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ORIGINAL ARTICLE

Exploring the central role of student authority relations in collaborative mathematics

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Abstract

How students build mathematics knowledge together in classrooms is of central concern in research focused on the role of language in learning and doing mathematics. This paper explores how students compose mathematics knowledge together in relation to the social construction of influence. Drawing on the influence framework (Engle et al. in J Learn Sci 23(2):245–268, 2014), core interactional components are made salient: gaining access to the conversational floor and interactional space, being perceived as intellectually meritorious, and being positioned with social and intellectual authority. Of these, being positioned with social and intellectual authority is argued to be most important. This paper highlights both the centrality of authority and its discursive nature and connects these ideas to collaborative mathematics activity. Finally, the paper concludes with a discussion of the theoretical generativity of focusing on the functions of language in mathematics classrooms, in addition to its forms, to better articulate discursive mechanisms at play during collaborative mathematics learning activities.

Keywords Authority · Influence · Collaboration · Language · Identity

1 Introduction

How students construct mathematics knowledge together in classrooms is of central concern in research focused on the role of language in learning and doing mathematics (Pimm, 2014). The connections between language use and mathematics learning have been broadly examined, including studies of social interaction and communication in mathematics classrooms, the nature and use of the mathematics register and social construction of school mathematics discourse, and critical studies of language (in particular minoritized home languages) as a resource in multilingual settings (Morgan, Craig, Schuette, & Wagner, 2014; Planas, Morgan, & Schütte, 2018). Throughout, much of the research on language in mathematics classrooms has largely focused on how students communicate and/or construct mathematics knowledge and activity together through mathematics-specific forms of talk (Herbel-Eisenmann & Otten, 2011). Studies have shown how mathematics discourse is used to reference (Rowland, 1992) or construct (Sfard, 2001) mathematics ideas through dialogue (Brodie, 2007) made possible by particular kinds of classroom participation structures (Hufferd-Ackles, Fuson & Sherin, 2004). The focus has largely been on the forms of speech among interactants and how they are taken up and used to generate a mathematics learning space.

Part of the goal of this body of work is to understand the challenges students face in appropriating the technical forms of mathematical language that enable students to participate in disciplinary ways of knowing (Schleppegrell, 2007). Halliday (1978) highlighted these challenges through his explication of the mathematical register as a specialized form of discourse. Much of the work since has followed in the tradition of Halliday, producing robust knowledge of the complex forms of language and other representational and communicative resources that make up learning and doing mathematics.

Much less work has focused on how students navigate mathematics classroom discourse alongside others as resources for learning and doing mathematics together. Moschkovich (1996) argues that informal, everyday talk and extra-linguistic forms of communication such as gestures and the use of manipulates are valid mathematical forms of talk. Student learning is better supported when teachers focus on the mathematical meanings of

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such communications, rather than their technical form, especially in the case of students learning the language of instruction (Moschkovich, 1999). Yet, nearly all of this work considers students' use of language, both formal and otherwise, in the presence of a teacher, as in whole class discussion, where much of what "counts" as mathematics is ultimately governed by a more knowledgeable other.

How mathematics is constructed by students outside the presence of a teacher who can hold students accountable to disciplinary norms is far less clear. Research focused on student-led collaborative mathematics highlights complex interactions governed largely by student status rather than disciplinary engagement (Engle, Langer-Osuna, & McKinney de Royston, 2014). Such work suggests that students' *forms* of mathematical talk may not explain how ideas are taken up as true during small group work, so much as the ways in which talk, mathematical and otherwise, might *function* to determine and distribute status or other relations of power. Halliday's framework, for instance, does not contemplate this type of function.

In this paper I explore the research on how students construct mathematics knowledge together in relation to the discursive construction of influence among peers during student-led work. Discursively, influence is defined as interactions that mark a particular idea being taken as true, an outcome of convincing others that an idea is correct or a path should be followed (Engle, Langer-Osuna, & McKinney de Royston, 2014). Influence is primarily an outcome of discursive negotiations of both social and intellectual forms of authority and, as such, can be interactionally accomplished through formal and informal mathematics talk, as well as talk that is not mathematical in nature, including off-task conversations (Esmonde & Langer-Osuna, 2013). That such a variety of discourses can be directly utilized in the construction of mathematics discussions during collaborative mathematical activity serves to point researchers interested in the role of language in mathematics classrooms beyond content-specific talk into examination of the fuller range of linguistic resources at play.

In what follows, I explore the importance of focusing on the social construction of influence and the role of student authority relations in particular by bringing together research on authority in mathematics with research on student positioning during small group mathematics activity. I organize this exploration through the lens of the influence framework (Engle, Langer-Osuna, & McKinney de Royston 2014), which models influence during student-led work and offers useful constructs that can help shed light on how students engage in mathematical activity in the absence of teachers.

