DISCURSIVE AUTHORITY IN THE MATHEMATICS CLASSROOM: DEVELOPING TEACHER CAPACITY TO ANALYZE INTERACTIONS IN TERMS OF MODALITY AND MODULATION

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This paper discusses discourse analytic tools used to develop teacher capacity in analyzing classroom interaction. We examine the linguistic tools of modulation and modality (used to express degrees of obligation, inclination, probability and usuality) as markers of epistemic authority and deontic agency. We then discuss the first year results from a research project using these tools with beginning middle school mathematics teachers, and show how they developed skills at analyzing transcripts for evidence of discursive authority.

INTRODUCTION

This paper reports on a research project focusing on the social semiotics of whole-class interaction in mathematics classrooms. The ongoing project engages 12 middle school mathematics teachers who work in urban high needs schools in New York City. Teachers meet seven times per semester to collaboratively work on developing their understanding of the linguistic and semiotic challenges of teaching and learning mathematics. Session activities consist of a variety of investigations into the challenges of orchestrating meaningful whole-class conversations about mathematics problems. In this paper, we focus on the use of classroom transcripts in teacher development. In particular, we discuss one transcript that was analyzed and interpreted on two different occasions throughout the first year of the project, and we show how the two different sets of teachers' responses to the transcript indicate how their attention to correlations between language use and authority changed their interpretation of the given interaction, and increased their understanding of how grammatical modality and modulation are related to student agency.

Session activities throughout the first year were designed using a social semiotics framework. In this case, social semiotics is defined as a framework which focuses on the function of multiple semiotic systems (symbolic notation, oral and written language, graphs and visual displays, gestures and the use of material objects) and grammatical patterns (technical vocabulary, dense noun phrases, "being" and "having" verbs, logical conjunctions, visual codes, canonical gestures) in spoken, written and performed mathematical texts. The "social" part of social semiotics aims to unpack the complex use of multiple semiotic tools in positioning participants in terms of power, agency and authority. We draw on critical discourse analysis to help explore the manner in which classroom discourse constitutes and is constituted by power/knowledge relations, focusing on the use of language as a tool for negotiating

subject positions through interaction in particular contexts. This approach proposes that we interpret and analyze transcripts and other mathematics texts in socio-cultural terms, and attend more carefully to the ways that power relations are constituted through language use. For instance, critical discourse analysis examines the linguistic features of texts as a means of understanding the enactments of identity through inculcation of cultural norms, submission or resistance to authority, and positioning and agency between speakers (Fairclough, 2003).

In any mathematics text – be it spoken or written or gestured – one can identify an array of grammatical forms that imply different kinds of authority and agency. One can say that authority and agency are "realized" in particular grammatical forms, and in turn, that grammatical forms position participants, assign authority, and re-inscribe power relations between participants. For instance, while most mathematics texts employ a form of address that minimizes agency on multiple levels, as in *"What is the probability that a rolled die will be a 1?"*, where the "rolled die" occurs without a causal subject or agent, and the question demands a statement of fact, the same question can be re-written to convey *authoring* agency, that is, as a statement that recognizes the reader as uniquely inventive, as in *"How would you decide whether a 1 is likely to occur when you roll a die?"* Learning how to decode mathematics texts for implied forms of address that locate the reader in terms of agency and authority strengthens the capacity of teachers to modify resources so as to better engage students (de Freitas & Zolkower, 2009; Dowling, 2001; Morgan, 2006; O'Halloran, 2005).

