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Secondary mathematics teachers' attitudes toward alternative communication practices when doing proofs in geometry

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HIGHLIGHTS

- Teachers conveyed negative attitudes upon encountering unexpected instruction.
- Negative judgments were most prevalent types of negative reaction.
- Statements of negative affect projected onto students were also salient.

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ABSTRACT

We investigated secondary mathematics teachers' attitudes toward alternative ways of managing instruction on geometric proofs. Participants assigned to different experimental conditions viewed storyboard episodes of instruction. Some episodes showed instruction we hypothesized teachers would recognize as routine. Other episodes showed instruction that we hypothesized teachers would recognize as departures from routine. We found that, when participants were shown storyboards that represented what routinely happens in classrooms, positive and negative markers of attitude in their reactions to the storyboards occurred with equal frequency. But when presented with departures from routine, participants' reactions included significantly more negative than positive markers of attitude.

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1. Introduction

How do novices acquire fluency with the communication practices used by mathematical experts? A classic view is that novices gradually, tacitly develop discipline-specific communication skills as they apprentice into a field (Lemke, 2013). From this perspective, fluency with expert communication emerges as a consequence of expert knowledge. Research on mathematical discourse suggests an alternative: Discipline-specific communication practices can be described and taught (Fang, 2012; O'Halloran, 2010; Yore, Pimm, & Tuan, 2007). Advances in analyzing the multimodal nature of mathematical discourse (Greiffenhagen, 2014; O'Halloran, 2015) together with the push for mathematics teachers to create opportunities for students to hone discipline-specific communication skills creates urgency for researchers to shed new light on the "frustratingly slow pace" of instructional change in classrooms (Jacobs, Koellner, John, & King, 2014).

Researchers and reformers alike recognize that, typically, "instructional innovations are not implemented as their developers anticipated" (Richardson, 1990, p. 11), and that, "instruction reforms, especially those intended to help teachers move beyond typical teaching practices, have regularly fallen short of aspirations" (Camburn & Won Han, 2015, p. 512). If mathematics teachers are to create opportunities for students to hone discipline-specific communication skills, they will need to change their existing instructional routines. Historically, realizing such change has been challenging.

Various factors have been investigated to discern the reasons for the difficulty of effecting lasting instructional change. Studies of teacher motivation, perceptions of self-efficacy, and senses of autonomy have helped to deepen our understanding of the complex personal and institutional dynamics at play when teachers are called upon to implement externally generated changes (Ghaith & Yaghi, 1997; Gorozidis & Papaioannou, 2014; Guskey, 1988;

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Richardson, 1990; Stein & Wang, 1988). But teachers' expectations of student communication practices are not only individual preferences. They also are examples of socially shared professional values. One of the ways in which professional values are taught is through the critique of performances, where critique could be represented semiotically through linguistic choices that represent stances toward specific practices.

We report here a linguistic analysis of the *attitudes* (Martin & White, 2005) that secondary mathematics teachers conveyed toward episodes of instruction that represented alternative instructional practices. The purpose of our study was to investigate how secondary mathematics teachers reacted to episodes that showed teachers departing from instructional practices that we hypothesized were routine. We probed how teachers reacted to instructional alternatives to gain an understanding of the difficulties of incorporating meaningful instructional change into mathematics classrooms. Our work moves beyond deficiency-based explanations for these difficulties—e.g., skills that teachers lack, knowledge that teachers don't have—and instead considers how teacher reactions to instructional alternatives are typical of how social actors, in general, respond when situations unfold in ways they aren't expecting.

2. Background & research questions

2.1. Self-reports of attitudes toward instructional alternatives

Prior studies of teacher's attitudes toward instructional change have measured attitude via explicit surveys, such as the one developed by Guskey (1988). Participants were asked to "rate, on a series of five-point likert-type scales, the congruence, cost, difficulty, and importance" of a specific instructional alternative (Guskey, 1988, p. 7). The purpose of the questionnaire was to measure teacher's attitudes toward a planned program of instructional change—a mastery learning instructional practices program that was adapted from the work of Bloom. Guskey (1988) found a relationship between the attitudes teachers expressed toward the program of instructional change and their scores on a self-efficacy questionnaire: Teachers with greater senses of self-efficacy in the classroom had more positive attitudes toward implementing the program of instructional change.