2 The discursive construction of influence during student-led activity

The influence framework (Engle, Langer-Osuna, & McKinney de Royston, 2014) conceptualizes the interactional construction of influence during student-led collaborative work. The framework was developed based on a re-analysis of a case of productive disciplinary engagement in a student-led scientific debate among fifth graders (Engle & Conant, 2002). In the original analysis, Engle and Conant (2002) found four principles that accounted for the robust, spirited engagement by students in the debate: problematizing subject matter, giving students authority to address disciplinary problems, holding students accountable to one another and shared norms, and providing relevant resources. In their paper, student authority refers to students being afforded the agency to address disciplinary problems and being publicly identified with the claims, approaches, explanations, and products to the problems pursued. While their definition of student authority is juxtaposed with teacher and disciplinary authority (reviewed further below), it does not address how multiple students in a class negotiate the forms of authority broadly afforded to them by the teacher and classroom participation structures among one another. A re-analysis of the Engle and Conant (2002) case was conducted to address that limitation.

In the re-analysis, Engle, Langer-Osuna, and McKinney de Royston (2014) shifted the unit of analysis from the debate as a whole to the individuals within the debate, focusing on how particular students became more or less influential relative to one another. The analysis showed that each student's level of influence in a discussion emerged out of the social negotiation of influence itself and the following kinds of interactions: (a) the negotiated merit of each student's contributions; and each student's, (b) degree of intellectual authority, (c) access to the conversational floor, and (d) degree of spatial privilege. The influence framework further posits that these interactional components are related to one another in particular ways. The perceived merit of individuals' contributions and their positions of authority were each found to be directly linked to influence. That is, interactions that marked the uptake of a student's idea tended to be just subsequent to interactions where that student's idea was oriented to as high quality or where the student was positioned with authority by other students. To have the same degree of influence, students who were socially oriented to as having higher levels of authority did not need to provide as compelling arguments as those with less perceived authority. Indeed, the most influential student, Brian, had actually offered the lowest quality arguments of all the students. What mattered was that his ideas were socially positioned by other students as having high quality, as in the following exchange from the paper:

> "Brian: [while leaning in toward his main argument opponent] I've known a lot about whales, before I started researching. General KNOWledge, general knowledge. It's called the big NOGGin, you know that big, pinkish, grey GUSHy thing in your HEAD!
> Toscan: Okay, Brian has a very good point." (capitalization represents vocal emphasis; Engle, Langer-Osuna, & McKinney de Royston, 2014, p. 246)

Overall, negotiations of intellectual authority were most important to determining whose ideas were taken up as true. It was found to be the only kind of interaction that was bi-directionally related to influence. That is, moments of influence tended to occur subsequent to interactions that positioned a student with authority by other students and, likewise, students were likely to be positioned with authority subsequent to moments of influence. These discursive patterns served to create an interactional feedback loop that enabled particular students to become very powerful relative to others. This finding resonates with literature in mathematics education focused on authority, which overall claims that authority—of the discipline, of the teacher, and among students—is central to learning and doing mathematics. Given its core importance in regulating which ideas are taken up as true among peers, research on how students negotiate authority through talk is particularly important, though currently understudied and largely unaccounted for in work on language in mathematics teaching and learning.

In the sections that follow, I explore the importance of student authority relations as discursive acts in collaborative mathematics activity. Drawing on scholarship on authority in mathematics classrooms, as well as related research on positioning during small group mathematics activity, I highlight the ways in which authority relations mediate several core processes involved in learning mathematics, including the construction of solution paths, possibilities for mathematical reasoning, and the development of mathematics learning identities. The findings from these bodies of work are understood and re-interpreted from the perspective of the influence framework, allowing a clean synthesis of findings that illuminates the centrality of student authority relations and the discursive mechanisms that underlie their negotiation.

3 Authority in mathematics classrooms

Language takes form in particular social contexts. Erickson and Shultz (1981) argue that contexts consist of socially constructed and ratified definitions of a situation that are embedded in moments of time and dynamically change. As contexts change, the roles and relationships among interactants also change, and individual rights adjust accordingly in ways that structure who gets to speak, in what ways, and to what effect. The linguistic principle of reflexivity from Mehan (1979) highlights how language takes on meaning within social contexts, and thus its negotiated nature. This negotiated nature begins with the first utterance, which serves as a bid that calls forth possible responses. In small group mathematics learning contexts, students regularly make and respond to bids for authority using a range of mathematical and non-mathematical language forms.