MODULATION AND MODALITY

The concepts of modulation and modality offer insight into how authority is managed and marshalled during classroom interaction. Halliday (1985) examines modality within propositions (statements and questions) and modulation within proposals (offers and commands). In propositions, modality expresses the degree of usuality (sometimes, always) or probability (possibly, definitely), whereas in proposals, modulation expresses the degree of obligation (supposed to, must) and inclination (might, determined to). Halliday (1985) uses the term "modulation" for obligation and inclination, and uses "modality" for usuality and probability. Modality is often considered the domain of epistemic variation and modulation the domain of deontic variation, although it is evident that in certain cases the line between these two becomes fuzzy [1]. The focus on modulation and modality allows teachers to study the way that action (or imagined action) is built into particular linguistic functions. Prospective teachers can begin to decode classroom conversations in terms of the subject positions implied by the grammar ("Which number would (could, can) you try?", "The cube would (could, should) then have edges of length 12"). The focus on modality and modulation also reveals the crucial role of grammar in constituting the border between necessary and contingent truths ("This number must (could) be prime"), and thereby introduces teachers to the grammatical forms attached to logical implication. Discussing modality and use of pronouns also helps teachers examine

the ways in which their students are invited to participate. This speaks directly to issues of agency and authority in mathematical discourse, and reveals the complex relationship between language use and subjectivity.

Speakers use modality when operating between the polarity of yes and no. Polarity, according to Halliday (1985), is what makes something arguable: "Modality means the speaker's judgment of the probabilities, or the obligations, involved in what he is saying. A proposition may become arguable by being presented as likely or unlikely, desirable or undesirable – in other words, its relevance specified in modal terms." (p. 75). Modality is the means of mapping varying or intermediate degrees between the two polar extremes in various speech functions. According to Halliday (1985), "yes/no" utterances should be considered within the textual metafunction, because they relate the polarity to what has gone before, and play a huge role in sustaining the textual coherence of the conversation (p. 85). They are "intertextual" in an important way. Modality can be expressed via "finite verbal operators" such as: can, may, could, might (low modality), will, would, should, is to, was to (median modality), must, ought to, need, has to, had to (high modality).

Halliday (1985) considers other ways of expressing modality, such as "modal adjuncts" (usually, already, inclined, unfortunately, happily), which can express opinion, assertion, evaluation, prediction, validation, and desire. Examples are: "in my opinion, to my mind, personally" (opinion) or "I assure you, frankly, honestly, believe me, to tell you the truth" (assertion) or "as expected, by chance, to my surprise" (prediction) or "broadly speaking, on the whole, strictly speaking" (validation). In terms of its "arguable" status, and thus in terms of the authority and agency implied and construed by the utterance, the subject of the clause functions as that which is "responsible" for the modal claim; the subject is "something by reference to which the proposition can be affirmed or denied" (p. 76). It is the subject in whom is vested the success or failure of the proposition – that being the "functioning of the clause as an interactive event" (p. 76). The subject is not always the actor, but often the two correspond (in "I'll draw the graph" they coincide, but they don't in "I'll follow the instructions.")

Halliday (1985) argues that many instances of opinion ("I think the answer is two") are actually examples of interpersonal metaphor, since the "I think" stands in for the more congruent statement, "It might be two". The latter is considered more congruent (less metaphoric) because the low epistemic modality of "might be" better captures what the sentence is about (that being the measurement and its accuracy). "I think" is therefore metaphorical since thinking is not the theme or focus of the sentence. The "I think" is functioning as modal operator. This becomes clear when one considers the "tag" that might clarify the meaning of the statement, a tag defined in this case as the question posed to identify the subject responsible for the modal claim. For the statement, "I think the answer is two", the tag would be "isn't it?" not "don't I", thereby pointing out that it is not the belief that is up for question, but the validity of the assertion [2]. In the context of the mathematics classroom, this interpretation of "I

think" statements sheds light on the complex linguistic practices by which authority and agency are negotiated. Statements such as "I think" can be considered a form of "hedging" and an attempt to "manage" the affective consequences of participating in high risk and high modality mathematics discourse (Rowland, 2000). In studying students' language use as they grappled with mathematical tasks focused on generalizing, Rowland found that "I think" was the most common hedge used by students in their attempt to create "plausibility shields" (p. 138). These plausibility shields allowed them to move away from unqualified propositional statements, which were subject to truth or falsity judgments, and towards conjectural speech acts, for which less was at stake. Such plausibility shields, which also include adverbial prefaces of various kinds ("probably" or "apparently") do not effect the truth conditions of the proposition, unlike other hedges – such as approximators (about, around) – which modify the set of arguable options entailed.

