USING THEMATIC ANALYSIS TO STUDY CURRICULUM ENACTMENTS

Jeffrey Choppin, Demeke Yeneayhu, Zenon Borys
University of Rochester

We use thematic analysis to explore how mathematical concepts are developed in four enactments of the same task. Thematic analysis emerges from Systemic Functional Linguistics and provides a means to explore the development of mathematical ideas in the classroom discourse. Thematic analysis was used to explore how themes related to the comparison of like quantities were developed in a task designed to introduce different types of comparisons and different ways to represent comparisons. The thematic analysis showed similarities across the four teachers' enactments, suggesting an influence from the design of the task. There were also differences that pointed to teachers' different emphasis and their own understanding of the thematic pattern.

CURRICULUM ENACTMENT AS AN OBJECT OF STUDY

Teachers' use of curriculum materials has become an active field of study, especially since many districts have used innovative curriculum materials to drive instructional change (Remillard, 2005). The view of the teacher's role has expanded over the last two decades in response to new conceptions of teachers as curriculum developers (Ben-Peretz, 1990) and to the influx of innovative curriculum materials developed in the U.S. The enactment of curriculum materials is not straightforward, as there can be considerable variation in the ways teachers enact materials from the same program (cf. Remillard & Bryans, 2004; Tarr et al., 2008). To account for this variation, researchers have developed a number of perspectives to better understand curriculum enactments. These perspectives have focused on the extent to which curriculum content is covered, the fidelity with which teachers draw on the materials to design instruction, the kinds of instructional practices evident when using particular curriculum materials, and the level of cognitive demand of instructional activities (Chval, Wilson, Ziebarth, Heck, & Weiss, 2012). While these perspectives provide nuanced and detailed accounts of teachers' interactions with curriculum materials and, to a lesser extent, the curriculum received by students, they shed little light on how teachers use curriculum materials to develop mathematical ideas and on how different design features of curriculum materials influence the ways mathematical ideas get developed in curriculum enactments. This paper seeks to address that gap.

In this study, we use *thematic analysis* to explore how mathematical concepts are developed during the enactment of curriculum materials. Thematic analysis has been used to characterize discourse in mathematics classrooms (Herbel-Eisenmann & Otten, 2011) and in science classrooms (Lemke, 1990). Thematic analysis allows a researcher to explain the ways that concepts are developed by looking at the underlying semantic

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relations and the ways they are explicitly or implicitly constructed. Thematic analysis emerges from *systemic functional linguistics* (SFL) (Eggins, 2004; Halliday, 1978; Halliday & Martin, 1993), which looks at language as a *resource for meaning* rather than as a system of rules, so that language use is viewed in terms of "learning how to mean versus learning how to speak" (Halliday, 1978, p. xx).

THEMATIC ANALYSIS AS A FRAMEWORK

Systemic Functional Linguistics

Systemic functional linguistics looks at language as a meaning making resource rather than as a conduit through which thoughts and feelings are expressed (Halliday & Martin, 1993). As such, SFL is built on the supposition that language is not only situated in context but produces context, and moves away from idealized views of language and of speakers (Halliday, 1978). SFL treats grammar as the realization of discourse, as a means of expressing semantic relations that are the heart of meaning making, rather than inherently carrying some unambiguous meaning.

Thematic Analysis

Analysis of thematic patterns allows researchers to see how ideas and concepts are developed in the classroom discourse, where discourse is broadly construed to include language, gesture, and other resources for conveying meaning (Herbel-Eisenmann & Otten, 2011). Thematic analysis focuses on how relationships between discourse objects are expressed, how relationships are made explicit, and how these relationships cohere into themes (Lemke, 1990). Lemke states that a thematic pattern is a way of picturing the network of relationships among the meanings of key terms in the language of a particular subject. Often, students are drawing from one pattern that is based on their everyday experiences while teachers are drawing from a pattern that is based in the conventions of the discipline they are teaching. In order for students to learn disciplinary content, teachers must recognize students' thematic patterns and draw connections to the conventional disciplinary pattern (Lemke, 1990; Schleppregrell, 2007). Learning can thus be construed moving from thematic patterns based in everyday language use to those found in disciplines.