A focus on how language functions to negotiate authority, and thereby influence, places the analytic spotlight on how mathematical ideas are taken up as true among peers and make their way into collaborative solution paths—actions at the heart of mathematics learning activity. Yet, while the study of authority in mathematics is not new, it has received far less of an emphasis than research detailing other aspects of the construction and use of mathematics discourse. Further, much of the work has focused on teacher authority in mathematics with student authority coming into play only in relation to teachers'.

Clearly, teachers are powerful authorities at all times in their classrooms, whether or not they share the authority with students (Amit & Fried, 2005; Gerson & Bateman, 2010). They are positioned with institutional authority as teachers, and also hold expertise and mathematical authority (Gerson and Bateman, 2010), which comprise the authority to determine and evaluate appropriate mathematical ideas and procedures (Wilson & Lloyd, 2000). Wagner and Herbel-Eisenmann (2014) examined how teachers establish authority discursively within their classrooms, wherein they highlight the complex relations between the authority of mathematical truth claims, the teacher, and students. Like Pace and Hemmings (2007) and Amit and Fried (2005), they frame authority as a resource for control related to rights to lead and obligations to follow. Teachers can be both *an* authority through their mathematical knowledge (what the influence framework refers to as intellectual authority) and *in* authority through their right to issue directives to students and control behavior, a social form of authority. Through their analysis of lexical bundles, or pervasive speech patterns, they examined the relations between language practices and teacher authority, in particular. They found that the most common speech pattern called upon teachers' personal authority, which was linked to the issuing of directives to students, such as "I want you to". They found that, while this form of authority could exist among students, as well as among the teacher and students, it was found almost entirely related to teacher authority. Further, they found that both intellectual and social forms of authority (being an authority and in authority) interacted and fused during classroom interactions.

Many of these forms of authority, while held by teachers, can be shared with students, in particular by affording students agency to address mathematics problems and holding students accountable to their mathematical ideas (Bell & Pape, 2012; Hamm & Perry, 2002). Indeed, sharing forms of authority with students is at the heart of many of the progressive reform goals in mathematics education. These goals, as articulated by Amit and Fried (2005), are to support students in sharing authority with the teacher and one another in community together as they mutually seek fuller membership. Gerson and Bateman (2010) found that expertise authority can be held by both students and teachers, based upon the perception of expertise. Students can garner such authority by being positioned as competence at math. Further, they found that students may treat one another as authorities such that one student will simply listen and assent to the other without necessarily coming to consensus on an idea, reducing possibilities for dialogue.

Most of the research looking explicitly at authority in mathematics classrooms have understandably focused on teacher-student authority relations at the whole class level. However, at the small group level, where students engage in mathematics activity largely in the absence of a teacher, how students negotiate forms of authority remains unclear. Consider the following exchange among two-fifth graders engaged in collaborative problem-solving as partners:

Ana: Wait! These are sections, ok? We have 4 m in each one. [Draws individual square within rectangle with tick mark on each side.] One, one, one, one.
Jerome: [Stands and starts drawing on second row of rectangle.] Yeah I can do that.
Ana: There were some.. .. Do three.
Jerome: Huh?
Ana: Three only, okay? Only four on that one. [Points to squares on top row.] It says. Cuz.. . [looking back at the problem] and then the rest of them. [Returns to drawing.]
Jerome: [Draws three tick marks on the five internal squares on the second row.]

Like Wagner and Herbel-Eisenmann's (2014) findings of the discursive construction of teacher authority, here we see Ana's authority largely enacted through the issuing of directives. That is, Ana was able to tell Jerome what to do, and Jerome complied. How did Ana come to garner this social form of authority and what role did it play in the pair's mathematics sense-making?

This exchange comes from a data set wherein Langer-Osuna (2016) examined a case where the dynamics of authority were particular salient and analyzed the idea-by-idea construction of a pair of students' collaborative solution path onto a shared poster. As in Wagner and Herbel-Eisenmann's (2014) findings, this case revealed the central role of the social authority to issue directives and the fusion of social and intellectual forms of authority. Indeed the analysis revealed the importance of social authority, in particular the rights to issue directives to students, and intellectual authority, as well as their fusing in moments of influence. In this particular case, the students were solving the following problem, and their solution (see Fig. 1) was incorrect.

> Students in this fifth grade class were asked to solve the following problem:
> Avenue Crest Elementary is planning to design a fruit or vegetable garden. We have decided that it is best to divide our garden site into square sections that are 1 m on each side. We will use 4 m of rope to rope off the first section, and we'll only need 3 m of rope for each additional section. How many meters of rope do we need if we plan on creating a garden with ten sections if the sections are in a single row?