Halliday (1985) further classifies modality into implicit/explicit and objective/ subjective distinctions as in: I think Tamir knows (subjective/ explicit) and Tamir'll know (subjective/implicit) and Tamir probably knows (objective/implicit) and it's likely Tamir knows (objective/explicit). The subjective/objective distinction identifies to what extent the assertion seems to emanate from the person. Within the subjective/objective distinction, the explicit case involves a projection of fact ("it is") or subjectivity ("I think") that alternately identifies the subject as responsible or erases responsibility from the clause. Negation in these instances is also interesting in how it maps onto agency: "I don't think Tamir knows" or "it isn't likely Tamir knows". In these, the modality is what gets negated, despite that being obviously not the intent. As Halliday (1985) suggests, the modality takes on the burden of the negation because it is so strongly centered as theme. This transfer of the negation between the modality and the proposition itself occurs most often in the case of median modality (not high/low).

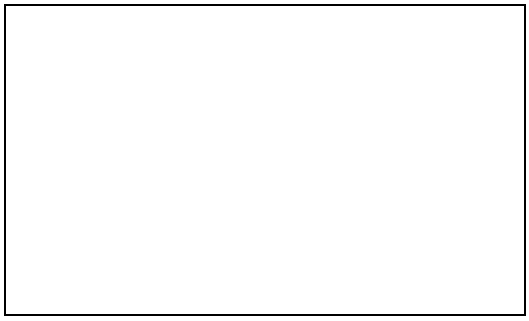
Finally, it is worth noting that there is a paradox in the modal system. We only say we are certain when we are not. Whenever we introduce modal operators like "I'm certain it's seven" we are actually acknowledging an element of doubt. If there weren't any doubt, we would simply say "It's seven."

TEACHERS ANALYZING TRANSCRIPTS

The transcript under discussion in this paper is a one page excerpt from a grade 8 classroom in which a problem and diagram were introduced to the whole class. This was the first transcript that the teachers in our study discussed as a group. We selected this transcript because it concerns a good non-routine problem and it appears on the surface to be an exciting discussion using an interesting problem. We wanted to use a transcript that was seemingly a strong example of rich classroom interaction, with classic examples of good teacher questions, such as "Can someone say that in a different way?", so as to elicit the teachers' first positive reading and then direct the teachers' attention to certain silences in the transcript that indicated serious problems

in terms of meaningful interaction. Below is the transcript (de Freitas & Zolkower, 2009):

The following problem is written on the blackboard



If E, F, G, H, and I are all midpoints, what is the relationship between the area of triangle GHI and the area of rectangle ABCD?

1	Teacher (T):	(Reading aloud.) What is the relationship between the area of triangle GHI and the area of rectangle ABCD?
2	Stud. 1 (S1):	Wait! You have to give us some numbers!
3	S2:	We don't have any measurements!
4	T:	No measurements
5	S2:	I don't get it. What are we supposed to do?
6	T:	Let's look closely at the statement written in here. What is this about?
7	S3:	A triangle and a rectangle.
8	S4:	One is inside the other.
9	S2:	It's about the areas of those shapes.
10	T:	Do we have to find the areas?
11	S5:	No, we have to find the relationship.
12	S1:	What do you mean by relationship?
13	T:	Can someone say that in a different way?
14	S6:	It asks how triangle GHI and rectangle ABCD relate to each other.
15	T:	That sounds like the same thing, right?
16	S2:	Oh, I get it! We have to figure out what part of the rectangle is occupied by the triangle.
17	S3:	It's a fraction… like a half or a third or… I don't know!
18	S4:	It has to be less than ½!
19	T:	How do you know that it's smaller than ½?
20	S4:	You can tell by just looking at the picture.
21	S2:	This reminds me of a problem we did about a garden covered with grass.
22	T:	Ok. So, if we put the problem in that context, what would we be looking at?
23	S7:	How much of this rectangular garden has grass in it.
24	S5:	Yes but we don't have to find how much it is. The question asks us to compare the two areas. It's like what S2 said before.

