Lexical bundle analysis in mathematics classroom discourse: the significance of stance

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Abstract In this article, we introduce the lexical bundle, defined by corpus linguists as a group of three or more words that frequently recur together, in a single group, in a particular register (Biber, Johansson, Leech, Conrad, & Finegan, 2006; Cortes, English for Specific Purposes 23:397–423, 2004). Attention to lexical bundles helps to explore hegemonic practices in mathematics classrooms because lexical bundles play an important role in structuring discourse and are often treated as "common sense" ways of interacting. We narrow our findings and discussion to a particular type of lexical bundle (called a "stance bundle" or bundles that relate to feelings, attitudes, value judgments, or assessments) because it was the most significant type found. Through comparing our corpus from secondary mathematics classrooms with two other corpora (one from university classrooms (not including mathematics classrooms) and one from conversations), we show that most of the stance bundles were particular to secondary mathematics classrooms. The stance bundles are interpreted through the lens of interpersonal positioning, drawing on ideas from systemic functional linguistics. We conclude by suggesting additional research that might be done, discussing limitations of this work, and pointing out that the findings warrant further attention to interpersonal positioning in mathematics classrooms.

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As researchers who are interested in the hidden curriculum of mathematics classrooms, we find it necessary to investigate mundane aspects of mathematics classroom discourse. By attending to high-frequency *lexical bundles*, we can examine "patterns of use that would otherwise go unnoticed by researchers" (Biber, Johansson, Leech, Conrad, & Finegan, 2006, p. 376). Lexical bundles are defined by corpus linguists as a group of three or more words that frequently recur together, in a single group, in a particular register (Biber et al., 2006; Cortes, 2004). Patterns that go "unnoticed" are important because they often are treated as common sense and index hegemonic practices in schools (Apple, 1990). Thus, these patterns contribute to the hidden curriculum. Some scholars (e.g., Bloom, 1972) have argued that the hidden curriculum has a greater impact than the intended curriculum because it is so pervasive. We add that its impact is compounded because hidden things act subtly. As noted by Gayer (1970), teachers' language choice, which we address later, is integrally related to the hidden curriculum.

Clarity of scope is important in discourse studies. We use the linguistic term *register* to refer to the discourse we analyze—the mathematics classroom register. Halliday's (1978) application of register to the analysis of mathematics discourse has been taken up by Pimm (1987) and others (e.g., Moschkovich, 1999). In this article, we use register to mean a situationally defined variety of the language. Although some mathematics education literature seems to discuss the *mathematics classroom register* in a way that suggests it is or should be synonymous with the *mathematics register*, it is useful to consider these two types of register to be related but different.[1] This article provides empirical evidence that the mathematics classroom register structures certain kinds of teacher stance. We attend to the differences between this register and others to identify what is particular to mathematics classrooms. The uniqueness of the mathematics classroom register becomes clear with evidence from an examination of lexical bundles in a large corpus of mathematics classroom observations. (See Section 3 for a description of the corpus.)

First, we delve into the linguistic concept of "lexical bundle" and the subcategories of lexical bundles (i.e., stance bundles, discourse organizing bundles, and referential bundles). We elaborate one type of lexical bundle—the *stance bundle* or a bundle that communicates "personal feelings, attitudes, value judgments, or assessments" (Biber, Conrad & Cortes, 2004a, p. 966)—in more detail because it relates to the findings we present. Second, we briefly review some of the existing literature on mathematics classroom discourse to describe the contributions that lexical bundle analysis might offer. Since there are limitations for any kind of analysis, we also discuss some of the aspects of classroom discourse that lexical bundle analysis does not address. Third, we provide a detailed account of the methods, including a description of the corpus and the analytic process of locating and parsing the lexical bundles. Fourth, in Section 4, we show that most of the lexical bundles identified in this analysis of a large body (i.e., corpus) of secondary mathematics classroom transcripts are, when compared with the analyses of other corpora, particular to secondary mathematics classrooms. Moreover, the most prominent lexical bundles in these secondary mathematics classrooms, which were spoken almost

[1] Recent articles by Hayfa (2006) and Kotsopoulos (2006) and responses by Pimm (2007) and Barwell (2007) make it clear that some mathematics education literature confuses these two registers. Lack of clarity can make it difficult to discern how a researcher is conceptualizing, using, and applying these terms.

exclusively by teachers, relate to the "stance" of the teacher. Finally, we close by suggesting additional work that might be done and discussing some primary issues this work raises.

1 Lexical bundles, stance bundles, and language choice

1.1 Defining and categorizing lexical bundles

In this article, we focus on *lexical bundles*, earlier defined as groups of three or more words that frequently recur, as multi-word groupings, in a particular register (Biber et al., 2006; Cortes, 2004). Lexical bundles in published academic writing have been shown to be discipline bound (Cortes, Jones, & Stoller, 2002), which demonstrates that different disciplines have different purposes and ways of seeing the world related to particular communicative conventions (Hyland & Hamp-Lyons, 2002). Examples of lexical bundles frequently found in academic prose include *as a result of*, *on the other hand*, and *the fact that the*, among many others (Biber, 2006; Biber et al., 2004a). In everyday conversation frequent lexical bundles include, for example, *I don't know why*, *what do you mean*, and *I said to him* (Biber et al., 2004a). Biber et al. (2004a) compared the structure of lexical bundles with idioms, which they pointed out are clearly prefabricated but rarely appear enough times in a corpus to be significant. Another difference between lexical bundles and idioms is that lexical bundles have transparent meaning that derives from the words, rather than deriving from some hidden meaning. For example, *he kicked the bucket* does not mean someone actually kicked a bucket, whereas the meaning *of I said to him* is pretty clear.

Two foundational studies of lexical bundles in corpus linguistics have focused on corpora from everyday conversations and from university teaching and textbooks. Biber et al. (2004a), extending their earlier work (Biber et al., 2006), examined a large corpus of university classroom teaching and showed that classroom teaching draws on both conversational and academic registers. Face-to-face interactions and real-time circumstances shape the classroom teaching register, as does the fact that teachers are trying to convey specific information to students. They also found the university classroom teaching register to be structured by even more lexical bundles than either conversations or academic registers. We will say more about this later when we compare our findings with these prior studies of oral corpora.

In these studies, Biber and his colleagues have also described four classifications for lexical bundles: stance bundles, discourse organizing bundles, referential bundles, and special conversational function bundles. Stance bundles were defined as words that communicate "personal feelings, attitudes, value judgments, or assessments" (Biber et al., 2004a, p. 966). For example, *I think it was*, *if you want to*, and *I want you to* express personal desire or obligation. Discourse organizing bundles serve the purpose of introducing and focusing topics and elaborating and clarifying topics. For example, *if you look* at, *in this chapter we*, *has to do with* all focus and clarify information about topics. Referential bundles "generally identify or single out some particular attribute of an entity as especially important" (Biber et al., 2004a, p. 393). For example, *at the same time*, *a lot of people*, and *the size of the* specify concurrent events, draw attention to the number of people and to how large or small something is. Special conversation function bundles comprise a few other bundles (only three) that do not fit the other three categories, for example, *thank you very much* which serves a politeness function. Although not always

distinct classifications, the first three of these groupings were found to have a very strong relationship between grammatical structure (e.g., being composed of primarily a noun phrase or prepositional phrase fragments) and discourse function (Biber et al., 2004a).

