A Framework for Interpreting Inquiry-Oriented Teaching

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In order to improve student learning many teachers, new and experienced, express interest in inquiry-oriented teaching. Such interest is often accompanied with queries regarding the role of a teacher in such classrooms and how inquiry-oriented teachers are able to facilitate classroom discussion in ways that lead to progress on their mathematical goals (Ball, 1993; Rasmussen & Marrongelle, 2006). The purpose of this report is to contribute to the research agenda on inquiry-oriented teaching by studying one particular teacher in an effort to uncover ways in which he was able to promote his students' mathematical learning through discourse. In doing so, we offer a framework that characterizes the discursive moves that a teacher can use to create and sustain an inquiry-oriented classroom learning environment.

Our analysis builds on and extends earlier work by Rasmussen and Rhodehamel (2006), who reported on students' substantial mathematical progress in an inquiry-oriented differential equations class. Using Toulmin's (1969) scheme as an analytic tool, this prior research revealed the rich and diverse student-generated justifications and resulted in discovering the geometric structure of solutions to systems of linear differential equations. For example, over the course of four classroom sessions, students offered 61 arguments while the teacher only offered 7 arguments. As such, this analysis highlighted progress in student explanation and justification while backgrounding the role of the teacher. In the analysis reported here we complement this earlier work by foregrounding the role of the teacher.

Background

Perhaps not surprisingly, different research communities characterize inquiry in different ways. For example, in science education the National Research Council (1996) states that inquiry includes identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. In the philosophy of mathematics education, Richards (1991) characterizes inquiry as learning to speak and act mathematically by participating in mathematical discussions, posing conjectures, and solving new or unfamiliar problems. Both characterizations highlight important aspects of student activity. While such characterizations of student activity are essential, they only address part of the process of inquiry. In order to more fully understand the complexity of classroom learning, our definition of inquiry also encompasses *teacher* activity as well as student activity (Rasmussen & Kwon, 2007). In particular, inquiry-oriented teachers routinely *inquire* into their students' mathematical thinking and reasoning. Teacher inquiry into student thinking serves three important functions. First, it enables teachers to construct models for how their students interpret and generate mathematical ideas. Second, it provides opportunities for teachers to learn something new about particular mathematical ideas, in light of student thinking. Third, it better positions teachers to build on students' thinking by posing new questions and tasks.

Students, on the other hand, learn new mathematics through *inquiry* by engaging in mathematical discussions, posing and following up on conjectures, explaining and justifying their thinking, and solving novel problems. Thus, the first function that student inquiry serves is to enable students to learn new mathematics through engagement in genuine argumentation. The second function that student inquiry serves is to empower learners to see themselves as capable of reinventing mathematics and to see mathematics itself as a human activity (Rasmussen &

Kwon, 2007).

Methods

Data for this analysis comes from four class sessions of an eight-week classroom teaching experiment (see Cobb, 2000 for additional details of the teaching experiment methodology) conducted in an undergraduate differential equations course. Data sources consisted of video recordings of whole class and small group discussions, researcher field notes, and copies of student work. The classroom teaching experiment was conducted as part of a larger research program aimed at developing an inquiry-oriented, research-based instructional approach in undergraduate mathematics. We began the data analysis by transcribing the four classroom sessions. A coding scheme was then developed as we observed video and simultaneously highlighted the teacher's discursive moves in the transcripts. We refined and revised our coding scheme based on review of the literature (e.g., Forman et al, 1998; Krussel, Edwards, & Springer, 2004; Lobato et al, 2005; Mehan, 1979; Smith, 1996) and multiple passes through our data. We used problematic or especially interesting episodes to sharpen and refine the coding scheme. This collaborative, iterative coding process provided multiple occasions to share and defend interpretations of the video and corresponding transcripts, thereby minimizing individual bias by each researcher and eliminating interpretations not grounded in the video (Jordan & Henderson, 1995). In addition, we explained our coding scheme to a mathematics education graduate student who then independently coded all transcripts, resulting in over 80% agreement.

Results

The main result of our analysis is a framework characterizing inquiry-oriented teaching. The framework consists of four different discursive moves and the relationships between these discursive moves and the various functions that inquiry serves (three teacher functions and two student functions as previously defined). As such, we present the Inquiry-Oriented Discursive Move (IO-DM) framework (see Table 1) as a coordination of two dimensions (discursive move on one axes and function of the discursive move as it relates to teacher and student inquiry on the other axes). The black cells in Table 1 that are teacher discursive moves that we see as most strongly connected to specific functions of teacher and student inquiry. The grey cells are teacher discursive moves that have a secondary connection.

