Chapter 3
Transforming Mathematics Teaching through Games and Inquiry

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ABSTRACT

This chapter describes the design, development, and testing of a successful mathematics game-based intervention, Math Snacks, for students in grades 3–7. This program shows the impact of an integrative approach of developing Technological Pedagogical Content Knowledge (TPACK), where interactive digital media are combined with inquiry-based activities in classrooms facilitated by teacher involvement. Teachers played a key role in development and testing of Math Snacks, both by using them in their classrooms and by teaching core mathematics concepts connected to each module during annual summer camps. Via this multi-faceted participation, teachers experienced a change in their understanding of how digital tools can connect with inquiry-based pedagogy, mathematical content and pedagogical knowledge to facilitate successful learning for students. Teachers began to approach multimedia and games as part of an inquiry-based pedagogical approach for mathematics learning, rather than seeing games as tools for student practice after learning a concept.

INTRODUCTION

The *Math Snacks* suite of games, animations and learning tools engages students with critical math content. Produced in collaboration among mathematics educators, mathematicians, learning specialists and game developers, *Math Snacks* supplements instruction by making core math concepts more accessible and conveying topics in a creative, visual, and applied way. For example, in *Game Over Gopher* the learner distracts space gophers from eating a prize carrot by placing feeders at points, or vectors, along the coordinate grid. *Ratio Rumble* features a Bejeweled-like board that starts with simple recipes

DOI: 10.4018/978-1-5225-0120-6.ch003

for two-part, whole-number ratios, and gradually guides students toward mastery of three-part ratios and ratios with fractions and decimals. *Scale Ella* is an animated superheroine who uses the power of scale factor to set things right when the villain *Scaleo* transforms their length, width, and height. Each of the modules focuses on a core math concept and aligns with Common Core Mathematics Standards (CCSS-M). Each module is accompanied by teacher and learner guides, a teaching protocol, and an instructional video.

Teachers participated in development of the materials, were involved in research on the effectiveness of the tools, and continue to use the successful game-based intervention designed to address gaps in the conceptual understanding of mathematics for students in grades 3–7. Specifically, this chapter focuses on changes in teachers' understanding of how games can be used when connected to integrated mathematics pedagogy and content to support new ways to facilitate mathematics learning. During development of the *Math Snacks* tools, teachers designed related inquiry-based materials to complement the concepts targeted by the games. They also tested *Math Snacks* materials in their classrooms, during summer camps, and met with the researchers to share how they used the games.

The background for this project shares how research began prior to the development of student and teacher conceptual understanding of specific mathematics content. The theoretical framework for this project provides specific information on how the digital games blend mathematical and pedagogical knowledge to provide new ways for teachers to teach and students to enjoy and access mathematics. A description of teachers' roles in assisting developers to create a successful mathematics intervention that connects games with classroom-based inquiry shows the success in teaching mathematics concepts that have been challenging in traditional mathematics teacher-directed classrooms. While the study was not initially grounded in the TPACK framework (Koehler & Mishra, 2009; Niess, 2013), the study of teacher's interaction with games while teaching mathematics can be further understood by referring to the evolving work in this area and Niess's (2005, 2013) work in studying the integrated approach of teacher development in technological pedagogical content knowledge (TPACK).

BACKGROUND

The design of *Math Snacks* began with an investigation of common gaps in students' understanding of math concepts in grades 3–7. The mathematics education research team in the Institute for Excellence/Equity in Mathematics and Science Education (IEMSE) at New Mexico State University analyzed the results of 24,000 student scores on the New Mexico Standards-Based Assessment (NMSBA). On this test, half of the items were open-ended or short answer questions, so it was possible to see student misconceptions in mathematical thinking in ways not possible on multiple-choice-only tests. Researchers looked at the analysis of test results in several different districts and puzzled over almost identical patterns of strengths and weaknesses in student performance across districts, regardless of economic status, number of English Language learners, or size of the district. For example, students across all districts had particular trouble with number concepts and operations, as demonstrated by low average score points on test items focused on operations with decimals and fractions. Similar patterns of common mistakes were found across the districts in all of the mathematics strands, including geometry, data, and algebra. This research provided a road map for developers interested in designing materials to address common student misconceptions. These findings became the basis of an NSF-awarded grant for the development of innovative media, resulting in modules called *Math Snacks*.