Chapter 19
Supporting Online Collaborative Mathematical Exploration:
Studying the Development of Collective Knowledge within Math-Towers

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ABSTRACT

Math-Towers is a collaborative mathematics environment for pupils in grades 7 to 9. Using a fantasy adventure game context, students are presented with a mathematical challenge, given online tools for working on the problem, and provided with a messaging system by which they may exchange ideas and partial solutions. This paper presents the philosophy behind the design of Math-Towers and, using a complexity science framework, explores the extent to which it has been successful in meeting goals. The technical and social problems encountered and revisions made to address these are also described.

INTRODUCTION

Over the past two decades a movement towards a social constructivist (Ernest, 1998) view of mathematics has driven significant international changes in education (Black & Atkin, 1996; Romberg, 1992). Across jurisdictions new mathematics curricula call for students to engage in investigations and mathematical talk (NCTM, 2000) through which, research has shown, they can collaboratively construct deep robust knowledge (Cobb, Boufi, McClain, & Whitenack, 1997; Hufferd-Ackles, Fuson, & Gamoran-Sherin, 2004). A Google search on the words "mathematical" and "investigation" shows over 14 million pages, but when "collaborative" is added as a search term the number of hits drops to just over 140 thousand; a reduction by a factor of 100. Examining a sample of the listed sites shows that in fact many do present interesting mathematical explorations, often supported by online tools that permit visitors to manipulate objects and adjust parameters, observe the effects, and make mathematical conjectures. But, these sites rarely provide tools that allow users to share their thoughts and collectively build solutions to the problems presented.

Synchronous online communication tools such as text chat (Stahl, Ou, Cakir, Weimar, & Goggins, 2010), and voice and application sharing (Roulet, Mackrell, Taylor, & Farahani, 2004) have been suc-

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cessfully employed to build computer-supported collaborative learning (CSCL) spaces (Lehtinen, 2003) for mathematics, but in the asynchronous mode significant problems arise. Nason and Woodruff (2004) argue that most school mathematics problems do not engage students in extended conversations and online collaborative learning environments do not support the simple exchange of mathematical ideas in symbol or image forms. The Math-Towers site (www.math-towers.ca) is an attempt to address these two issues and provide online collaborative mathematical explorations for students in grades 7 to 9 (ages 12 to 14 years).

METHOD

Math-Towers Design

In Math-Towers, explorations, set within a medieval castle context, are initiated by challenges delivered to visitors by the Lord or Lady of the castle (Figure 1), thus using fantasy, a known motivator of student attention and work (Bergin, 1999). Each user is then sent off to a tower where they are provided with a laboratory containing virtual manipulatives (applets) that support investigation and tools and places to record their observations and conjectures (Figure 2). Student work is saved so that participants may visit the tower multiple times, climbing up the floors as they solve aspects of the problem, and finally emerge on the tower ramparts to be invited to now again meet the Lord or Lady and attempt to address the initial challenge. In the tower halls beside each laboratory door there is a scroll on which students can present their emerging understanding of the problem (Figure 3). In addition, users may, to illustrate their thoughts, append a copy of their manipulatives and tools in any state. After posting a message a user is free to explore the ideas shared by others, add comments, and if they wish, take any of the accompanying tools back to their laboratory for further exploration.

Math-Towers may be described as an "empty technology" (Zucchermaglio, 1993). That is, the computer does not provide instruction, nor does it monitor student work and provide assessment or advice. The laboratory tools permit any user to test the accuracy of shared conjectures and

Figure 1. Presenting the billiard challenge