Chapter 19

An Algebra Teacher's Instructional Decision-Making Process with GeoGebra:
Thinking with a TPACK Mindset

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ABSTRACT

This chapter shares results of a classroom-based action research study on instructional decision-making when teaching a unit on linear functions with GeoGebra, a dynamic algebra environment. The TPACK / Student Knowledge Matrix developed by Niess (2008) provided a structure for unit planning and lesson development. The matrix combines the three categories of teacher knowledge – technological, pedagogical, and content – with four levels of student knowledge – declarative, procedural, schematic, and strategic. While implementing the four-week unit, the algebra teacher used multiple data sources to document day-to-day decision-making. Data analysis revealed decisions were guided by the need to improve clarity, to increase interactivity, to highlight connections between representations, and to use GeoGebra as a tool to increase understanding. Throughout the unit, GeoGebra became a tool for computation, transformation, data collection and analysis, and error checking.

INTRODUCTION

What does it mean to teach mathematics with technology? How would one go about investigating this question? What characteristics of teaching and learning indicate best practice when it comes to the integration of technology in the planning and implementation of a lesson or unit of instruction? Felger, a 6th through 8th grade math and science teacher, completed an action research study to examine his instructional decisions regarding the use of one piece of technology, GeoGebra, in the planning and

implementation of a unit on linear functions. His goals were to examine the types of decisions needed to support students' conceptual understanding through the integration of technology, to improve lesson structure and format, and to plan for maximum student engagement in a technology-rich unit. For the purposes of this chapter, conceptual understanding is defined as "comprehension of mathematical concepts, operations, and relations" (National Research Council, 2001, p. 5). In addition, the authors collaboratively agreed on the use of Miller and Pine's (1990) definition of action research: "We conceive action research as a recursive ongoing process of systematic study in which teachers examine their own teaching and students' learning through descriptive reporting, purposed conversation, collegial sharing, and critical reflection for the purpose of improved classroom practice" (p. 57).

This action research was completed to fulfill the requirements of a master's degree program in mathematics education. Shafer, a teacher educator, guided Felger's learning throughout the study and collaborated with him on this chapter. The desire to investigate the affordances of technology to support conceptual understanding developed during Felger's participation in the master's program. While completing the program, he gained a deep awareness of the importance of student understanding and transitioned from a supplier of information to a partner in mathematical investigation. Felger learned to pose authentic mathematical tasks and began to use technology as a tool for supporting student understanding, as opposed to a tool for classroom organization or lesson presentation. This change in purpose and use of technology was augmented by regular documentation and reflection that took place while taking a mathematics technology course.

Reflecting on a suggestion to document "how you do what you do," Felger began investigating what worked, what did not work, and why. Analyzing these essential questions led to the use of the TPACK (Technological Pedagogical Content Knowledge) (Mishra & Koehler, 2006) framework for considering how knowledge of technology, curriculum, and pedagogy interacted. The Background section of this chapter provides a literature review regarding teaching with technology, instructional decisions, and the TPACK framework. The Action Research Study and Results sections of this chapter describe Felger's instructional decision-making regarding the use of technology to support conceptual understanding in a unit on linear functions.

BACKGROUND

Principles and Standards for School Mathematics (NCTM, 2000) suggests important standards regarding the teaching and learning of linear functions in middle grades. First, students should be able to compare the properties of linear versus nonlinear functions and describe the nature of change between quantities in a linear relationship. Linear patterns should be expressed in tables, graphs, rules, words, and symbols (NCTM, 2000, p. 223). These multiple representations become important as students learn to model and solve contextualized problems in various ways. As Bayazit and Aksoy (2010) noted, "... students' ability to see interrelations between representations and between ideas is seen as a crucial stage in developing conceptual understanding of mathematics" (p. 94).

Graphing technologies, such as GeoGebra, can help students develop a deeper understanding of function through the use of multiple representations. Referring to early versions of these technologies (e. g. graphing calculators), Leinhardt, Zaslavsky, and Stein (1990) stated, "The issue of multiple representations may become more salient in the context of these technologies. Working simultaneously with at least two linked representations is more manageable with these media" (p. 7). Current interactive mathematics

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