Chapter 11
A Theoretical Framework for Implementing Technology for Mathematics Learning

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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
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, phenomenog-
raphy 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 ques-
tions 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 constructiv-
ism 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 Peda-
gogical 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 implica-
tions 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 learn-
ing 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 origina-
tors 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 phenom-
enography 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 lead-
ing theories could lead to alternative conclusions
regarding their influence upon the implementation
and study of technology use in mathematics learn-
ing. 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 Na-
tional 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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