The expected representation included a single row of 10 sections with shared internal borders and the expected answer was thus 31 m of rope. The dyad's representation (see Fig. 1), intellectually led by Ana, included a 2×5 array with additional tic-marked squares inside. The squares on the top row had four tic marks, and the squares on the bottom row had three. The squares on the top row had four tic marks in response to the problem stating, "we will use 4 m of rope to rope off the first section" and the squares in the bottom row had three tic marks in response to the problem stating, "we'll only need 3 m of rope for each additional section". That is, the students treated the top row as "the first section" and the bottom row as the "additional section". Ana then recast each column of their array as a "single row" and determined that there were "five single rows" in their representation. Against recasting "rows" as "sections", she determined that they needed 10 single rows/sections, doubling their number of tic marks (35 in the drawn representation) to a total of 70 m of rope, which was their final answer.

The analysis show that each moment of influence - that is, when a particular contribution was written onto the shared poster[1]—was largely organized around negotiations of social and intellectual authority, which became concentrated in Ana. At the start of the lesson, students were expected to cut the problem from a worksheet and paste it onto a shared poster. This was generally taken as a one-person job and, across the classroom, there were many partners waiting for that to occur before working together on the problem itself. Yet, Jerome was the only student who was regularly called

[1] The analysis operationalized influence in terms of each written contribution to the shared poster for the sake of analytic clarity.

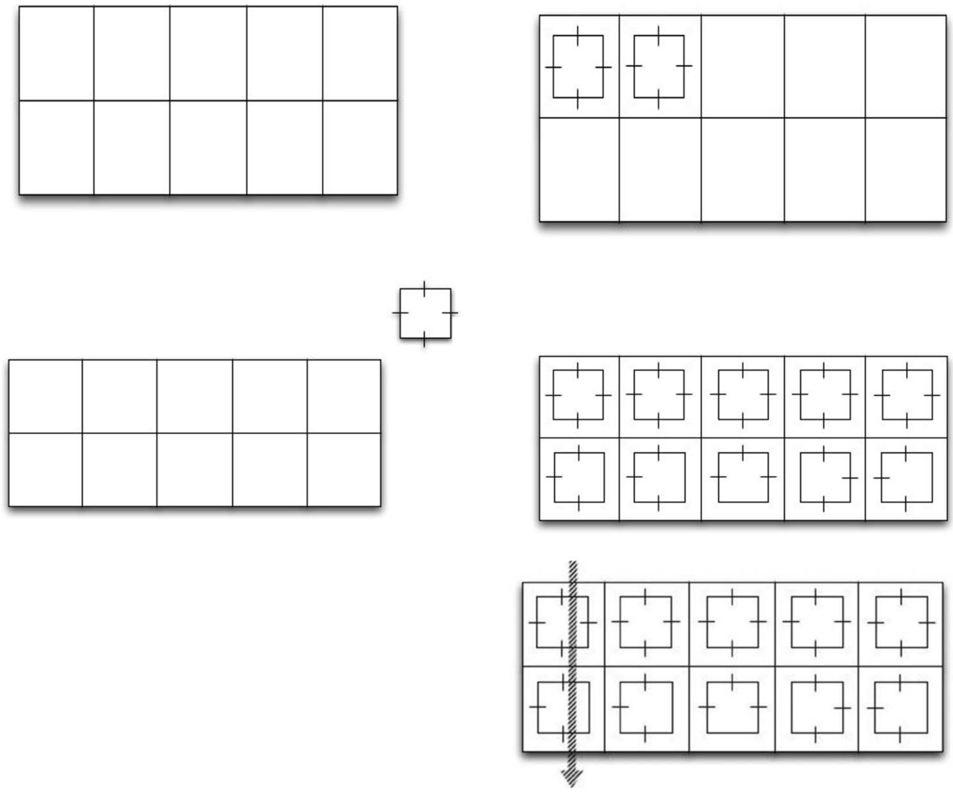

Fig. 1 Each iterative drawn contribution to the dyad's problem representation

Table 1 Frequencies of uptake and rejections across kinds of interactions about Ana or Jerome

	Bids	Directive authority	Intellectual authority	Social merit	Intellectual merit	Influence	Floor	Space
Ana	–	− 1	− 1	− 1	0	− 1	− 5	− 2
	+	20	15	2	13	6	40	17
	Net	19	14	1	13	5	35	15
Jerome	–	− 4	− 2	− 10	− 3	− 1	− 7	− 6
	+	3	4	1	3	2	23	14
	Net	− 1	2	− 9	0	1	16	8

out by the teacher for it. The teacher's demotions of Jerome's behavior were taken up by Ana and set the stage for their dynamics. Jerome's position as disengaged, or problematically off-task and in relation to Ana, was linked to Ana subsequently becoming positioned with the right to issue Jerome directives. As she repeatedly and successfully issued directives to Jerome, Ana's directive authority became intertwined with her intellectual authority, as the nature of her directives increasingly included mathematical ideas, and Jerome increasingly asked Ana for help on implementing those ideas and treated Ana as a credible source of information. Because Ana's social authority, which derived from the teacher's evaluations of Jerome and Ana's relative behaviors, had become quite pronounced, by the time Ana used that authority to direct the mathematics itself, there was little discursive possibility for Jerome to effectively push back, even as he expressed confusion (e.g., "huh?"). Ana's intellectual authority, which mediated her influence, did not arise from the form of her mathematical arguments, but rather because of the ways in which their exchanges functioned to regulate access, privilege, and status.