1.2 Stance bundles, interpersonal meaning, and language choice

To narrow the scope of this article, we focus on the most prevalent type of lexical bundle identified in the corpus of secondary mathematics classrooms: the *stance bundle*. Stance bundles provide a framing for the words that follow them. They either note the status of the certainty of the information (called "epistemic stance bundles") or communicate the speaker's attitudes toward the proposition's actions or events (called "attitudinal/modality stance bundles"). *Personal* stance bundles are noticeably attributed to the speaker/writer and *impersonal* stance bundles provide similar meanings, but without direct attribution. Previous findings from Biber and colleagues' work have indicated that most epistemic stance bundles are personal and that they tend to express uncertainty more often than certainty. Impersonal epistemic stance bundles, in contrast, tend to express certainty (e.g., *are more likely to*).

Attitudinal/modality stance bundles, which also are more often personal than impersonal, have four major subcategories: desire, obligation/directive, intention/prediction, and ability. These subcategories are fairly self-descriptive. The desire bundles, for example, frame "self-motivated wishes and desires or inquire about another participant's desires" (Biber et al., 2004a, p. 390). The obligation/directive expresses a commitment to something or provides instructions that one might follow. The aspect that makes obligation/directive stance bundles different, however, is that they almost always have a second person pronoun *you* as the subject or direct object (rather than first person pronoun *I*). Biber et al. (2004a) report that, depending on the context of their use, several bundles can fit either the desire or the obligation/directive category. Intention/prediction bundles are explicitly personal, "expressing the speaker's intention to perform some future action" (Biber et al., 2004a, p. 391). They also predict future events, as in *what we're going to do*. The only stance bundle that is primarily impersonal is the ability bundle. These also often occur with directive bundles and indicate some of the skills one might need to accomplish a given task. The relationships between the different stance bundles are provided in Figure 1.

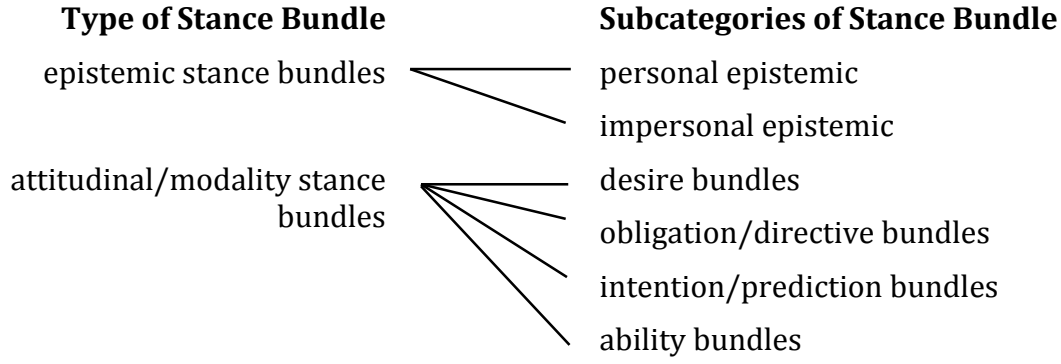

Fig. 1: Stance bundle categories developed by Biber and colleagues

Because stance bundles are closely related to language that construes interpersonal meaning in the way Halliday (1978) and Morgan (1998; 2006) describe it (each of whom were describing mathematics discourse), we draw on systemic functional linguistics in our interpretations. Halliday (1978) described the *interpersonal* function of text in this way:

> The interpersonal component … is the participatory function of language, language as doing something. This is the component through which the speaker intrudes himself into the context of the situation, both expressing his own attitudes and judgements and seeking to influence the attitudes and behaviour of others. It expresses the role relationships associated with the situation, including those that are defined by language itself, relationships of questioner–respondent, informer–doubter and the like. These constitute the interpersonal meaning of language. (p. 112)

As noted, the interpersonal function of a text includes close examination of the speaker's attitude, much like stance bundles. Furthermore, stance bundles are identified by linguistic aspects like modality (Biber et al., 2006) and first person pronouns (Biber, 2006), which are linguistic characteristics examined when analyzing the interpersonal function of language, as elaborated below.

First, we identify distinctive features of modality identified in the literature. Modality refers to "indications of the degree of likelihood, probability, weight, or authority the speaker attaches to the utterance" (Hodge & Kress, 1993, p. 9). Modality of the text can be found in the "use of modal auxiliary verbs (*must, will, could,* etc.), adverbs (*certainly, possibly*), or adjectives (e.g., *I am sure that*…)" (Morgan, 1996, p. 6). As Martin and Rose (2005) suggest, language allows us to express attitudes with varying intensity. Modality is one way that people amplify something. Some of the gradations of amplification can be seen in auxiliary verbs (e.g., *you must divide* instead o*f you might divide*).

Secondly, along with modality and attitude, personal pronouns have been identified as markers of positioning (Fairclough, 2001; Wetherell, 2003) which relates closely to stance. Pimm's (1987) detailed look at teachers' use of *we* is relevant. Often in mathematics teaching, the teacher uses the pronoun *we* when addressing students, but it is not always clear to whom *we* refers: the teacher with the mathematical community, the teacher with the students, the teacher as an individual (the royal *we*), the students, or any combination of these. Rowland (2000) showed how the pronoun *you* can be ambiguous in a way similar to *we*: like *we*, *you* can be "an effective pointer to a quality of thinking involving generality" (p. 113). This sense of generality, which refers to no one in particular, suggests that anyone would or must do or understand the same thing. Though these pronouns recognize students' mathematical action, they also take authority away from the students because it is implied that anyone would concede. There is no choice. The personal pronouns *we* and *you* seem to replace the alternative *I*, which would, by contrast, not point to generality in most cases.

Why might examining these aspects of language in mathematics classrooms be important? Many authors who study the use of language assume that language choice is important because it encodes a particular set of values, dispositions, and ideologies (e.g., Lemke, 1990; Christie, 1995; Morgan, 1996). Speakers make (often unconscious) choices about the selection and organization of words. These choices affect the functions of the words and the meanings that others may make of those words. A speaker has a "set of

resources which constrain the possibility [of specific language choices], arising from her current positioning within the discourse in which the text is produced" (Morgan, 1996, p. 3).

As the Morgan quotation above highlights, the notion of "positioning" is important to work related to interpersonal relationships. Harré and van Langenhove (1999) describe positioning as the ways in which people use action and speech to arrange social structures. *Positioning* can refer to physical positioning, as it does in Goodwin's (2007) study of how parents and children physically position themselves while the children do mathematics homework, but more often *positioning* is used metaphorically to represent relationships.