Other studies have used surveys and other measures to further investigate teachers' attitudes toward instructional alternatives. Stein and Wang (1988) triangulated classroom observations, individual interviews, and responses to a Teacher Perceptions and Attitudes Questionnaire (TPAQ) to examine "the relationship between teacher success in implementing innovative practices, teacher perceptions of self-efficacy for implementing the practices, and the teacher-perceived value of the innovative practices" (p. 176). Ghaith and Yaghi (1997) adapted the attitude survey developed by Guskey (1988) to investigate teacher attitudes toward a different program of instructional change. More re-cently, Saborit, Fernández-Río, Estrada, Méndez-Giménez, and Alonso (2016) used a survey to measure teacher attitudes toward implementing a program of cooperative learning.

Teachers' attitudes toward instructional innovation "are fundamental to the success of change efforts" (Donnell & Gettinger, 2015, p. 48). We agree that teacher attitudes are an important consideration and further, we raise a methodological issue about how attitudes are measured. Survey-based studies of teacher attitudes (e.g., MacFarlane & Woolfson, 2013; Troia & Graham, 2016; Yan & Cheng, 2015) grant that subjects can reliably self-assess and self-report their attitudes and values. However this is not necessarily the case: Answers to surveys are shaped by the questions and the choices available (Schwarz, 1999). As an alternative to self-reports of attitude on closed-ended survey questions, we investigated teachers' attitudes toward instructional alternatives indirectly, by analyzing their reactions to episodes of instruction that depicted alternatives to what we hypothesized were normative instructional practices.

2.2. Attitudes manifest in reactions to episodes of instruction

The analytic tool we used was the linguistic conceptualization of *attitude* (Martin & White, 2005) as framed by systemic functional linguistics (SFL; Halliday & Matthiessen, 2004). Martin and White (2005) define *attitude* as a system of language choices through which people convey positive or negative feelings; attitude is one of the components of the *appraisal* system of language. They identify three classes of attitude: *affect, judgment,* and *appreciation.* These different categories of attitude correspond to accounts of personal feeling (affect; e.g., *I am happy*), evaluations of people and their deeds (judgment; e.g., *she is a capable teacher*), and qualitative statements about events or things in the world (appreciation; e.g., *a beautiful proof*).

Attitude, and the appraisal system more generally, are among the linguistic resources that realize the *interpersonal* metafunction of language (Halliday & Matthiessen, 2004)—i.e., how language construes the relationship between writers (or speakers) and audiences. By conceptualizing attitude linguistically, we sought to mitigate the biases that are endemic to self-reports and to provide a more fine-grained analysis of the various aspects of the instructional practices that teachers were (or weren't) valuing. We describe the coding scheme we developed from the *attitude* framework in the section that reports our analysis.

2.3. Normative practices for communicating when doing proofs in geometry

The specific practices we investigated for this study pertained to how teachers expect students to communicate when doing proofs in geometry (Herbst & Brach, 2006), a classroom activity during which there could be opportunities for students to learn discipline-specific communication skills. We derived descriptions of extant communication practices from analyses of video records of geometry classrooms in which teachers checked student proofs and students presented proofs to a class (Dimmel, 2015). Two sets of communication practices were the focus of the multimedia survey experiment.

One set of practices concerned how teachers expect students to communicate the details of proofs. Despite the image of mathematical proofs as complete records that proceed incrementally by making all deductions explicit (Dickerson & Doerr, 2014), mathematicians routinely omit details in proofs that readers are expected to supply (Davis, 1972). We observed in the video study that teachers did not expect students to declare conclusions that could be tacitly warranted by diagrams, such as a claim that three points lie on the same line, before using those conclusions to make other statements, such as the statement that two angles form a linear pair.[1] At the same time, teachers did expect students to declare conclusions that followed from written givens or from properties that can be marked in diagrams—what Manders (2008) refers to as *co-exact* properties, such as a conclusion that two seg-ments determined by the mid-point of a segment are congruent. We refer to these practices for stating or omitting steps in a proof as the *details* norm (Dimmel, 2015).

A second set of practices concerned how teachers expect

[1] A linear pair is a set of adjacent angles formed by two intersecting lines.

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