Utilizing all components of the influence framework, with the addition of directive authority, Table 1 shows the frequencies of the coded interactions among Ana and Jerome. These frequencies contain all the bids and their successful uptake (as a positive value) and their rejections (as a negative value). When focusing on the positional functions of these interactions, the net magnitude of positive (successful) and negative (rejected) interactional bids can serve as a marker of how students were positioned relative to the other in relation to each kind of interaction. For example, of Ana's 21 bids for directive authority, all but one was taken up by Jerome. In contrast, of Jerome's seven bids for directive authority, only three were successfully taken up by Ana. These frequencies highlight both that Ana was discursively able to bid for authority far more often than Jerome and that her success in bidding for authority positioned her as socially dominant relative to Jerome. Similar outcomes were found across all of the interactional components that led to Ana becoming more influential than Jerome, highlighting the "thickening" of each student's positionality during the problem-solving session (cf., Wortham 2006). In this sense, the net magnitude can loosely represent the discursive possibilities that eventually "stick" to a person, constructing them as a kind of student (Anderson 2009). In this case, Ana became socially constructed as a competent and influential kind of student, even though the ideas she offered were replete with error. Likewise, Jerome became socially constructed as a lazy loafer, even though the behavior that started him down that path—waiting for Ana to cut the problem from the worksheet—was common across the classroom and to be expected. In framing their interactions both in terms of influence and positionality, we can see that the social construction of mathematics solutions and the development of identities as kinds of mathematics students occurs in concert, is not necessarily related to the actual competence of students, and is largely undergirded by relations of authority.

In the next section, I expand this exploration of positionality, student authority, and influence in collaborative mathematics by focusing on research in mathematics education that draws on positioning theory and other similar frameworks focused on how social interaction can function to position students in relation to one another and mathematical activity. In doing so, I link the findings of the body of work focused on positioning to the influence framework in order to illuminate more of the discursive mechanisms at play.

4 Positioning as a core function of talk to negotiate authority

Student interaction during collaborative mathematics activity serve multiple functions; interactions function to communicate ideas and they function to position students in relation to one another and the activity at hand. Research on how student interactions during collaborative mathematics activity function to position one another often (though not exclusively) draws on positioning theory (Harré & van Langenhove, 1998), which asserts that individuals draw upon and mutually construct storylines as they engage in conversation in order to make sense of discursive events and establish inter-subjectivity. While the register of school mathematics is made up of particular linguistic and extra-linguistic forms that serve mathematics functions during collective activity, the storyline of school mathematics includes characters such as teacher and student (and kinds of students, such as competent, slow, learning disabled, disruptive, and so on), as well as plots that organize what teachers and students do together. Characters, plots, and forms of participation are linked, such that a teacher can reprimand a student, though not the other way around, and smart students can tell others what to do. Individuals take on these characters through acts of positioning, discursive events where interactions serve to make claims about who a person is at a particular moment.

Kotsopoulos (2014) offers a dramatic example in the case of Mitchell, a low-status student who actively resisted his peers' negative interactional positionings with no success. The three-dimensional cube he constructed as part of his small group activity was regularly demoted, which, from the influence framework, can be seen as a demotion in intellectual merit. Further, Mitchell's participation was positioned as "nothing" or "lazy", which likewise served as demotions in social merit. Ultimately Mitchell was positioned as lacking both intellectual and social authority, leading to his cube not being included in the final presentation and instead used as the group's garbage can, which he himself was asked to throw out. This outcome can be framed as a dramatic case of losing influence.