Attention to positioning helps us recognize that authority and power are dynamic constructs (see Wagner & Herbel-Eisenmann, 2009). When people "have" authority, it means that there is an expectation that they exercise their agency; they are licensed to be agents of change. One can exercise agency, however, even when others do not authorize that agency. For example, in Powell's (2004) account of agency, he recognized the agency of students when they expressed themselves in ways authorized by their teacher, but in Houssart's (2001) account of a different classroom, students were exercising agency without teacher authorization. In our interpretation of lexical bundles, we notice the implied structuring of authority. How might students be invited to have agency? And, by contrast, in what ways are they expected to follow particular authority structures?

Because lexical bundles are mundane and often go unnoticed, we see them as being part of hegemonic practices in the mathematics classroom, which are structured by certain kinds of positioning and authority relationships. We agree with Apple (1990), who argued that it is important to examine what is learned in the hidden curriculum because such an examination helps us better understand our commonsense assumptions: "Not to engage in such continual questioning is to abrogate one's responsibility to the current and future lives of thousands of students who spend so many years in schools" (p. xi).

2 Mathematics education literature: distinguishing, locating, and scrutinizing lexical bundle analysis

Over the last two decades, mathematics education researchers have used numerous tools to examine discourse in various contexts. Some of this scholarship has focused on trying to understand the complex dynamics between teachers and students in the mathematics classroom (e.g., Atweh, Bleicher, & Cooper, 1998; Brodie, 2007; Hufferd-Ackles, Fuson, & Sherin, 2004; Moschkovich, 1999, 2007; O'Connor, 2001; Shreyar et al., 2009; Staples, 2007; Wood, 1999; Zolkower & Shreyar, 2007). Other researchers have interviewed students about issues related to classroom discourse and have set this alongside an analysis of classroom discourse (e.g., Jansen, 2006; Wagner, 2007). Some have applied linguistic tools to written mathematics texts, which include textbooks, student work, and mathematician's published work, to identify and discuss issues related to language (e.g., Burton & Morgan, 2000; Herbel-Eisenmann, 2007; Morgan, 1998).

As this kind of work has grown over the past three decades, we notice some commonalities across the studies. First, this literature has drawn almost exclusively on qualitative research methods. Second, the texts that the authors analyzed were selected by the researchers for particular purposes, resulting in detailed analyses of a relatively small set of examples. Finally, as is common in qualitative research, the themes or findings that were reported were either predefined by the researcher (e.g., a focus on how students use

pronouns; Rowland, 2000) or discourse-related categories emerged from what the researchers saw as qualitatively prominent or relevant to the specific goal of the paper (e.g., Hufferd-Ackles et al., 2004).

Though we value and have contributed to the literature that comprises in-depth analysis of selected transcripts of mathematics education settings, we note that there are other types of discourse analysis that are distinct from these that can also add to our understanding of mathematics classroom discourse. In this article, our analysis of the mathematics classroom register draws upon a large database of transcripts of mathematics classroom observations from many contexts. Linguists use the word *corpus* for this kind of large body of discourse samples. In mathematics education, a few corpus studies have been reported. For example, Monaghan (1999) used a large database of mathematics curriculum materials to investigate the ways in which the word *diagonal* was used in textbooks and developed across the years. Monaghan, like the other researchers listed above, chose the word *diagonal* as the object of analysis. We (Wagner & Herbel-Eisenmann, 2008) have also contributed a corpus analysis that focused on a word that students identified as significant for them in mathematics classroom discourse—the word *just*.

Our lexical bundle analysis in this article is distinct from the above studies because neither we, nor teachers, nor students identified the focus of analysis. Rather, lexical bundle analysis was designed to find patterns in a large set of transcripts, which are identified empirically using a special computer program that works on a corpus of texts. Lexical bundle analysis identifies what one may not otherwise notice about the mundane yet important language patterns. A focus on lexical bundles, in particular, is an important analytic approach because, as Cortes (2004) points out, recurring fixed phrases can play an important role in fluent linguistic production of a register people are learning. The results we report should not be surprising, in fact, because the identified word combinations pervade the register. Anyone well acquainted with mathematics classrooms and classrooms in general should recognize the bundles as commonplace.

Because lexical bundle analysis of a register rests on a very large sampling of diverse representative contexts, it becomes possible to identify characteristics of the register in a more comprehensive way than analysis of a few selected situations. We will show that the secondary mathematics classroom register is structured by more set-word combinations (lexical bundles) than university teaching or conversation registers. The lexical bundles we examine here, in fact, were spoken almost exclusively by teachers. We highlight the fact that the lexical bundles that encode stance or interpersonal positioning are especially significant in the register.

We recognize that any methodological choice allows us to see particular things and thus not see other things. Even with lexical bundle analysis, we make choices as researchers. The choice and scope of a corpus are significant, and we also interpret the results generated by the software by comparing with other corpora, by drawing on particular theories of language to categorize the identified bundles, and by considering how they work in their contexts. Though a lexical bundle approach does not lead the researcher to attend to context in the early stages of analysis, the benefit is the exposure of patterns across a huge set of data from a range of mathematics classrooms.

Though lexical bundle analysis offers a powerful way to identify pervasive language patterns, it is essential to acknowledge that lexical bundles do not define a discourse. Rather, lexical bundles allow one to focus on mundane combinations of words that often go

unnoticed but that also have important structuring and signaling effects in the discourse (Biber et al., 2004a; Nesi and Basturkmen, 2006). Language is an important component of the teaching-learning process because it can help establish routines and regularities within which learning can take place (Voigt, 1985; 1995). Language also is used for many other purposes in classrooms. Language is a medium of information, and, with word and grammatical structure choices, teachers "shape the ways that students approach knowledge, helping them to assess how statements are to be interpreted (e.g., whether they should be adopted as fact, criticized, or understood from a particular perspective)" (Biber, 2006, p. 87). By interrogating commonsense practices (in this case, practices that underlie mathematics teacher stance and thus mathematics classroom discourse), "we can better understand the conditions under which education operates and the possibilities for altering these conditions" (Apple, 1990, p. xi).

3 Methods: a lexical bundle approach to studying classroom discourse

3.1 Corpus description

The data set from which we draw includes 148 classroom transcripts from classroom observations of eight different teachers' classrooms in seven different schools in the USA, selected to represent diversity in multiple ways. These observations were part of a larger project, which focuses on collaborating with secondary mathematics teacher–researchers to examine how doing action research on classroom discourse might impact teacher–researchers' beliefs and practices over time.[2] In the first year of the project (September 2005–May 2006), we collected baseline data of the teachers' classroom discourse. Since one of the primary goals of this project has been to better understand the nature of secondary mathematics classroom discourse, we have drawn on and used a range of methods and tools from discourse analysis.[3]

In this article, we report the findings from one of the analyses that used the entire 148 classroom transcripts, which comprise the Secondary Mathematics Classroom (SMC) Corpus. The transcripts come from a range of contexts, as the teachers in the project taught in different kinds of communities (rural (n=2), urban (n=4), and suburban (n=2)), with students from varying levels of poverty (free and reduced lunch percentages varied from 12% to over 65%) and in different kinds of schools (e.g., a school where over 65% of the students are achieving well below grade level, a school where all the students are labeled as talented and gifted). Six of the teachers taught in middle school settings (grades 6–8), one in a high school (grades 9–12) and the one who taught in the talented and gifted school taught students from grades 5 to 12. Three of the teachers were working in schools in which NSF-funded curriculum materials have been used for more than 10 years. The other five teachers taught in schools in which more conventional curriculum materials were adopted and used.