25 S1: So I think that what we have to do is first find the area of the rectangle, then find the area of the triangle, and then see what fraction is one from the other.

26 S2: But how are we going to find those areas if we don't know the lengths and stuff?

The teachers first focused on the student contributions. They noted (1) the high frequency of student contributions, (2) the students were "fixated" on measurement and didn't attend to qualitative aspects of the problem, (3) the word "relationship", which was in the problem, was causing confusion, and (4) the students' demonstrated "accountable talk". One teacher then pointed out that she liked the way the students were "talking about what a fraction is before they use the word fraction: 'What part of the whole is something?'" and this observation shifted the conversation to the place in the transcript where a student introduces the word fraction with the statement "It's a fraction … like a half or a third or … I don't know!" Another teacher then suggested that the students were pushing back until this moment, and that this "big leap" is where the "lesson took off". The moderator then asked the teachers: "How does the teacher use the diagram?" and one replied that she didn't because she was focusing on the language of the problem. When asked by the moderator "Are there any points where you think she could go to the diagram?" the teachers then debated the teacher moves in lines 16-24. One teacher suggested that after contribution 20 "You can tell by just looking at the picture", an alternative teacher contribution might have been "Let's look at the picture and think about why we might know that?" The grammar of this phrase stands in stark contrast to the question that was actually asked, "How do you know that it's smaller than ½ ?" Comparing the two, in terms of grammar, reveals that the proposed alternative:

(1) Commands the students to perform a perceptual act - to "look". This emphasizes the central role of material actions in doing mathematics, and the importance of interacting with the diagram on the perceptual plane.

(2) Uses an inclusive command "Let's look at …" instead of the interrogative "How do you …" The former commands the class as a collective, while the latter isolates the speaker.

(3) Uses the low epistemic modality mental process ("think about") instead of the high epistemic modality mental process ("know");

(4) Uses a low modality verbal operator "might" in "we might know".

The proposed alternative highlights some of the key issues regarding modality and modulation in classroom discourse. These key issues became the focus of many subsequent discussions of classroom transcripts. Our aim was to help the teachers – especially those who initially disagreed with the proposed alternative – to begin to think more explicitly about the linguistic choices they were making during whole-class interaction.

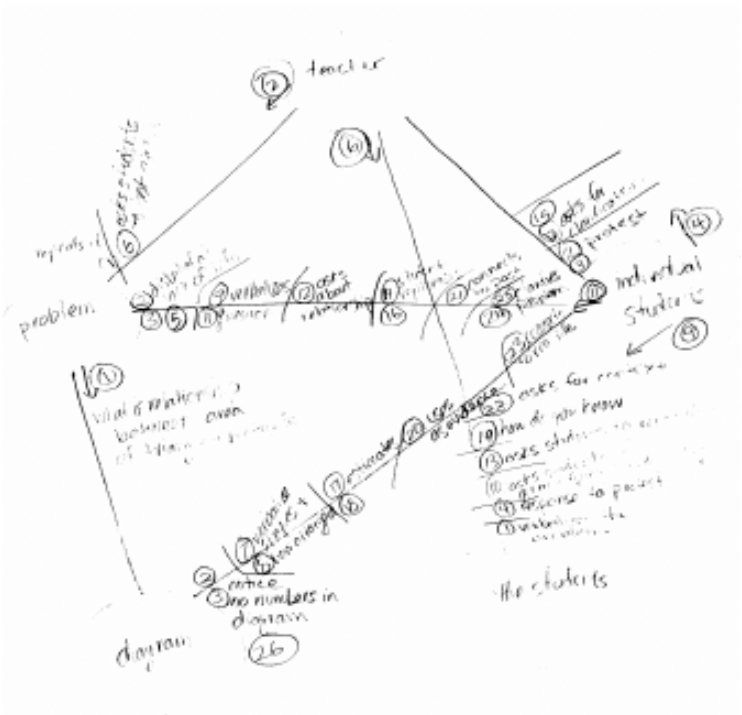
During the next few months, teachers studied other transcripts and discussed modality and modulation, as well as other semiotic and linguistic patterns in classroom conversations, often focusing on how particular grammatical choices functioned to position students and teachers in particular ways. Teachers examined transcripts to see how different teacher moves changed the texture of the conversation, and in particular how changing the modality and modulation of the statements, questions, commands and offers seemed to impact on the kind of agency the students enacted during the interaction. Re-examining the important moves of students S2, S3 and S4 in lines 16-24 in the above transcript, for instance, one can see that the participating students move from low modulation in "we have to figure out" to a medium modality, made medium by the use of the explicit subjective "I don't know" to the high epistemic modality in "It has to be less than ½!".