We see findings again resonating with the influence framework in Bishop's (2012) analysis of the discursive patterns in the interactions among two students, Bonnie and Teri, during partner work in a seventh-grade classroom. Bishop found particular kinds of positioning moves led to particular mathematics identities as "smart" or "dumb" among the students, which affected the nature of their mathematics discussions. The particular kinds of positioning moves found through their analysis resonates with the influence framework's interactional components. For instance, they describe students' "use of authoritarian voice" in ways that are similar to directive authority, with examples including "quit messing around" and "you need to sharpen your pencil". They also found that interactions that marked inferiority and superiority or controlled problem-solving were also important, both of which were defined similarly to intellectual authority, including examples such as "I don't know about this thing", "You looked at mine to see what you could figure out", or "I'll show you more in just in a minute", all of which serve to position a student relative to being a credible source of information. Bishop then looked at who had the floor (conversational floor) and whose ideas were taken up (influence) in relation to these positions of authority and found that, like Ana in Langer-Osuna (2016), the more powerful student controlled the uptake of both her partner's and her own ideas.

The distribution of authority among students can also fundamentally affect the discursive possibilities for mathematical reasoning in a small group. DeJarnette and Gonzalez

(2015) examine negotiations within three groups of four students as a function of authority, which they defined in terms of expert and novice positional identities. They found that one group had a clear expert who no one in the group challenged, while the two other groups had evidence of shared authority. These two latter groups, which regularly challenged experts or shared positions of novice and expert, respectively, were able to engage in longer and more elaborate mathematical deliberations and in exploratory, dialogic talk. They found that not only the particular positions of authority as expert or novice, but more importantly, their distribution, was related directly to the group's mathematical reasoning.

Negotiations of authority among students can also affect how students' come to identify with mathematics as a discipline (Anderson 2009). In a sophisticated and multi-layered analysis of the construction of "kinds" of people in a mathematics classroom, Anderson (2009) followed how the focal student, Nate, became a kind of student within his small group and with the teacher. Small group interactions served to delegitimize and devalue his participation, regardless of his evidence to the contrary, as well as to position his reasoning as not understandable and him as "confused".

Further, these negotiations can draw on multiple storylines. Langer-Osuna (2011) examined a case where two group leaders—Kofi, a boy and Brianna, a girl—served as group leader within the same group at two different points in the year. The group leader role positioned students with social authority in particular, as they were expected to manage the group and thus issue directives. Brianna and Kofi performed the group leader role in very similar ways. The forms and substance of their talk were similar and even the delivery of their directives was similar. However, group members responded negatively to Brianna's directives significantly more often than to Kofi's directives. Group members successfully took up an average of 30.1% of Brianna's directives, resisted an average of 46.8% of them, and ignored or rejected an average of 22.5% of them. In contrast, Kofi had little trouble managing the group. In particular, group members successfully took up an average of 77.0% of Kofi's directives, resisted an average of 16.5% of them, and ignored or rejected an average of 6.5% of them.

Looking at the nature of their responses, the group members increasingly positioned Brianna as "bossy," claiming that Brianna was overstepping her authority by assigning tasks or trying to keep students on task. Over the course of the academic year, Brianna's engagement plummeted, as she became marginalized from the group. In an interview, Brianna offers a gendered interpretation of what happened, claiming that "boys don't listen to girls." She also recast her identity in relation to the class from someone who "used to want it" to a "workaholic" who "was just doing it a little bit too much, but now I feel that I'm doing enough." When asked why working hard was a problem, she returned to a gendered interpretation, stating, "I think I was, all I had was boys. So that also, like, put me in a tragedy."

Across these studies, researchers have found that students negotiate positions of social and intellectual authority through a range of talk. For example, Wood (2013) found that particular positions supported or constrained opportunities to engage in mathematical reasoning. That is, positions that afforded intellectual authority, such as the "mathematical explainer" or the "mathematical student", increased opportunities to engage in mathematics in-the-moment and those that reduced intellectual authority, such as "the menial worker" decreased mathematical engagement. But where did the subject position of "menial worker" come from? In Wood's analysis, the specific subject position of "menial worker" arose from the storylines that organized the talk among the focal students, in particular the way the focal student's directive authority became intertwined with the racial narrative of subservience denoted in the usage of the term "boy" by his white female peer toward a black boy. This finding resonates with Langer-Osuna's (2011) finding, described above, of the term "bossy" bringing a gendered storyline into the positional acts among Brianna and the other students in her small group. Likewise, in the case of Ana and Jerome, described earlier in the paper, Jerome's positioning as lazy and in need of being regulated by Ana evokes a racial stereotype of African-American males like Jerome.

In sum, students' negotiations of authority occur discursively through acts of positioning wherein talk and actions function to regulate intellectual and social power among individuals engaged in collaborative mathematical activity. These negotiations affect core components of mathematical work, including gaining access to and maintaining the conversational floor and interactional space, being perceived as having or lacking social and intellectual merit, and, ultimately, becoming influential or not. Such interactions around authority affect possibilities for mathematical reasoning among group members collectively. All in all, the discursive negotiation of authority among students in collaborative group work is central to the ways in which they engage with school mathematics.