The teachers in these classrooms were purposefully selected to vary gender, context of teaching situation, certification level, years of teaching experience, extent of involvement in professional development, reasons for entering the teaching profession, and so on. Five of

[2] For additional details about the context and project activities, see Herbel-Eisenmann and Cirillo (2009).

[3] Other analyses using different methods and tools have been reported elsewhere or are forthcoming (e.g., Cirillo, 2008; Herbel-Eisenmann & Cirillo, 2009; Herbel-Eisenmann & Cirillo, 2009; Herbel-Eisenmann & Otten, in review; Males, 2009; Males, Otten,

the teachers were female and three were male. Five were certified to teach secondary mathematics, and the remainder were elementary certified. The number of years they had been teaching mathematics ranged from 2 to 18 years. Some of the teachers had master's degrees in mathematics, mathematics education, or science.

Each set of classroom observations took place for 1 week at a time in September, November, January, and March. The "one week" was based on a typical week and included six teachers who taught regular class periods that lasted 35–50 min, one who taught a modified block schedule 4 days/week, and one who taught a block schedule every other day for 90 min. The teachers selected a focus class that they felt was representative of the students they typically taught. The mathematics courses included grades 6, 7, and 8 regular and non-tracked[4] mathematics courses as well as high school algebra and geometry. Topics ranged from number and operations, to area, to solving equations, to trigonometric functions, and proof.

Typically, one university-based researcher (professor or graduate assistant) observed, took field notes, and videotaped observations. The camera was mainly focused on the teacher, who wore a microphone. An additional microphone was attached to the camera and picked up much of the classroom talk. The amount of student talk captured varied from observation to observation because the classrooms were of varying shapes and sizes and students talked at different volumes. All classroom observations were transcribed by paid transcribers using Transana (Fassnacht & Woods, 2005). The transcribers were asked to capture, as accurately as possible, the words they heard the teacher and students speak. For example, if they heard the student say "gonna" instead of "going to," they were asked to record it that way. Speaking turns were distinguished by returns and each speaking turn was associated with its designated speaker (by name, as "teacher," or, if name was unrecognizable, to label as "Ms" and "Fs" for male and female student or "Ss" for a response in which multiple students were involved). The Transana program also allows the transcriber to connect the transcript to the time in order to facilitate a playback that links the point in the transcript to the time the words took place. Transcribers were asked to insert a time code for every new speaking turn and to include more time codes if there was a long pause. These transcripts, which make up the SMC Corpus, were exported as rtf files and served as the primary data source for this study. Other data were collected (e.g., observers' field notes, teacher journals, and project meeting transcripts), but were not used for this particular analysis.

3.2 Comparative corpora

Since we will be making comparisons with previous corpus studies involving conversation and university classroom teaching, we include a brief description of the other corpora in order to situate the comparison. The conversation corpus originated from the *Longman Grammar of Spoken and Written English* (LGSWE) corpus (Biber et al., 2006) and included English speakers in the USA and in England. Participants were sampled based on demographic lines across age, sex, social group, and regional spread. The participants carried a high-quality tape recorder with them and recorded all of their conversational interactions over a week (see Biber et al., 2006, p. 29).

[4] Regular mathematics exists in the schools in which students were tracked into below grade level, at grade level (or regular), and advanced courses. The non-tracked systems were in the two rural classrooms in the same school.

The university teaching and textbook corpus came from the TOEFL 2000 Spoken and Written Academic Language (T2K-SWAL) Project (see Biber et al., 2004b), which included data collection at four universities in the USA. This project was sponsored by the Educational Testing Service and was used to "carry out a comprehensive linguistic analysis of university registers, with the ultimate goal of determining whether the language used in the TOEFL exam tasks is representative of actual language use in universities" (Biber, 2006, p. 23). This corpus was developed to capture a range of spoken and written activities that one would encounter in academic life at the university and included six major academic disciplines at three academic levels. Study participants recorded 176 class sessions, which comprised 1,248,800 words in the classroom teaching part of the corpus. Within the delineation of sub-disciplines that were included in the academic disciplines, mathematics was not included.

When comparing different-sized corpora, the process of normalization by scaling to one millions words is common in lexical bundle analysis (e.g., Biber & Barbieri, 2007, p. 268). Thus, the values reported in Biber's previous research were all scaled to one million words in order to make comparisons between corpora. The process of normalization used to compare corpora of different sizes is complex for lexical bundle analysis (Cortes, 2002). That said, because we adopted a much more conservative cut-point (40 words as compared with Biber's ten words), our findings in some ways are more noteworthy because we quadrupled the number of occurrences for a data set that was about 70% of the million word comparison value.

Another important point for us to make is that, by describing these comparison corpora, we recognize that our data set is distinguished from the other two because it is situated in *secondary* school classrooms and they were *mathematics* classrooms. Thus, in our interpretations, we draw on these two contextually unique aspects of our corpora to offer potential interpretations of the lexical bundles we found. Similar to our previous work, we do not say what this discourse *should* be nor do we claim that our interpretation is the *only possible* interpretation. Rather, we provide descriptions of the patterns we found and offer multiple interpretations of them, based on our prior experiences of researching secondary mathematics classrooms, collaborating with the teachers who teach in these classrooms, and teaching secondary mathematics ourselves.

3.3 Identifying lexical bundles in a corpus

The data set that we focus on here consists of 679,987 words, which is in line with the sizes of specialized oral corpora used by linguists. As detailed earlier, there is sufficient diversity of contexts in the corpus, which is a necessary characteristic of a representative corpus. In order to prepare transcripts for the lexical bundle analysis, they must first be completely cleaned (removing non-spoken text such as names of the people speaking or the time codes). Although we removed the names of the speakers in the dataset when the computer program located the lexical bundles, we did distinguish the contributions by teacher and student at the next stage of analysis. This was important to understanding context as contributions made by teachers might be interpreted differently than contributions made by students. For example, some question forms ("Would you please close the window?") might actually be a directive when spoken by a teacher. Furthermore, since very few examples of utterances with lexical bundles in them were spoken by students, this helped us to see that stance (as expressed in stance bundles) was expressed most often by

teachers. Although we frame this as being about "teacher stance," teacher stance necessarily influences the mathematics classroom discourse.

The Lexical Bundles program (LBP), designed by Cortes, identifies frequently occurring lexical bundles. Lexical bundles are defined by frequency; a specific grouping of words, in the same order, must repeat frequently in order to be considered a bundle. Biber et al. (2004a) pointed out that frequency data are important because "they are one reflection of the extent to which a sequence of words is stored and used as a prefabricated chunk, with higher frequency sequences more likely to be stored as unanalyzed chunks than lower frequency sequences" (p. 376).

Different studies have set different frequency cut-off points. For Biber and his colleagues (Biber et al., 2006), a four-word combination had to recur ten or more times in a million words and in five or more texts in order to be considered a bundle. We adopted a more conservative cut-point of 40 instances of four-word combinations appearing in five or more classroom settings. All of the bundles identified by the LBP were stored in a database, which also recorded the frequency with which each word combination occurred and the number of classrooms in which it was used. This frequency count, called "spread" (pervasiveness across settings), is important because we need to be sure that the bundles occur in many classrooms rather than being unique to one or two settings.