As a result of these discussions, teachers became more sensitive to the impact these small changes in language use had on classroom interaction. During the end of Year One of the project, teachers examined the original transcript that they had discussed the previous semester, and they were asked to draw an interaction map that represented the whole-class interaction, and then explain their map to the others. They were given the following assignment to do individually:

> Consider the five participants in this interaction: (1) the teacher, (2) the problem statement, (3) the diagram, (4) the students (realized grammatically via ''we''), and (5) individual students (realized via ''I''). Use the transcript to draw an interaction map that visualizes the number and nature of interactions between these participants. Take note of the use of grammatical choices in student responses such as "you have to give us some numbers" and "The question asks us to compare the two areas" to help draw your interaction map. How does your interaction map represent the agency or authority (or lack thereof) for each participant in the classroom discourse?

In this paper, we discuss four participant responses to this task, and include two of the diagrams. Bonnie, having counted interactions and looked for the ranking of frequencies, concluded that most students interacted with the problem statement, and that "the problem [statement] has the most authority". She pointed to "We have to find …" and "It asks how …" and "The question asks us to compare the …" as evidence that students and teachers interacted most with the problem statement, and that the nature of these interactions inscribed a certain authority onto the statement itself. When asked to explain what sort of authority, she claimed that its authority lay in it being the target of the students' questions, that they were "trying to get at it", and she pointed to particular pronouns, as in "The question asks …" and "It asks …" as support of her claim. The use of "it" as a linguistic pointer is an important part of mathematics classroom discourse when students are grappling with concepts they have yet to name (Rowland, 2000; Pimm, 1987). This deictic use of "it" is effectively leveraged by students as they answer vague questions such as "what do you notice?" or "What is the relationship between A and B?" In her interaction map, Bonnie connects the problem statement to the diagram because she felt that the former

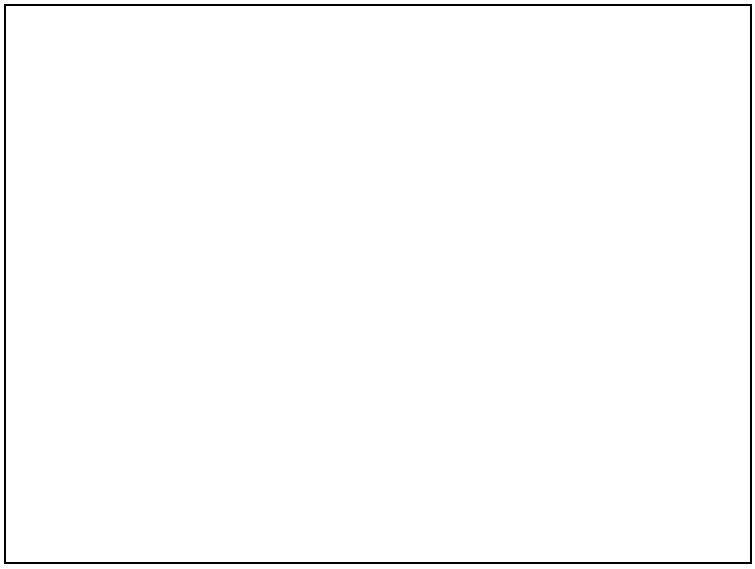
implicitly referred to the latter. She also maps student-diagram interactions, revealing that the students were indeed interacting with the diagram, despite the fact that the teacher was directing their attention away from it and towards the language in the problem statement.



