Chapter 2

Sometimes Less is More: Examples of Student–Centered Technology as Boundary Objects in Differential Equations

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ABSTRACT

As described in the communities of practice literature (Lave & Wenger, 1991; Wenger, 1998), boundary objects are material things that interface two or more communities of practice. Extending this, Hoyles, Noss, Kent, and Bakker (2010) defined technology-enhanced boundary objects as, “software tools that adapt or extend symbolic artefacts identified from existing work practice, that are intended to act as boundary objects, for the purposes of employees’ learning and enhancing workplace communication” (p. 17). The authors adapt this idea to the undergraduate mathematics classroom and use the phrase “classroom technology-enhanced boundary object” to refer to a piece of software that acts as a boundary object between the classroom community and the mathematical community. They provide three extended examples of these objects as used in a first semester differential equations classroom to illustrate how students’ mathematical activity may advance as they interact with the software. These examples show how the applets operate to provide a way for the classroom community to implicitly encounter the mathematical...
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community through the authentic practices of mathematics (Rasmussen, Zandieh, King, & Teppo, 2005). The first example centers on students beginning experience with a tangent vector field applet. The second example develops as the students learn more about solutions to differential equations and leads to a statement of the uniqueness theorem. In the third example, students use a specially designed applet that creates a numerical approximation and its associated image in 3-space relating to a non-technological visualization task that introduces solutions to systems of differential equations.

INTRODUCTION

Visualization offers students a window into the world of mathematics. Technology used in mathematics at the university level plays many roles in facilitating visualization. For example, in beginning calculus many classes use software such as Mathematica, Matlab, or Maple to help students to visualize graphs of functions, derivatives, integrals, and series. Animations are often available for use with these programs, and instructors or programmers may set up demonstrations to show students a visual illustration to help them understand the mathematics. Additionally, the development of Java applets to illustrate a specific idea in calculus, differential equations, non-Euclidean geometry, and other courses can provide an opportunity for students to visualize the intended mathematics. Over the past several years, we have been engaged in designing and studying innovative learning environments in differential equations that provide students with significant opportunities to visualize concepts as they reinvent key mathematical ideas (Rasmussen & Kwon, 2007). The use of specially designed technological tools has been a central component of these efforts. The purpose of this chapter is to illustrate how these technological tools function as boundary objects between the classroom community and the broader mathematical community.

As illustrated in the communities of practice literature (Lave & Wenger, 1991; Wenger, 1998), boundary objects are material things that interface two or more communities of practice and satisfy the informational requirements of all of them (Bowker & Star, 1999; Lee, 2007). A community of practice is a collective construct in which the joint enterprise of achieving particular goals, such as doing mathematics, evolves within the social connections of that particular group (Lave & Wenger, 1991; Wenger, 1998). Boundary objects can be mathematical symbols, technology, documents, software, or other items that allow people to cross between different communities and work together. Hoyles, Noss, Kent, Bakker (2010) define Technology-Enhanced Boundary Objects (TEBOs) as, “software tools that adapt or extend symbolic artifacts identified from existing work practice, that are intended
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