Thematic patterns involve the construction of lexical relations and lexical chains. Lexical relations (Eggins, 2004), or semantic relations (Lemke, 1990) express relationships between various discourse objects. Lexical relationships include taxonomic relations such as hierarchy, similarity, or contrast, and nuclear relations, such as agent-process-medium and activity sequences (Martin & Rose, 1993). Taxonomic relations include the ways terms are similar (synonyms) or contrast (antonyms) in addition to hierarchical relations such as hyponyms (member – class relationship), co-hyponyms (two members of the same class), meronym (part of a whole) and so forth (Lemke, 1990). Lemke states that semantic relations tend to be variants of a relatively small number of basic ones, and which form thematic patterns that are highly standardized in each field of science.

Lexical chains or strings (Eggins, 2004) or *semantic chains* (Lemke, 1990) provide insights into how thematic patterns are developed. Eggins defines a lexical string as a list of "all of the lexical items that occur sequentially in a text that can be related to an immediate prior word" (p. 44) either taxonomically or through an expectancy relation (word or phrases that we expect to see used in proximity to each other). These strings contribute to the *cohesion* of a text. Eggins (2004) defines cohesion as "how what we're saying hangs together and relates to what was said before and to the context around us" (p. 12). Text cohesion builds within a clause via expectancy relations or via the ways that clauses are connected by conjunctions.

METHODS

Thematic analysis was conducted on transcripts of four teachers' enactments of the same task. The *Bolda Cola* problem introduces the *Comparing and Scaling* unit in the Connected Mathematics Project (CMP) curriculum (Lappan et al., 2006). The unit explores different ways to compare like and unlike quantities, eventually leading into unit rate and algebraic representations of unit rate. The Bolda Cola problem asks students to explore four claims around a fictional taste test of two brands of cola, Cola Nola, and Bolda Cola. The purpose of the problem is to introduce different kinds of comparisons (part to part and part to whole) and ways to represent comparisons (e.g., fraction, percent), ideas that will be explored for several more tasks over the span of a week or more.

The thematic analysis involved the construction of lexical chains and maps of the lexical relations based on the transcripts from each enactment, to focus on similarities and differences in those thematic patterns. The transcripts were first parsed into Topically Related Sets (TSRs)(Mehan, 1979), which consist of a series of exchanges around a single topic, such as discussion around a strategy or a specific question.

Each TRS was parsed into two separate themes, one related to mathematical concepts and the other related to the context of the Bolda Cola problem. This was done by creating a column for mathematical terms and language and a column for references to the taste test context. A third column was used to track which part of the Bolda Cola task was being addressed during the TRS. A column was created to track the conjunctions and prepositions to help map the relationships being constructed between the lexical items in the mathematics and context columns. Another column was created as well to keep track of the verbs being used, in order to consider the ways that mathematics was being construed in each class (Herbel-Eisenman & Otten, 2011). For each topically related set, we summarized the mathematics and context themes, which now became the lexical items used in subsequent parts of the analysis.

To construct the lexical chains, we used the summaries of the mathematics and contextual themes from each TRS and created a new spreadsheet which tracked these lexical items across the TRSs, with the mathematical themes and contextual themes grouped separately, with a third grouping for the task part being addressed in that

particular TRS. This spreadsheet showed how lexical items were used over time, whether they appeared in multiple TRSs, and how they mapped on to the task parts.

The different lexical items and the relationships expressed between each of the items from the TRS summaries were then used to create a transcript-based map. Lemke (1990) stated that thematic patterns are best expressed in the form of diagrams that can show the interconnected semantic relationships among several terms or thematic items. These transcript-based maps were adapted from the 'clean map' (Herbel-Eisenmann & Otten, 2011), which was constructed based on an analysis of the lexical relations expressed in the textbook, on discussions with one of the textbook authors, and on our own understanding of mathematics. The clean maps were used to identify key concepts that were the intended focus of the Bolda Cola task and the Comparing and Scaling unit in general.

A final spreadsheet was created, using the primary concepts in the unit as column titles and the TRS number as row title. Then, the lexical items identified in the first spreadsheet were placed under the column or columns that represented the concepts referenced by the lexical item. We were looking for instances in which a lexical item appeared multiple times in one column, which formed a lexical chain for that concept. These lexical chains not only exhibit the development of the thematic pattern, but also how the mathematical and contextual themes worked in tandem to express the underlying mathematical concept.