Annette and Lada focused on the use of I/you/we pronouns, and concluded that most of the students who used "I/you" were asking the teacher for help, whereas those using "we" engaged the diagram. "You" frequently functions in mathematics classroom discourse as a generalizing pronoun to designate a form of abstract agency, as in "Then you subtract 4 from both sides". Rowland (2000) notes that students often switch from "I" to "You" when grasping and communicating the generality of a pattern, and that "you" in such instances indicates a detachment from the strategy or actions described (p. 112). These instances contrast with the use of "you" as a form of address, which is considered a high-stakes enactment of a power relation. The two uses of "you" are found in the given transcript: the first in "You can just tell by looking at the picture" and the second "Wait! You have to give us some numbers!" Annette felt that the students who used "I/you" were tentative in their engagement with the conversation. She decided that students who used "we" were positioned in terms of strong agency because they interacted with the diagram, and that they were able to use "we" effectively precisely because they were interacting with the diagram. During previous discussions, we had debated the way in which "we" is operationalized in classroom discourse, pointing out that teachers often use "we" in strategic ways that tacitly enlist the listener into complicity. According to Wills (1977), "we" is highly imprecise in terms of its referent, and for that reason the pronoun is regularly exploited in manipulating conversations. Furthermore, Pimm (1987) suggests that teacher use of "we" is sometimes used to bolster the authority of a particular utterance, by implicitly citing an absent (expert) collective. Lada, who

focused on the same use of pronouns, disagreed with Annette, and stated that the students who used "I" were more confident and more engaged, and that the less confident students hid behind the "we". She pointed to the statements with high obligation modulation as evidence of limited agency, as in "Do we have to find the areas?", but then pointed to statements that used explicit subjective modality, as in "So I think that what we have to do …" as evidence of how confidence mapped onto the use of pronouns.

Cameron stated that the problem statement dominated the classroom interaction because the word "area" was a key word that caught their attention, and that the students became fixated on their measurement associations with the word area. Area, according to Cameron, was a "huge word" which directed the conversation. When asked if the concept of area should be considered a participant in the interaction, Cameron thought it wasn't that significant. Again, one can see in Cameron's interaction map that the teacher fails to interact with the diagram. Her map also indicates the different students that used "we" and "I" and how these addressed either the diagram or the problem statement.



CONCLUSION

During the first year of the project, teachers developed skills at attending carefully to different patterns in transcript data. Focus on modality and modulation allowed them to look for grammatical patterns that might easily be associated with authority and agency. The interaction maps offered an opportunity to trace the complex network of exchanges in an alternative format, and to visualize the relationships between participants. They justified their maps and their understanding of the distribution of authority by reference to the degrees of modality and modulation found in the transcript. Teachers were asked to consider the problem statement as a participant in the interaction, and were able to see how particular grammatical constructions assigned authority to it. They were also asked to consider the problem diagram as a participant, in order to raise their consciousness about how the diagram was an

important but neglected "agent" in the making of a meaningful interaction. Their attention to the use of pronouns in conjunction with modality and modulation helped the teachers trace the agency of the students during the interaction. Although these results don't yet speak to how their teaching practice was affected by participation in the lesson study, they do indicate that the teachers have developed an increased awareness of the connections between language use, agency and the distribution of authority.

NOTES

1. In other domains, such as modal logic, the term modality is used for both cases.

2. Consider "John thinks the answer is two, doesn't he?" where "thinks" is no longer metaphorical.

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