Teacher Discursive Move	**Teacher Inquiry**			**Student Inquiry**	
	A	**B**	**C**	**A**	**B**
Revoicing					
Repeating					
Rephrasing					
Expanding					
Reporting					
Questioning/Requesting					
Evaluating					
Clarifying					
Explaining					
Justifying					
Telling					
Initiating					
Facilitating					
Responding					
Summarizing					
Managing					
Arranging					
Directing					
Motivating					
Checking					

Teacher inquiry
A - model student thinking
B - learn new math
C - Next tasks, questions

Student inquiry
A - engage in argumentation
B – affect, beliefs

Table 1. Discursive move framework

The four discursive moves are Revoicing, Questioning/Requesting, Telling, and Managing. Operational definitions for each of these discursive moves are beyond the scope of this short paper. As example, however, consider Revoicing, which is defined as reuttering – or saying again (could be verbal, symbolic, or gestural) – of someone else's utterances (symbolizing or gesturing). This may be a direct (immediate) restatement or it may involve an adaptation of the original utterance. Our definition of revoicing is drawn from O'Connor and Michaels (1993) and Foreman et. al. (1998). O'Connor and Michaels (1993) introduce four subcategories of Revoicing, referred to as repeating, rephrasing, expanding, and reporting, each with operational definitions. Briefly, repeating refers to instances of revoicing when the teacher repeats a student's utterance. Rephrasing is when a teacher states a students' utterance in a new or different way. Expanding refers to those instances when a teacher adds information to a student's utterance. Finally, reporting is when a teacher attributes an idea, claim, or argument to a specific student. Examples of the four types of revoicing are shown in Table 2. When we coded the data, all instances of reporting were double coded with either repeating, rephrasing, or expanding.

Revoicing Category	Description	Example
Repeating	Teacher repeats a student's utterance	S: e^{4t} is a positive exponential and it's growing up exponentially, so it's not going to go backwards to zero, it's going to go forward. T: e^{4t} is a positive exponential.
Rephrasing	Teachers states a student's utterance in a new or different way	S: e^{4t} is a positive exponential and it's growing up exponentially, so it's not going to go backwards to zero, it's going to go forward T: So e^{4t}, as time goes on this becomes bigger and bigger and bigger and bigger.
Expanding	Teacher adds information to a student's utterance	S: The only equilibrium solution is at (0, 0) T: The only one here is $x(t) = 0$ and $y(t) = 0$.
Reporting	Teacher attributes an idea, claim, argument to a specific student.	T: Recall that Julio argued that these are the same graphs, but just shifted along the t-axis.

Table 2: Examples of the four types of revoicing. In the examples, S stands for student and T stands for teacher.

Similarly, the remaining three discursive moves (Questioning/Requesting, Telling, and Managing) each have four subcategories. Moreover, in a longer paper that we are currently working on, we detail the relationship between subcategories within a particular discursive move. For example, the four subcategories of Questioning/Requesting reflect a general progression in mathematical complexity – from declarative knowledge (knowing that and how) to relational knowledge (knowing why).

Concluding Remarks

It has been shown that the IODE approach positively contributes to students' conceptual understanding, problem solving, retention, justification, and attitudes toward mathematics (for example Kwon, Rasmussen, & Allen, 2005, Rasmussen, Kwon, Marrongelle, Allen, & Burtch, 2006). However, we still have to resolve the notorious dilemma of an inquiry-oriented mathematics class for teachers, that is, "how to teach without teaching?" In this report, we have provided a framework by deeply looking at a teacher's discursive move in response to the dilemma. The significance of this work is two fold. First, the IO-DM framework offers teachers a rich and detailed picture of how one particular teacher enacted and achieved an inquiry-oriented classroom. We are currently using our coding scheme to reveal patterns of interaction that depart from tradition Illicitation-Response-Evaluation patterns. Second, the IO-DM framework can serve as a tool for analyzing and comparing different classroom environments. For example, our extended research group is currently examining the extent to which this framework is useful in characterizing two different middle school mathematics classrooms, one that was taught by in an inquiry-oriented manner and one taught in a traditional, teacher centered manner. Finally, the IO-DE framework offers other teachers a potentially useful lens for reflecting on their own teaching practices.

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