5 Negotiating positions of authority through off-task talk

Storylines, which serve as interpretive tools, can be invoked through a wide range of talk. Students can garner authority through talk that is not mathematical in nature, but that functions to position students powerfully in social hierarchies. These acts of positioning can draw on mathematics discourse that becomes gendered, racialized, or otherwise intertwined with storylines about social identity groups. These acts can also draw on a multiple of other possible storylines through off-task talk that nevertheless affects the collaborative mathematics activity.

Langer-Osuna, Gargroetzi, Munson, and Chavez (2018) examined the functions of 56 instances of off-task talk across 14 videos of collaborative problem solving in a fourth-grade mathematics classroom. Results showed that the majority of instances functioned to support the collaborative problem-solving process. These functions included: warming up to the collaboration, gaining the attention of others, recruiting others into participation, gaining access to the collaboration for self, extending the task, and resisting concentrated authority. Drawing on positioning theory, Langer-Osuna, et al (2018) further found that off-task interactions offered students the ability to position themselves with relatively greater social power than was available through on-task interactions and in ways that students could leverage during their collaboration.

Sullivan and Wilson (2015) similarly found that students used what they refer to as "playful talk" to negotiate status during collaboration. In playful talk, students use imaginative storylines unavailable in the official collaborative learning activity to position themselves or others as either more or less capable, that is, in relation to intellectual authority. For example, a student with low status engaged in playful talk to position herself with competence, while a high-status student engaged in playful talk to position others as less competent and, in doing so, maintain his status. These acts of positioning functioned to influence opportunities to learn within the group, and to establish and maintain group cohesion.

Other studies have likewise found that off-task interactions, which draw on a range of storylines beyond that of school mathematics, were central to students' capacities to negotiate social and intellectual authority. Additionally, these negotiations had direct effects on the nature of the group's mathematics discussions. For example, Esmonde and Langer-Osuna (2013) examined a small group made up of a white ninth-grade boy and two African-American tenth-grade girls in a tenth-grade math class. Riley was the only ninth grader enrolled in the course and was considered by the class in general to be the smartest student in math. Within their small group, the boy, Riley, had high academic status and regularly dominated the mathematics discussion. The two girls contested the boy's concentrated authority by drawing on storylines of friendship and romance, both of which were explicitly gendered and racialized, in ways that positioned them with social forms of power. They were able to leverage their position to control who spoke when and in what ways, recasting Riley as a mathematical resource, while creating opportunities for all three students to engage in mathematical practices such as conjecturing, clarifying ideas, and providing evidence.

The social positions made possible during off-task activity seem to also serve as resources for the construction of positive mathematics learning identities. Langer-Osuna (2015) examined a case of a ninth-grade student who began the year disengaged and de-identified from mathematics and whose engagement and positionality shifted positively across the school year. The classroom was one that afforded students a great deal of autonomy, both intellectually and socially. Students worked on open-ended and complex projects and were expected to make a number of mathematical and non-mathematical design-related decisions as they collaborated with their team. Students were expected to choose their group roles, distribute tasks among themselves, and create internal group deadlines in service of completion. Students could also manage on-task and off-task behavior with a great deal of autonomy. For example, students were allowed to listen to music on their headphones as they worked and engage in light socializing as long as progress continued. This created a learning context where doing mathematics co-occurred with many other activities, both project-related and off-task. The focal student, Terrance, began the year positioning himself in relation to out-of-school storylines through off-task talk, in particular about masculinity and neighborhood violence. In particular, he referenced neighborhood fights that he proudly participated in, highlighting a broken pinky from throwing a punch. This positioning was brought into on-task activity when a group member, tasked with finding a location for an imagined community pool in their neighborhood and navigating Google Maps online in search of a possible stretches of land, mentioned being near the area of Terrance's fights. This drew Terrance excitedly into the task of searching through the Map of their community and, ultimately, in contributing ideas to where to locate the imagined community pool they were tasked to design as their first algebra project of the year. By mid-year, Terrance positioned himself with respect to out-of-school storylines about as often as in relation to mathematics classroom activity. Again, his engagement with project-related tasks and the mathematics content in particular was aided by off-task talk, which occurred in parallel to on-task conversations and which continued to position him as "tough" in ways that allowed him to increase his engagement with the task and construct positive positional identities as a student, without feeling a loss to his valued personal identity, which he continued to evoke. Indeed, he mentioned this in an interview, where he claimed that he hadn't really changed at all over the academic year, he simply changed his behavior. In particular, Terrance claimed that he hadn't "changed at all other than in my actions."