4 Findings and discussion

In this section, we report the lexical bundles that were identified and offer interpretations of their role in the mathematics classroom register. Because the stance bundles were the most prevalent, we compare them with those that were found in previous analysis of corpora of university classroom teaching and conversations to identify the particularities of secondary mathematics classroom discourse. Since the teachers were the speakers in almost every instance of stance bundles, we connect the results to issues of teacher stance.

4.1 Lexical bundles in the SMC Corpus

Table 1 shows all 71 lexical bundles that occurred 40 times or more in the data set and in at least five classrooms. We provide a few general observations of these 71 lexical bundles and connect them to the categorizations developed by Biber and his colleagues. Only a few of the lexical bundles are specifically mathematical (i.e., we would not expect these to appear in everyday conversation), including *find the area of*, *the area of the*, *the square root of*, *the area of a*, *one and a half*, and *to find the area*. Though lexical bundles that are more than four words are very rare in lexical bundle analysis, some of the identified bundles may be overlapping categories that would form larger bundles. For example, if we expanded the number of words in the bundle search to more than four, we may have found *to find the area of the* or *to find the area of a* to be a six-word bundle. We would expect additional mathematical bundles to appear as the mathematics becomes more specialized. For instance, *the permutation of a set* may occur when studying group theory. Because we observed in different kinds of mathematics classrooms in grades 6–10, fewer lexical bundles related to the mathematics may have been found than if we had done a more concentrated look at a particular mathematical domain. We took seriously, however, the methodological requirements established in corpus linguistics to represent diverse contexts in the corpus. Because we did not focus on the teaching and learning of a specific

big mathematical idea, the findings reported here might be more generalizable[5] to secondary mathematics classrooms.

Other lexical bundles in Table 1 may refer specifically to mathematical aspects of the classroom discourse, but would require further examination, for example, *a little bit of, in front of the, a little bit more, to be the same*, and *is the same as*. These bundles may be referential bundles, more generally, but they may also serve more specific mathematical purposes. For example, "grab the calculator *in front of the* box" directs the hearer's attention to a location, whereas "the slope is the *number in front of the* x" helps the hearer locate the value of the slope in an equation.

There are also some lexical bundles that seem to focus on supporting students in articulating their thinking or explaining their solutions, for example, *what do you think, does that make sense, how do you know, what did you do, how did you get, what would you do, what do you mean*, and *what does that mean*. Some of these would be categorized as discourse organizers because they require elaboration or clarification. Furthermore *how many of you, what do you have, know how to do, is that what you*, and *what did you get* may serve assessment purposes. Rather than delve into these into more detail, however, we suggest that these warrant further examination and turn our attention to the most pervasive type of lexical bundle we found: the stance bundle.

4.2 Stance bundles in the SMC Corpus

Thirty of the 71 lexical bundles, representing 47.7% of all instances of lexical bundles (*n*=4,630 instances), were instances of stance bundles (*n*=2,207) as defined by Biber and his colleagues. We demarcate these bundles using bold and italicized text in Table 1. This finding is significant because lexical bundles are markers of what is important for people learning a register and they represent ways of thinking and speaking within the register. One of the most important findings of this research is the quantitative evidence that teacher stance is widespread in mathematics classroom discourse. In the next section, we draw on Biber's delineation of stance bundles and compare the stance bundles that we found in the SMC Corpus with the ones that have been found in other corpus analyses.

4.3 Stance and language choice in secondary mathematics classroom discourse

Even if these stance bundles were common outside the mathematics classroom register, they would be significant to mathematics learning because of their prevalence. These bundles influence the nature of interpersonal positioning in the register. Table 2 compares[6] the stance bundles found in the SMC Corpus with the stance bundles found in other corpus studies.[7] The prevalent bundles in the register encode the significance of particular forms of positioning in mathematics classrooms. Classroom discourse is not only about mathematical processes and procedures. It is also largely about structuring certain kinds of relationships among the various people (students, teachers, and mathematicians) and the discipline, which is mediated by various people (see Wagner and Herbel-Eisenmann, 2009

5 We are not using "generalizable" in a conventional statistical way because lexical bundle analysis relies on cut points determined by the field and not on *p* values or other measures of significance used in typical quantitative analyses.
6 In Table 2, we used a multiplier of 1.47 and rounded to the nearest whole number to categorize the prevalence (1,000,000÷679,987 words in our corpora=1.47).
7 Biber et al. (2004b) found *you're going to be/have, we're going to be/have*, and *so I'm going to* in the UCTC. They did not include them in the functional analysis, however, because the contracted form makes these four-word bundles but with five word units (with the two-word contraction)

for more on this). Noting significant differences, we considered in our analysis connections related to characteristics of secondary school mathematics learning. Bundles particular to the SMC Corpus demand special attention and are denoted with the symbol √ in Table 2.

Table 1: Full set of lexical bundles from the SMC Corpus

Lexical Bundle	Number of Instances	Spread across 8 classrooms
I want you to	333	8
what do you think	198	8
you don't have to	134	8
if you want to	97	8
does that make sense	95	7
want you to do	92	7
you are going to	90	8
is going to be	89	8
find the area of	84	6
to be able to	82	8
you have to do	82	8
do you want to	80	8
are we going to	78	8
the area of the	76	5
we're going to do	76	8
going to have to	75	8
see if you can	75	8
I don't know if	74	7
are you going to	73	8
how do you know	72	8
what I want you	70	7
the end of the	68	8
what did you do	68	8
am I going to	64	7
you to do is	64	7
do we have to	63	8
the square root of	62	6
we are going to	62	8
you want to do	62	8
to be the same	61	8
at the end of	59	8
you need to do	59	7
do we need to	58	8
a little bit of	57	7
it's going to be	56	8
to make sure that	54	8

... continued	Number of Instances	Spread across 8 classrooms
how did you get	53	8
take a look at	52	5
the area of a	52	6
you come up with	51	7
we have to do	50	8
what do you have	50	7
a little bit more	49	7
do you have a	49	8
we need to do	49	8
are going to be	48	8
do you have to	48	8
what would you do	48	8
and see if you	46	7
is the same as	46	6
do I need to	45	6
I'm not going to	45	8
so we're going to	45	7
I was going to	44	6
I would like you	44	7
on the other side	44	7
one and a half	44	5
so I'm going to	44	7
to find the area	44	7
how many of you	43	5
is that what you	43	7
what do we do	43	7
I don't know what	42	8
what do you mean	42	8
know how to do	41	8
to come up with	41	8
what did you get	41	8
what does that mean	41	8
you want me to	41	7
and I'm going to	40	6
in front of the	40	6