We also looked for when one TRS contained multiple concepts, which constituted a *thematic nexus*. Lemke (1990) explains that an important point in the development of a thematic pattern is when there is a *thematic nexus*, which multiple thematic relations are brought in contact with each other at one point in time.

RESULTS

The results show similarities in the transcript maps that potentially show the role of task design in eliciting and developing a thematic pattern related to comparing quantities. Conversely, there are subtle differences in the transcript maps and lexical chains that demonstrate different. First we discuss the lexical chain tables.

Lexical Chain Tables

The lexical chain tables provide an indication of how the lexical items varied across the enactment and how they mapped onto the part of the task being addressed. In Figure 1, for the teacher named Allen, the first section is the mathematical lexical items (e.g., comparing two quantities using a 'for every' statement; dividing the quantities by the same number gets a scaled down ratio), the second the contextual items (e.g., For every 17139 who liked Bolda Cola, 11426 liked Cola Nola; Dividing 17139 and 11426 by 5713 gives you 3 and 2), and the third section the task part (e.g., Do the four statements from the same data?). In figure 1, for the teacher named Allen, as the task part changes, one can see a related sequence of mathematical and contextual themes.

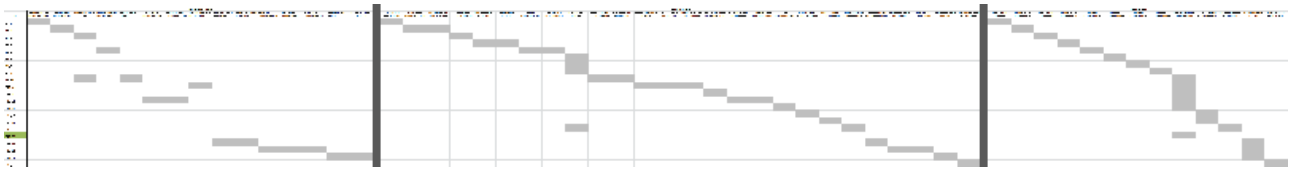

Figure 1: Lexical chain table of Allen.

The differences across the lexical chain tables of the four teachers indicate the extent to which the teachers focused on particular questions to develop the mathematical or contextual themes. Granville, for example, focused much of her discussion on whether all four statements came from the same data, during which nearly half of the mathematical themes were developed, as seen in Figure 2, while Sadosky focused a good portion of her discussion on the question most related to the context (which statement would make the best advertisement), which focused relatively more of her discussion on developing contextual themes than mathematical themes.

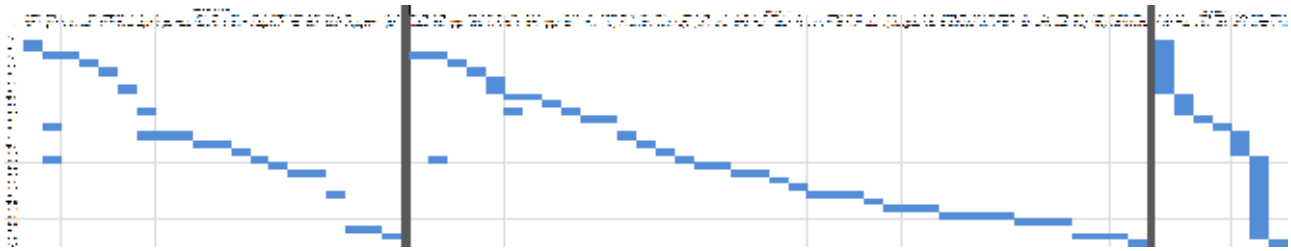

Figure 2: Lexical chain table of Granville.

Transcript Maps

The transcript maps showed which lexical items were discussed and how they were related in each enactment. Figure 3 shows the transcript map for Allen. The four transcript maps had roughly similar sets of lexical items and lexical relationships, which speaks to the design of the Bolda Cola problem. However, there were subtle differences between the maps that indicate teachers' intended focus for the task and perhaps their own understanding of the thematic pattern. Allen's map, for example, was not as clearly connected as the others and there was more ambiguity in the classification and composition of comparisons, particularly the ratio comparisons, as can be seen, for example, in the characterizing of most ratios as part to part ratios. Sadosky's map showed a relatively greater emphasis on processes and different ways of expressing comparisons but the taxonomic relations were not as coherent as those of Pless and Granville. Pless's map was parsimonious but coherent, showing a clear taxonomy of terms. Granville's map was the most elaborate and well-connected, reflecting the greater amount of time spent on the task and the greater explicitness in discussing the lexical relations as seen in Figure 4.