In sum, students engage in a range of discursive activity as they work on mathematics problems together. Much of their talk, both during on-task and off-task activity, functions to negotiate authority. These negotiations are central to core processes involved in learning mathematics, including constructing solutions, reasoning collectively, and developing mathematics learning identities. One implication is that off-task talk might be more important to collaborative activity than currently understood. When viewed from a positioning perspective, off-task talk accesses storylines beyond those related to doing school mathematics that can offer resources that students can leverage to gain access to interactional space and the conversational floor of the collaborative context. Once they have gained access to the conversational floor and interactional space, a student can more likely offer a contribution or recruit new collaborators. Discursively, school mathematics tasks offer relatively narrow possibilities for positioning with intellectual or social authority; indeed, Langer-Osuna, et al (2018) found that students typically engaged in off-task talk when their bids for access or authority through on-task talk failed.

6 Discussion

The goal of this paper is to highlight the ways in which language beyond mathematics-specific discourse functions to regulate several important aspects of learning and doing mathematics together. Specifically, students draw on a range of linguistic practices to position themselves and one another with social and intellectual forms of authority, which seem to regulate who participates and in what ways, opportunities for mathematical reasoning, and as whose ideas are taken up as true.

A reasonable skeptic might challenge the idea that these kinds of exchanges are necessarily mathematical. That is, these sorts of interactions are broadly social processes that take place across all disciplines and therefore may not pertain specifically to the mathematics classroom. This is particularly important in light of calls to increase the focus on the mathematics being constructed in classroom discourse studies. I argue that, while acts of positioning broadly, and the negotiation of authority in particular, certainly occur across all kinds of social contexts, there are ways in which these acts may be particularly germane to the context of school mathematics. One, while authority plays out across many social contexts, it plays a particularly important role in mathematics because of the central importance of truth claims (Wagner & Herbel-Eisenmann, 2014) and thus its negotiation is particularly impactful to the construction and evaluation of mathematical ideas. Two, the mathematics register is well documented as highly specialized and specific, constraining the discursive avenues by which students can become positioned with authority. Off-task talk potentially offers alternate pathways into the collaborative dynamics, which may well be particularly important in mathematics because of the ever-present vulnerability of marginalization. Third, who gets to enact mathematical authority has historically been narrowly defined (Langer-Osuna, 2017) and remains linked to racial and gender stereotypes and storylines about who is good at mathematics (Cvencek, et al, 2015; McGee, 2013; Shah & Leonardo, 2017; Varelas, Martin, & Kane, 2012). Students from historically marginalized social identity groups are thereby particularly vulnerable to having their bids for authority rejected regardless of the content, quality, or truth of their mathematical argument.

A focus on student authority relations additionally has implications for the role of identity processes in learning and doing mathematics. Sociocultural and situative theories of learning fundamentally consider identification processes as part and parcel to learning-in-activity. Indeed sociocultural and situative studies on identity and learning in mathematics, “rarely distinguish between learning and identity but rather talk about participation, engagement, identity, and learning fluidly” (Hand & Gresalfi, 2015, p. 192). Across studies, greater identification with mathematics has been shown to afford greater engagement in learning activities, which can lead to more learning opportunities, which can thereby afford greater identification, and so on (Hand & Gresalfi, 2015). Still, the nature of the relations between identity and learning remains unclear. And the interactional mechanisms by which learning and identity processes affect one another remain particularly opaque.

Sociocultural theories of learning, such as the communities of practice perspective, have long posited, though insufficiently addressed, the role of power in organizing students’ classroom experiences (Esmonde, 2017). These limitations were pointed out by Walkerdine (1997) who, using a post-structural analysis, examined the regulation of individuals within communities of practice, wherein individuals are differentially positioned as relative insiders and outsiders. Mathematics classrooms, as communities of practice, are, in this sense, “discursive formations within which what counts as valid knowledge is produced and within which what constitutes successful participation is also produced” (Lerman, 2000, p 31). These processes can account, in part, for different trajectories of learning and identity for individuals participating in the same community of practice. In mathematics classrooms, “power” can be operationalized usefully as negotiations of social and intellectual forms of authority. As such, its study can help augment sociocultural theories of learning by more centrally considering these relations as they play out in activity.

The influence framework can help to elucidate the discursive mechanisms that the heart of relations between identity and learning as they play out in the mathematics classroom. In particular, the negotiation and distribution of authority seems to mediate both the construction of knowledge (via

Influence) and the construction of identity through the positional functions of the interactional components from which influence emerges. Taken altogether, three main implications emerge that, as a whole, frame relations of authority as especially central to knowing and being in collaborative mathematics classrooms. Those implications are: (1) authority relations mediate the co-construction of knowledge and identity; (2) the negotiation of authority can draw on a range of storylines that serve as interpretative and positional tools; and (3) these negotiations happen through both on-task and off-task talk, which co-occur in collaborative activity.

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