The bold and italics denote the stance bundles that we examine more closely here

Table 2: Comparing SMC stance bundles with other corpus findings

Lexical Bundle	SMC Corpus	Classroom Teaching Corpus	Conversation Corpus
attitudinal/modality – desire			
if you want to	***	***	**
do you want to	***	*	***
√ *you want to do*	**		
√ *I would like you*	**		
attitudinal/modality – obligation/directive - personal			
I want you to	***	***	**
you don't have to	***	**	**
√ *want you to do*	***		
you have to do	***	**	*
going to have to	***	**	**
√ *what I want you*	***		
√ *you to do is*	**		
√ *do we have to*	**		
you want me to	**		**
√ *you need to do*	**		
√ *do we need to +*	**		
√ *we have to do*	**		
√ *we need to do*	**		
√ *do you have to +*	**		
√ *do I need to*	**		
attitudinal/modality – intention/prediction - personal			
√ *you are going to*	***		
are we going to	***	*	**
we're going to do	***	**	
are you going to	***	*	***
√ *am I going to*	**		
√ *we are going to*	**		
I'm not going to	**		
√ *so we're going to*	**		
√ *so I'm going to*	**		
I was going to	**	*	***
√ *and I'm going to*	**		

*** indicates the bundle appears over 100 times per million words
** indicates the bundle appears 40-99 times per million words
* indicates the bundle appears 10-39 times per million words (would not have appeared in our findings because they would not have met our criteria)
√ indicates unique to SMC

All of the stance bundles identified in the SMC Corpus encode attitudinal/modality stance. None of the SMC Corpus bundles encode epistemic stance. We see that personal epistemic stance abounds in the University Classroom Teaching Corpus (UCTC) and the Conversation Corpus (CC). Epistemic stance bundles relate to epistemology and thus demonstrate awareness or acknowledgment of various perspectives at work. Epistemic stance bundles identified in the UCTC and CC corpora generally encode uncertainty and imprecision. They include, for example, *I don't know if, I don't know what, I think it was, you know what I*, and *I don't think so*. The absence of such bundles in the SMC Corpus encodes the relative absence of interaction about personal perspective. This absence in the SMC context might occur because mathematics is often characterized in secondary mathematics classrooms as abstract and focused on truth that spans contexts or perspectives. With mathematics teaching reform, however, classroom tasks that open up multiple possible solutions have been promoted. In such contexts, one might expect discourse that encodes epistemic stance. Thus, the result is surprising.

Within the SMC Corpus stance bundles, of which all encode attitude/modality, other striking patterns appear. Four of the bundles encoded "desire" using the classification developed by Biber et al. (2004a). Eleven encoded "intention/prediction" and 15 encoded "obligation/directive." Within the categories of obligation/directive and intention/prediction, all the bundles are classified as "personal" and none as "impersonal." Reporting from Biber and colleagues reveals that impersonal directives did not appear in the classroom teaching (UCTC) or conversation (CC) corpora either, but did appear in textbooks and academic prose. Examples of impersonal directives are *it is important to* and *it is necessary to*. We might expect such impersonal obligations/directives in mathematics classroom discourse to reflect abstraction similar to epistemic stance. Both would encode necessity that ignores personal stance or perspective. Instead, we find in the plethora of personal obligations/directives within the SMC Corpus many bundles that encode such necessity but clothed in the language of personal positioning, including *I want you to, you are going to*, and *we have to do*. Five of these personal obligation/directive bundles appeared in the conversation and classroom corpora studied by Biber and colleagues even with their more inclusive filter rules, but the other ten only appeared in the SMC Corpus.

We recognize from this that this particular feature of the SMC Corpus warrants more careful attention to the way necessity is encoded in the secondary mathematics classroom. Thus, we have developed our own categorization of the stance bundles from the SMC Corpus to identify nuances within the encoding of perspective (Herbel-Eisenmann & Wagner, 2010). Similarly, the bundles classified as encoding intention/prediction in the SMC Corpus are all personal, and over half of them do not appear in the other two corpora. The "impersonal intention/prediction" bundles that appear in the conversation (CC) and classroom corpuses (UCC) are again notably absent.

The stance bundles that are not particular to the SMC Corpus were even more prevalent in the secondary mathematics classroom than they were in the UCTC. Looking more closely at the linguistic forms of these bundles, we see the pronouns *I, you*, and *we* and we notice the prevalence of the verbs *want*, *need to*, *have to*, and *going to*. The variations of these pronouns and verbs increase dramatically when we compare our findings from the SMC with the other two corpora. For example, the pronouns *I* and *we* occur in nine stance bundles in the SMC and only two in the others. Many of the occurrences of *I* include *you* as the direct object, as in *I want you*. The number of stance bundles in which *you* is used as the

subject of the SMC stance bundles is about double the number of times it appears in the others. Though Pimm (1987) and Rowland (2000) noted the prevalence of these personal pronouns to mathematics discourse, especially relating to specialized ways of using *we* and *you* to encode generalization, we find in mathematics education scholarship little analysis of the very prevalent pronoun *I*. Thus, the prevalence and nature of the stance bundles in the SMC Corpus suggest a need for further investigation. We think that such investigation would complement current foci on identity and cultural specificity in mathematics education.

Along with the prevalence of personal pronouns, another distinguishing feature of the stance bundles is the modal verbs. These modal verbs are especially significant in bundles classified as obligation/directive, which comprise the majority of bundles in the SMC Corpus. Most notably, the modal verbs "need to" and "have to", which are common in these bundles, encode necessity that seems to conflict with personal agency. This conflict is of interest because of recent attention to students' agency in mathematics classrooms (e.g., Boaler, 2003; Powell, 2004; Wagner, 2007).

Furthermore, *I want you to* was the most common stance bundle in both the SMC Corpus and the UCTC. The common characteristic of these two contexts is that of being in a classroom. Thus, we wonder if this encoding of obligation/directive through an expression of personal desire ("I want") influences classroom interactions in particular ways. Although the directions in each instance make sense without being preceded by *I want you to*, the teachers continually used it. Why might the teachers have used these words? Perhaps it was to provide students with a brief pause between directions, as a space filler that allowed students to process or react to the instructions. A teacher may use it because it is more polite than using bald imperatives. The choice of the specific words "*I* want *you* to," however, implies a *personal* obligation is involved—the students may be compliant in order to make the teacher happy rather than because there are mathematical purposes for doing what they are doing. Again, further investigation of teachers' motives for saying I want you to and students' experience of this practice is warranted.

Significantly, many of these stance bundles do not appear in mathematics textbooks; personal pronouns in any form are characteristically absent from mathematics textbooks. We suggest that this absence in textbooks implies a form of positioning that would be extremely awkward in face-to-face human relations. The textbook format, replete with imperatives (see, e.g., Herbel-Eisenmann, 2007), would seem bossy coming from a human. Such bossiness might be mitigated in classroom speech by politeness constructions, such as *what I want you to do is* followed by an imperative.

5 Concluding comments

In this article, we described and elaborated an idea from corpus linguistics: a lexical bundle. We explained some of the affordances and limitations of a lexical bundle analysis and elaborated how the stance bundles we found in secondary mathematics classrooms were particular to the context of secondary mathematics classrooms in comparison with previously analyzed corpora. We offered broad observations of our findings rather than more detailed analysis of these categories. We close this article with two concluding observations about our findings.

