Capturing Qualities of Mathematical Talk via ‘Coding And Counting’

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Abstract: We report on findings generated by a new method of quantified discourse analysis aimed at capturing qualities of mathematical talk according to Sfard’s (2008) “communicational framework”. The method is inspired by Systemic Functional Linguistic system of ‘Transitivity’. Findings revealed significant differences between two instructors' mathematical talk in a teachers’ college course. These differences were mainly seen in the amount of ‘objectified’ vs. ‘personified’ talk of each of the instructors.

Introduction

Methods for analyzing classroom discourse have proliferated in recent years together with the surge of interest in promoting ‘discourse rich’ instruction (Mercer, 2010). And yet, these methods are mainly concerned with what may be termed the ‘social’ rather than disciplinary aspects of talk. As useful as these methods are, they have difficulty in capturing aspects of the *content* of talk rooted in disciplinary practices. As such, important aspects of talk such as the level of abstractness or conceptual depth of the talk have not received as much attention as needed.

We suggest a new method for quantitative analysis of *mathematical* talk which is based on a ‘communicational’ framework for analyzing mathematical discourse (Sfard, 2008). Sfard conceptualizes mathematical learning as change in participation in a certain type of discourse. She distinguishes between ‘objectified’ talk and ‘syntactic talk’ which treats the mathematical signs without relating to the objects that are signified by them. Most often, this syntactic talk is accompanied by personified talk where the student talks about what they *do* to the mathematical signifiers, how they move them around, etc. The difference between personified talk and objectified talk has been captured by many others as the difference between “procedural” or “calculational” vs. “conceptual” talk (Rittle-Johnson & Alibali, 1999). Our goal in this work was to come up with a ‘coding and counting’ method that would capture quantitatively the difference between personified and objectified talk.

Methodology

The data was taken from a larger project that aims at making explicit teaching and learning processes of prospective elementary school mathematics teachers in a college for education in Israel. For this purpose two similar courses were video-taped and fully transcribed. For the current analysis, two segments, similar in their mathematical content, were taken from the 6th and 7th lesson of each course (out of 14 lessons, 90 min. long).

The ‘objectified’ vs. ‘personified’ distinction was captured by SFL’s system of ‘Transitivity’ (Eggins, 2004, p. 207). Three types of categories were found to be most relevant: (a) Material: clauses that include an Actor and a Goal. We distinguished between material processes in which the Actor is human (ex. *You* multiplied *the two numbers*) from processes where the Actor is the mathematical object itself (ex. the x moves up by 1). The objectified quality of talk has been associated by Sfard (2008) with ‘being’ verbs. According to SFL, there are two main types of being processes: *Existential* processes, where things are simply stated to exist; and *Relational* processes, where things are stated to exist in relation to other things (are assigned attributes or identities). Thus, our next two categories are: (b) Existential processes that posit that ‘there was/is something’ (ex. ‘There is a linear function’). (c) Relational processes include (c1) Intensive attributive processes, in which an attribute is assigned to a participant (ex. ‘The slope **is** steeper’) and (c2) Intensive identifying processes, which are about *defining* (ex. ‘Intercept *equals* negative five’).

When looked at from a mathematical-communicational perspective, intensive:identifying, intensive:attributive and existential clauses may be indicators of a general ‘objectified’ quality of the talk, so long as the subject of the clause (Token or Carrier) are mathematical objects. In contrast, process:material clauses may indicate personified talk, so long as they include a human agent as the Actor of the clause.

We checked the reliability of our coding in three phases. After resolving disagreements, an agreed upon ‘clean’ version of the clause segmentation was prepared for further coding. The three phases were: 1. Reliability of clause segmentation (85% agreement). 2. Reliability of selection-for-coding: 89% (Kappa 0.76). 3. Reliability of clause-codes (according to the 5 categories described above) 100% (Kappa:1.0).

Findings

Findings pointed to significant differences in the two instructors’ talk. Whereas Instructor 1 talked about mathematical objects mostly in a personified way (24%) or by giving the mathematical objects some agency (41%), Instructor 2 used mostly Intensive Identifying and Intensive attributive clauses. Thus 72% of instructor2 clauses could be considered as 'objectified' while only 35% of instructor1 clauses could be considered as such. A chi-test revealed this difference to be highly significant ($p<0.001$).

Following is a very short example of the two instructors' talk that we coded and compared. Both excerpts deal with the definition of 'slope' of a linear function.

Spkr	**What is said (clauses delineated by [a],[b], etc.)**	**Coding**
Inst.1	[a] 'cause what is slope? [b] Again, what is slope? [c] How do you say that [d] this equals three? (*points to the segment where the slope is 3*) [e] For one unit [f] that we move on the x axis, [g] by how much did the y value increase? For the same unit.	[a]II [b]II [c]HP [d]II [f]HP [g]OP

In contrast, Instructor 2's definition of 'slope' was very different:

Inst.2	[a] To determine, to determine whether [b] the slope is bigger or smaller, [c] then it is possible to look at the angle between the x-axis, [d] or some line parallel to the x-axis, ok? [e] And each of those graphs. [f] And it is possible to look at, [g] as we spoke last time, [f]the size of the step. [h]Now, note that [i]to determine [j] bigger or smaller [k] both ways are fine.	[a]HP [b]IA [c,d,e,f,i]HP [j,k] IA
	A discussion revolves around what "a step" is after which Inst. 2 summarizes her definition of slope:	
Inst.2	[a] The height of the step when [b] the step's width is one unit. [c] That is, it is the change in the function's value when [d] the x value changes by one unit.	[a]II [b]II [c]II [d]OP

The qualitative analysis of the episodes from which these excerpts were taken revealed that through their talk, the two instructors made different realizations of the concept of slope available for their students. While instructor1 directed her students to realize "slope" only as a result of one type of routine (counting the difference in y values over one step of x), instructor2 elicited several different routines and thus made different realizations of slope (as an angle; as a "step" or quotient of dy and dx) available to her students. We believe the quantitative analysis partially captured this qualitative difference by showing that instructor 2's talk was much more objectified than that of instructor 1.

Discussion and Conclusions

We believe that the presented method, and especially its application together with qualitative methods of analysis, holds much promise. In recent decades, significant advancements have been made in understanding processes of teaching and learning mathematics via employing methods of discourse analysis (Ryve, 2011). Yet the potential of the findings from these studies to be generalized has been seriously limited by the qualitative and episodic nature of these methods. The present method is intended to extend the power of discourse analytical methods, and in particular, Sfard's (2008) communicational framework, to enable comparison between teachers, classrooms and students. Such comparisons should provide us, in the future, with means to address important questions such as the relationship between the quality of teachers' talk and students' achievements.

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