. As a theory of learning, the aligned variation theory focuses upon guiding learners to an awareness of the different aspects of the learning object.

This chapter considers three essential questions regarding the implementation and study of technology within the mathematics curriculum:

1. How is the application of a learning theory influential in the implementation and study of technologically enhanced mathematical learning?
2. What is the derivation of the variation theory of learning, and how does it apply to the teaching and learning of mathematics?
3. How can variation theory help to establish an effective framework for implementing and researching technology use in mathematics education?

The chapter first briefly examines constructivism and the situative perspective, two predominant theories of learning in mathematics education. This is followed by a discussion of the central tenets and historical development of variation theory from phenomenography. Next, variation theory conceptualizations of learning mathematics via technology are presented as a guide for the development of effective technology-enhanced experiences that facilitate mathematics learning, a concern of the mathematics Technological Pedagogical Content Knowledge (TPACK) Framework (Association of Mathematics Teacher Educators, 2009; Mishra & Koehler, 2006; Niess et al., 2009; Ronau, Rakes, Wagener, & Dougherty, 2009). Finally, the chapter concludes with the implications of phenomenographic methods and the pre-

sented framework for research of technology-rich learning opportunities in mathematics courses. These research considerations also align with the TPACK framework (AMTE, 2009; Mishra & Koehler, 2006).

METHODOLOGY

The initial search of the existing literature for this work was part of a comprehensive and broader doctoral dissertation literature review (Miller, 2007). Searches for recent publications on learning theories and technologies utilized the ERIC, Educause, and JSTOR databases to focus upon issues in education. Manuscripts were included based upon two criteria: (1) examination of either the constructivist or situative perspectives, and (2) application of technology to improve learning. Article selection considered a historical view of the theories via publications from their originators alongside more recent interpretations and applications. Identification of writings regarding phenomenography and the variation theory of learning took a similar, albeit more comprehensive, approach. A more thorough review of phenomenography and variation theory was facilitated by their more recent development and the smaller body of published work.

There are both benefits and limitations to this selection method. It could be argued that inclusion of additional and more delineated learning leading theories could lead to alternative conclusions regarding their influence upon the implementation and study of technology use in mathematics learning. However, these two perspectives are regarded as dominant in the realm of mathematics education in the United States (Cobb, 1994; Cobb & Bowers, 1999; Davis & Sumara, 2002; Oregon Technology in Education Council, n.d.). Constructivism forms the basis of the Principals and Standards of the National Council of Teachers of Mathematics (1989, 1991, 2000) and the benefits of situated learning is evident in their attempt to emphasize meaningful,

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