First, and most importantly, this quantitative demonstration of pervasive stance bundles in the mathematics classroom register substantiates the claims in qualitative

research that teacher stance is significant to teachers' and children's experience in mathematics classrooms. There are characteristics of this positioning that are particular to mathematics classrooms and thus fundamental to students' experiences of mathematics. Thus, it supports the value of existing and upcoming research that investigates socio-cultural and linguistic phenomena that are associated with authority and related issues, such as positioning. Unlike other studies involving discourse analysis in which the researcher analyzes a small set of transcripts in depth, our study, with its large data set, allowed us to consider patterns in a much bigger set of transcripts. And, unlike other studies, the word selections in our study were identified by a computer program used in corpus linguistics that identified the patterns.

This is not without limitations, however. We reiterate that, although we used both a teacher microphone and an external microphone in the classrooms, we were still unable to capture all of the student's contributions. Our recordings were fairly clear whenever the teacher was involved in the interaction. Admittedly, this focus tells us little about what students were saying outside of the whole-group or the small-group interactions in the presence of the teacher. As previous research has shown (e.g., Esmonde, 2009), authority and agency issues can be quite amplified in small group work. Additionally, students make interesting contributions related to teacher stance which are very difficult to capture, for example, when they whisper to each other or make comments under their breath. Houssart (2001) provides a rich illustration of students expressing authority in contributions that are on the margins of the mathematics classroom register. These students' contributions are present in the classroom, but somehow unrecognized in the discourse practice.

Some of the findings we report also need to be explored further, in other contexts (e.g., Advanced Placement courses, university courses, elementary mathematics classes), and require a closer read of the context related to excerpts including a smaller set of lexical bundles. For example, studies that also interview the teachers and students about the different ways stance is encoded in mathematics classroom discourse could broaden the field's perspectives related to some of these findings. Other researchers have shown that students offer different interpretations than researchers and teachers (e.g., Ainley, 1988; Wagner, 2007). It would also be important to explore further the fact that epistemic stance bundles were absent. Given the fact that, in three of the eight classrooms, teachers were using curriculum materials that have tasks designed to solicit multiple solution strategies (i.e., *Mathematics in Context* (National Center for Research in Mathematical Sciences Education & Freudenthal Institute, 1997–1998) and the *Connected Mathematics Project* (Lappan, Fey, Fitzgerald, Friel, & Phillips, 1998)), we wonder what we might have found had we examined those classrooms separately. Exploring differences between contexts, by comparing classrooms with different curriculum materials or comparing classrooms situated in different cultural contexts, for example, could surface some interesting linguistic differences as they relate to stance.

Second, this demonstration that the structuring of stance is central to mathematics classroom discourse makes it clear that the mathematics classroom register includes features that are not present in what many scholars see as the mathematics register—namely the pervasiveness of references to personal identity (represented by the pronoun *I*) and the tendency to appeal to the teacher's personal desire when requesting obligation (see Herbel-Eisenmann & Wagner, 2010, for more about this). Both of these features do not appear in school mathematics textbooks, which are part of the classroom register but may

be seen as straddling the line between it and the mathematics register. We suggest an imperative that arises from this finding. Related to scholarship, there needs to be more clarity regarding writing about registers. If the distinction between the mathematics register and the mathematics classroom register is blurred, there is the danger that the mathematics register would be taken as the norm for mathematics classroom discourse. The density of the mathematics register and its obfuscation of agency may repress the kinds of conversations about stance that could be helpful in classroom discourse. As revealed in the lexical bundles that pervade secondary mathematics classroom discourse, reference to persons and stance abounds in mathematics classrooms. The key question, which is only partially answered with this broader analysis of these bundles, is this: How are these persons positioned?

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References

Ainley, J. (1988). Perceptions of teachers' questioning styles. In A. Borbás (Ed.), *Proceedings of the twelfth annual meeting of the International Group for the Psychology of Mathematics Education* (vol. 1, pp. 92-99). Vaszprém: Hungary.

Apple, M. (1990). *Ideology and curriculum*. New York: Routledge.

Atweh, B., Bleicher, R. E., & Cooper, T. J. (1998). The construction of the social context of mathematics classrooms: A sociolinguistic analysis. *Journal for Research in Mathematics Education*, 29(1), 63–82.

Barwell, R. (2007). Semiotic resources for doing and learning mathematics. *For the Learning of Mathematics*, 27(1), 31–32.

Biber, D. (2006). *University language: A corpus-based study of spoken and written registers*. Philadelphia: John Benjamins.

Biber, D., & Barbieri, F. (2007). Lexical bundles in university spoken and written registers. *English for Specific Purposes*, 26, 263–286.

Biber, D., Conrad, S., & Cortes, V. (2004a). If you look at...: Lexical bundles in university teaching and textbooks. *Applied Linguistics*, 25(3), 371–405.

Biber, D., Conrad, S., Reppen, R., Byrd, P., Helt, M., Clark, V., et al. (2004b). *Representing language use in the university: Analysis of the TOEFL 2000 spoken and written academic language corpus*. Princeton: ETS.

Biber, D., Johansson, S., Leech, G., Conrad, S., & Finegan, E. (2006). *Longman grammar of spoken and written English* (5th ed.). London: Longman.

Bloom, B. (1972). Innocence in education. *School Review*, 80, 333–352.

Boaler, J. (2003). Studying and capturing the complexity of practice—The case of the "dance of agency". In N. Pateman, B. Dougherty, & J. Zilliox (Eds.), *Proceedings of the 27th Conference of the International Group for the Psychology of Mathematics Education held jointly with the 25th Conference of PME-NA*, vol. I (pp. 3–16). Hawaii: Honolulu.

Brodie, K. (2007). Teaching with conversations: Beginnings and endings. For the Learning of Mathematics, 27(1), 17–23.

Burton, L., & Morgan, C. (2000). Mathematicians writing. *Journal for Research in Mathematics Education*, 31, 429–453.

Christie, F. (1995). Pedagogic discourse in the primary school. *Linguistics and Education*, 7, 221–242.

Cirillo, M. (2008). *On becoming a geometry teacher: A longitudinal case study of one teacher learning to teach proof*. Unpublished Doctoral dissertation, Iowa State University, Ames, IA.

Cortes, V. (2002). *Lexical bundles in public and students' academic writing in history and biology*. Flagstaff: Northern Arizona University.

Cortes, V. (2004). Lexical bundles in published and student disciplinary writing: Examples from history and biology. *English for Specific Purposes*, 23, 397–423.

Cortes, V., Jones, J. K., & Stoller, F. (2002). Lexical bundles in ESP reading and writing. Paper presented at the TESOL.

Esmonde, I. (2009). Mathematics learning in groups: Analyzing equity in two cooperative activity structures. *Journal of the Learning Sciences*, 18(2), 1–38.

Fairclough, N. (2001). *Language and power*. New York: Longman.

Fassnacht, C., & Woods, D. (2005). *Transana v2.0x*. Madison: The Board of Regents of the University of Wisconsin System.

Gayer, N. (1970). On making morality operational. In J. R. Martin (Ed.), *Readings in the philosophy of education: A study of curriculum* (pp. 264–273). Boston: Allyn & Bacon.