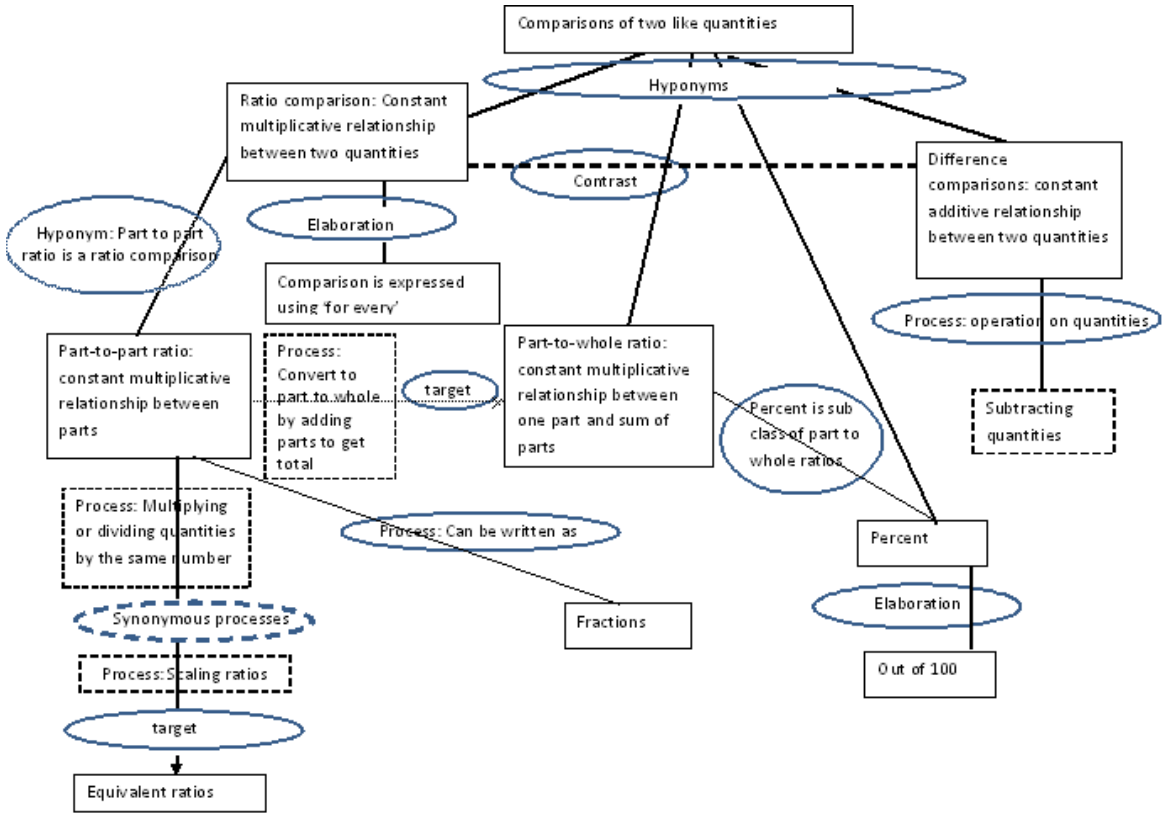

Figure 3: Transcript map for Allen.

