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Meaning for fraction multiplication: Thematic analysis of mathematical talk in three fifth grade classes

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ABSTRACT

In this article we share the results of an analysis of the mathematical talk that occurred in discussions of a fraction multiplication task in three different fifth grade mathematics classes. The purpose of the analysis was to determine whether and how fraction multiplication might be construed differently through the use of language, even in classes where the same task was being enacted. We found that the discussions in each class did construe fraction multiplication differently, providing opportunities for students in different classes to develop different conceptions of what fraction multiplication means. This research represents an example of how thematic analysis can be used to shed light on the mathematics of the mathematics classroom, and has implications for research on the enacted curriculum as well as the teaching and learning of fraction multiplication.

1. Introduction

The relationship between language and meaning is of fundamental importance in any context where communication is taking place. In mathematics classes, language has a complex relationship with mathematical meaning (Pimm, 1987). For example, Mick and Sinicrope (1989) described a sixth grade student who was able to make sense of the phrase "one-half of one-half," but was stymied by the expression "one-half times one-half." When faced with finding the solution to the latter, he responded with confusion and eventually used addition, saying, "Oh. . .times. . .this will be a big number though. . .one-half times one-half. One-half plus one-half will equal one whole" (p. 632).

The disconnect between "of" and "times" for this student illustrates the potential of the language used in a classroom to shape student learning. Understanding classroom discourse is important not only because it can reveal the positioning of students, teachers, and textbooks in relation to each other, but also because *mathematical meaning* is construed for the learner through the ways that words are used and understood. For the sixth grader, "of" and "times" apparently represented distinct mathematical operations.

While there is a substantial body of research documenting the fact that teachers use curriculum materials in very different ways (see Remillard, 2005), there are few studies that compare different enactments of the same lesson across teaching contexts. In our review of the literature, we could find no study comparing mathematical language use among multiple classes enacting the same lesson plan. Such comparisons would be valuable because variations in language use could potentially construe mathematical meaning differently, leading to variation in opportunities for students to learn.

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In the area of fraction multiplication, there are several studies that indirectly attend to language in order to make inferences about student learning and/or teacher knowledge (Izsák, 2008; Mack, 1998, 2001; Mick & Sinicrope, 1989). We hypothesize that a detailed analysis of the language used in the classroom can reveal opportunities for students to see an operation such as fraction multiplication in different ways. The purpose of the analysis described in this paper was to examine this hypothesis using linguistic analysis tools. In particular, we used *thematic analysis* (Herbel-Eisenmann & Otten, 2011; Lemke, 1990) to examine different ways that fraction multiplication was construed in three classes where teachers were enacting the same lesson plan.

2. Literature review

The following review of literature describes how thematic analysis can shed light on how mathematical ideas are construed in the classroom. It connects our work, which compares mathematical language use in three different classes where the same lesson was being used, with research on the enacted mathematics curriculum. Finally, it situates our study within research on the teaching and learning of fraction multiplication, and we argue that our approach adds depth to this literature by comparing different enactments of the same lesson and by making classroom language the central object of study.

2.1. Thematic analysis

Discourse analysis has been used to examine many aspects of the mathematics classroom, most having to do with how students are positioned in the classroom with respect to each other and their teachers (e.g., Bishop, 2012; Herbel-Eisenmann, 2007; Herbel-Eisenmann, Wagner, & Cortes, 2010; Khisty & Chval, 2002; Le Roux, 2008; Wagner, 2007). Discourse analysis has not often been used to investigate how *mathematical ideas* are communicated. To fill this gap, Herbel-Eisenmann and Otten (2011) provided a blueprint for how one might use thematic analysis (Lemke, 1990) to explore the relationship between language use and the mathematical meanings that come about in a classroom.

Herbel-Eisenmann and Otten (2011) take the stance that communicative resources, including language, only have meaning to the extent that people in particular contexts make sense of those meanings (see Halliday, 2004). In the mathematics class, for example, a word like "fraction" may be interpreted by some participants according to its everyday meaning, "a portion," which implies that a fraction is always less than its referent whole. This example highlights the idea of a "mathematics register," a sort of sub-language that includes both technical terms and phrases as well as variations in meaning that may be quite different from everyday English usage (Chapman, 1993; Pimm, 1987). To investigate the semantics at play in the mathematics classroom, Herbel-Eisenmann and Otten (2011) developed a method of analyzing the system of meaning, or the "web of relationships," among mathematical ideas as represented in the language used in a mathematics classroom. These relationships are crucial to inferring the meanings that are possible or likely to be understood by participants in the classroom discourse (Halliday, 2004; Lemke, 1990).

Herbel-Eisenmann and Otten (2011) outlined a sequence of analytical activities to investigate webs of relationships between mathematical words. This sequence includes creating *lexical chain tables* to map out classroom dialog in terms of foundational content words and identify semantic relationships between these words. In their study, this technique was used to show how the mathematical concept of *area* was construed in two different classes. The analysis revealed potential mathematical confusion in the teaching episodes due to the semantic relationships evident in the discourse. For example, one teacher used the words "base" and "height" interchangeably with "length" and "width," and vaguely defined rectangles as parallelograms, leading to semantic ambiguity about the relationship between area formulas for the two classes of shapes.

Herbel-Eisenmann and Otten's (2011) analysis showed how, in the course of a lesson enactment, mathematical meanings can be constructed in inconsistent and potentially problematic ways. It also revealed something about how these meanings might impact students' opportunities to understand mathematical ideas. As the authors noted, "People who are seen as capable participants in mathematical discourse tacitly move as needed between these meanings in fairly unproblematic ways. For less experienced participants in mathematical discourse, however, these dual meanings could create some confusion" (p. 479). However, because Herbel-Eisenmann and Otten examined two lessons with different activities and somewhat different learning goals, there was no opportunity to compare opportunities to learn in relation to lesson-specific goals across lesson enactments. In this paper, we argue that the use of thematic analysis to analyze the enactment of the *same* lesson in multiple contexts can provide new insights into how different enactments convey different meanings for the same mathematical idea.

2.2. The enacted curriculum

The *enacted curriculum* refers to the "interactions between teachers and students around the tasks of each lesson and accumulated lessons in a unit of instruction" (Remillard & Heck, 2014, pp. 130–131). This definition acknowledges that the enacted curriculum is not just controlled by the teacher, but includes "the educational experiences jointly created by students and teachers" (Cal & Thompson, 2014, p. 5). Research on the enacted curriculum has revealed that while some opportunities to learn are provided by curriculum resources like textbooks, these opportunities are altered during teaching due to a variety of factors (Remillard, 2005).