Goodwin, C. (2007). Participation, stance and affect in the organization of activities. *Discourse and Society*, 18(1), 53–73.

Halliday, M. (1978). *Language as social semiotic: The social interpretation of language and meaning*. Baltimore: University Park Press.

Harré, R., & van Langenhove, L. (Eds.). (1999). *Positioning theory: Moral contexts of intentional action*. Oxford: Blackwell.

Hayfa, N. (2006). Impact of language on conceptualization of the vector. *For the Learning of Mathematics*, 26(2), 36–40.

Herbel-Eisenmann, B. (2007). From intended curriculum to written curriculum: Examining the "voice" of a mathematics textbook. *Journal for Research in Mathematics Education*, 38(4), 344–369.

Herbel-Eisenmann, B., & Cirillo, M. (Eds.). (2009). *Promoting purposeful discourse: Teacher research in mathematics classrooms*. Reston: NCTM.

Herbel-Eisenmann, B., & Wagner, D. (2010). Appraising lexical bundles in mathematics classroom discourse. *Educational Studies in Mathematics*, 75 (1), 43-63.

Hodge, R., & Kress, G. (1993). *Language as ideology* (2nd ed.). London: Routledge.

Houssart, J. (2001). Rival classroom discourses and inquiry mathematics: 'The whisperers'. *For the Learning of Mathematics*, 21(3), 2–8.

Hufferd-Ackles, K., Fuson, K., & Sherin, M. G. (2004). Describing levels and components of a math-talk learning community. *Journal for Research in Mathematics Education*, 35(2), 81–116.

Hyland, K., & Hamp-Lyons, L. (2002). Issues and directions. *Journal of English for Academic Purposes*, 1, 1–12.

Jansen, A. (2006). Seventh graders' motivations for participating in two discussion-oriented mathematics classrooms. *The Elementary School Journal*, 106(5), 409–428.

Kotsopoulos, D. (2006). Researching linguistic discrimination. *For the Learning of Mathematics*, 26(3), 21–22.

Lappan, G., Fey, J., Fitzgerald, W., Friel, S., & Phillips, E. (1998). *The connected mathematics project*. Palo Alto: Dale Seymour.

Lemke, J. (1990). *Talking science: Language, learning, and values*. Norwood: Ablex.

Males, L. M. (2009). Confronting practice: Critical colleagueship in a mathematics teacher study group. In S. L. Swars, D. W. Stinson, & S. Lemons-Smith (Eds.), *Proceedings of the 31st annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 929– 937). Atlanta, GA: Georgia State University.

Males, L., Otten, S., & Herbel-Eisenmann, B. (2010). The challenges of critical colleagueship: Examining and reflecting on study group interactions. *Journal of Mathematics Teacher Education* (Special Issue on Teacher Change) (in press).

Martin, J., & Rose, D. (2005). *Working with discourse: Meaning beyond the clause.* New York: Continuum.

Monaghan, F. (1999). Judging a word by the company it keeps: The use of concordancing software to explore aspects of the mathematical register. *Language and Education*, 13(1), 59–70.

Morgan, C. (1996). "The language of mathematics": Towards a critical analysis of mathematics texts. *For the Learning of Mathematics*, 16(3), 2–10.

Morgan, C. (1998). *Writing mathematically: The discourse of investigation*. Bristol: Falmer Press.

Morgan, C. (2006). What does social semiotics have to offer mathematics education research? *Educational Studies in Mathematics*, 61, 219–245.

Moschkovich, J. (1999). Supporting the participation of English language learners in mathematical discussions. *For the Learning of Mathematics*, 19(1), 11–19.

Moschkovich, J. (2007). Examining mathematical discourse practices. *For the Learning of Mathematics*, 27 (1), 24–30.

National Center for Research in Mathematical Sciences Education & Freudenthal Institute (Ed.). (1997– 1998). *Mathematics in context*. Chicago: Encyclopaedia Britanica.

Nesi, H., & Basturkmen, H. (2006). Lexical bundles and discourse signaling in academic lectures. International Journal of Corpus Linguistics, 11, 147–168.

O'Connor, M. C. (2001). "Can any fraction be turned into a decimal?" A case study of a mathematical group discussion. *Educational Studies in Mathematics*, 46, 143–185.

Otten, S., & Herbel-Eisenmann, B. (2009). Multiple meanings in mathematics: Beneath the surface of area. In S. L. Swars, D. W. Stinson, & S. Lemons-Smith (Eds.), *Proceedings of the 31st annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 296–303). Atlanta, GA: Georgia State University.

Pimm, D. (1987). *Speaking mathematically*. London: Routledge.
Pimm, D. (2007). Registering surprise. *For the Learning of Mathematics*, 27(1), 31.
Powell, A. B. (2004). The diversity backlash and the mathematical agency of students of color. In M. J. Høines, & A. B. Fuglestad (Eds.), *Proceedings of the twenty-eighth conference of the International Group for the Psychology of Mathematics Education* (Vol. 1, pp. 37-54). Bergen, Norway: Bergen University College.
Rowland, T. (2000). *The pragmatics of mathematics education: Vagueness in mathematical discourse*. New York: Falmer.
Shreyar, S., Zolkower, B., & Pérez, S. (2009). Thinking aloud together: A teacher's semiotic mediation of a whole-class conversation about percents. *Educational Studies in Mathematics,* 73, 21–53.
Staples, M. (2007). Supporting whole-class collaborative inquiry in a secondary mathematics classroom. *Cognition and Instruction*, 25(2), 161–217.
Voigt, J. (1985). Patterns and routines in classroom interaction. *Recherches en Didactique des Mathematiques,* 6, 69–118.
Voigt, J. (1995). Thematic patterns of interaction and sociomathematical norms. In P. Cobb & H. Bauersfeld (Eds.), *The emergence of mathematical meaning: Interaction in classroom cultures* (pp. 163–201). Hillsdale: Lawrence Erlbaum.
Wagner, D. (2007). Students' critical awareness of voice and agency in mathematics classroom discourse. *Mathematical Thinking and Learning*, 9(1), 31–50.
Wagner, D., & Herbel-Eisenmann, B. (2008). "Just don't": The suppression and invitation of dialogue in mathematics classrooms. *Educational Studies in Mathematics*, 67(2), 143–157.
Wagner, D., & Herbel-Eisenmann, B. (2009). Re-mythologizing mathematics through attention to classroom positioning. *Educational Studies in Mathematics*, 72, 1–15.
Wetherell, M. (2003). Paranoia, ambivalence, and discursive practices: Concepts of position and positioning in psychoanalysis and discursive psychology. In R. Harré & F. Moghaddam (Eds.), *The self and others: Positioning individuals and groups in personal, political, and cultural contexts* (pp. 99–120). London: Praeger.
Wood, T. (1999). Creating a context for argument in mathematics class. *Journal for Research in Mathematics Education*, 30(2), 171–191.
Zolkower, B., & Shreyar, S. (2007). A teacher's mediation of a thinking-aloud discussion in a 6th grade mathematics classroom. *Educational Studies in Mathematics*, 65, 177–202.