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Authority in an agency-centered, inquiry-based university calculus classroom

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ABSTRACT

Authority roles among teachers and students have traditionally been hierarchal and centered with the expertise and power of the teacher limiting opportunities for students to act with autonomy to build and justify mathematics. In this paper we discuss authority roles for teachers and students that have been realized in an inquiry-based university, honors calculus classroom. We define and discuss four types of authority we identified from video data: institutional, expertise, mathematical, and performative. We suggest that the institutional authority of the instructor is present whether or not she is acting with the intention to bear authority, thereby interfering with the instructor's ability to share authority with her students. Further, we believe that the traditional focus on the bearer of authority limits our ability to create environments wherein authority can be shared. Instead we suggest that a focus on empowering the receiver to recognize expertise and mathematical authorities may be more fruitful.

1. Introduction

With one of the goals of improved mathematics learning and teaching being to foster mathematical autonomy among students (NCTM, 2000), much attention has been given to supporting teachers as they undergo a process of changing their roles, functions, and dispositions within the classroom (Ding, Li, Piccolo, & Kulm, 2007; Wilson & Lloyd, 2000). Authority roles among teachers and students have traditionally been hierarchal and centered with the expertise and power of the teacher (Herbel-Eisenmann, Wagner, & Cortes, 2008). Hierarchal authority roles limit opportunities for students to act with autonomy to build and justify mathematical understandings (Amit & Fried, 2005).

In 1970 Benne introduced an ideal type of authority, anthropogogical authority, which is shared among teachers and students and, if realized, would foster autonomy with interdependence. Studies have shown that autonomy is fostered in inquiry environments (Goos, 2004; Rasmussen & King, 2000; Yackel & Cobb, 1996), which gives us possible indirect evidence that authority relationships among teachers and students, particularly in inquiry-based settings, are evolving from classical types of authority to types of shared authorities. However, there have been very few studies of authority in mathematics education, and none to date have documented shared authority among teachers and students (Amit & Fried, 2005). Herbel-Eisenmann et al. (2008) have called for "more in-depth investigations of authority structuring in particular classroom situations" (pp. 3–159). This paper aims to outline some new authority roles for teachers and students that have been realized in the mathematics classroom, that can dissolve the traditional hierarchy of subordination and give way to the realization of autonomy with interdependence as called for by Benne (1970).

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Hemisphere Water Tank

A certain water tank is a hemispherical bowl of radius 5 feet. Water flows into the tank at the rate of 10 cubic feet per minute.

A. Find the volume of the water in the tank when the water is 3 feet high at the center of the tank.

B. Find an equation for the volume of the water in the tank for any given height, h, of the water at the center of the tank.

Extension: How fast is the water level rising when the water is 3 feet high at the center of the tank.

Fig. 1. The Hemisphere Water Tank Task.

1.1. Setting

In winter 2007, the instructors team-taught and conducted a teaching experiment (Steffe & Thompson, 2000) in university honors Calculus II as a continuation of a one-semester course in honors Calculus I offered in winter 2006, and fall 2007. The Calculus II course was based, in part, upon our belief of the importance, indeed the necessity, of personal agency for learning (Brown, 2005; Kohn, 1998; Rogers, 1969; Walter & Gerson, 2007). We previously defined agency as "the requirement, responsibility and freedom to choose based on prior experiences and imagination, with concern not only for one's own understandings of mathematics, but with mindful awareness of the impact one's actions and choices may have on others" (Walter & Gerson, 2007). In the teaching experiment ideas brought forward by the students drove the curricula of the course. Pedagogical decisions were made in response to student ideas as well as the learning outcomes of the course.

In this teaching experiment, 20 students built meaning for cognitively important calculus concepts through collaborative engagement in rich tasks in place of direct instruction. Each task was designed to have multiple points of entry, allow for the exploration of varied calculus content and allow students to connect with prior knowledge and learning as guided by their own thinking and group and class discussions.

In this paper we focus on students as they engaged in the Hemisphere Water Tank Task (Fig. 1), a commonly assigned homework problem in Calculus II, usually given after the development of the disk and/or shell methods. In this case, the task was given to students before learning the disk or shell methods. Thus in order for students to complete the task, they had to develop a method for calculating the volume of a solid of revolution and justify their methods and answers.

In this paper we will focus on presentations made by two different groups: Danielle and Derrick, both Freshmen, and Paul, a junior, from Group One; and Michael, Heber, and Tyler a senior, junior, and freshman from Group Two. Danielle and Heber were mathematics education majors and Derrick, Michael, Tyler, and Paul were studying engineering. Derrick had taken the experimental Calculus I the previous semester, but the other students were new to the calculus experiment. Three other participants played a role in the interplay between the presenters and the audience, Timbre, a sophomore majoring in biophysics and dance, Daniel, a sophomore majoring in statistics, and John, a senior majoring in history. Timbre and Daniel were prior participants in the teaching experiment and John was new.

1.2. Questions

As a part of the larger teaching experiment we videotaped classroom sessions and collected student work. The research presented in this paper stems from a compelling episode that occurred after two groups of students presented their work on the Hemisphere Water Tank Task to the class. Both groups of students answered part A using different mathematical models of the tank. Michael wondered how the equations generated by the two models calculated the volume of water, and why they were different. At the end of their presentation, Michael, with Heber's help, decided to explore the two equations in front of the class. After about 9 min the instructors opted to end the exploration. However, Heber and Michael chose to continue for two more minutes at the front of the class and several minutes after the launch of a new task. In this compelling episode, we recognized that Michael was acting with authority to first, pose new questions and explorations to the class and second, continue his exploration with Heber even after one of the instructors attempted to close the discussion. These two enactments of authority struck us as quite different from the traditional student/teacher authority relationships.

In order to gain more insight into authority in this setting, we chose to examine the key episode and those surrounding it in great detail in order to answer the questions: 1. What types of authority are held by the students in this setting, 2. Upon what authority did Michael act to pose new questions and explorations to the class, and 3. Upon what authority did Michael and Heber act to continue the exploration after the teacher closed the discussion. As we explored these questions, we categorized the different types of authority enacted in the teaching experiment, built theory about how authority can be identified in videodata, and used the theory to study authorities enacted by Michael and Heber and their classmates.