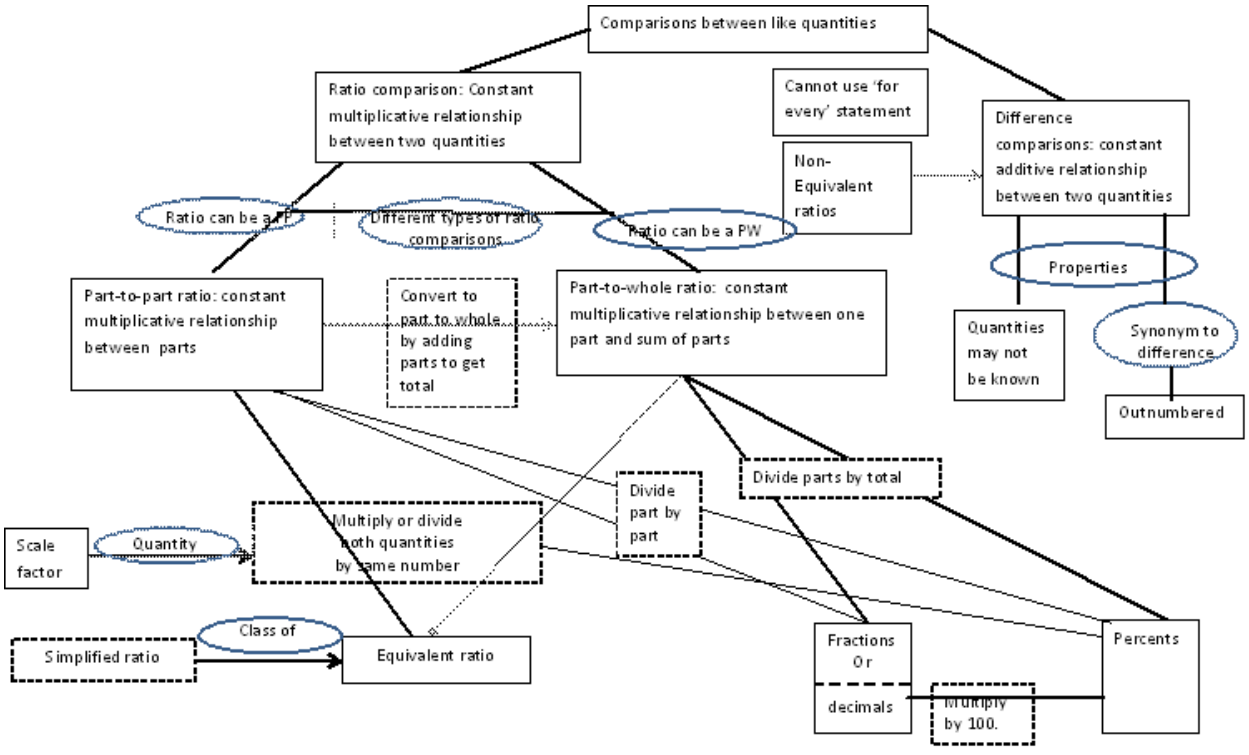

Figure 4: Transcript map for Granville.

The final spreadsheets, reflecting lexical strings for the main concepts and any occurrences of a thematic nexus, primarily showed the distribution between the mathematical themes and contextual themes for developing the thematic pattern. The tables showed how couplings of math/context themes occurred relatively frequently and how each contributed to the various lexical strings and the overall thematic pattern. Figure 5 shows how Pless explicitly describing the lexical relations, which contributed to her coherent transcript map.

Part to part comparison		Part to whole comparison		
Ratios can be simplified or scaled up	Ratios can be written as fractions or percents	To get the total you add the parts	Ratios can be simplified or scaled up	Ratios can be written as fractions or percents
A big number is unlikely to be a simplified ratio				
A big number means it's the actual number of people surveyed				
The bigger numbers means the majority of people preferred BC				
The quantities can be written in the ratio 17139 to 14126				
There are different types of ratios				
BC to NC ratio and BC to total ratios are different				
There are part to part and part to whole ratios				
BC to NC ratio and BC to total ratios are different				
		One type of ratio compares people who like one brand of coke to the total population surveyed.		

Figure 5: Partial Second Lexical Chain Table for Pless.

DISCUSSION

The paper set out to show how mathematical ideas were developed in four separate enactments of the same task. A goal was to introduce a perspective on studying curriculum enactments that allowed researchers to better understand how teachers' uses of curriculum materials provides opportunities for students to develop understanding of mathematical concepts. Thematic analysis allowed for a fine-grained and multi-tiered analysis of the development of mathematical ideas across the four classrooms. The results also show how thematic patterns related to problem contexts can be used to develop mathematical thematic patterns.

The thematic analysis showed similarities across the four teachers' enactments, suggesting an influence from the design of the task. There were also differences that

pointed to teachers' different emphasis and their own understanding of the thematic pattern. Future research needs to look at enactments of tasks from different curriculum materials and at how thematic pattern related to comparison of like quantities develops over multiple tasks from the same instructional sequence.

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