Discourse Patterns in a Small Group "Collaboration": The Case of Uma and Sean

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In this study we present the results of a discourse analysis of the interactions between two partners, Uma and Sean, through a lens of positional theory. During nearly five hours of small group work in a teaching experiment, the way in which each partner used language to position each other's thinking as mathematically significant and establish a collaborative environment varied dramatically. Specifically, Uma shouldered the burden of continuously working to maintain collaboration, oftentimes at the expense of having her thinking positioned as mathematically significant. On the other hand, Sean regularly offered little opportunity for Uma to engage openly with his thinking, while simultaneously positioning his own thinking as mathematically significant. Language enacts and constructs identification with social groups and positions of privilege; thus, we also describe the role of Uma and Sean's identities, particularly gender-roles, in potentially explaining the nature of their interactions.

Keywords: discourse analysis; gender-identities; group work; attitude, affect, and beliefs

Collaborative group work in undergraduate mathematics has become an essential pedagogical feature of active learning (CBMS 2016), was deemed an element of ambitious teaching in college calculus (Sonnert, Sadler, Sadler, & Bressoud, 2014), and has been associated with undergraduate students' positive attitudes (Sonnert et al., 2014) and interest (Williams, 2016) towards learning mathematics. Research examining what students say during class discussions with a lens focused on mathematical ideas and reasoning is essential for understanding collective and individual development. Such research has demonstrated the importance of interacting with peers' thinking for students' own learning (Rasmussen, Apkarian, Tabach, & Dreyfus, n.d.), and aligned mathematical development with the nature of collective mathematical argumentation during class discussions (e.g., Rasmussen, Wawro, & Zandieh, 2015). Additionally, language does much more than establish normative ways of reasoning about mathematics. In fact, discourse allows conversants to enact and construct their identities—consciously and subconsciously (Gee, 2014; Langer-Osuna & Esmonde, 2017). Therefore, discourse occurring within small groups simultaneously offers students opportunities to learn mathematics and enact or construct their identities. The purpose of this study is to re-examine the collaboration between two students—Uma and Sean—attending to how their use of language positioned each other's mathematical thinking as significant and established a collaborative working environment.

Theoretical Framework

This study is guided by positioning theory (Davies & Harré, 1999) which posits "individuals construct subject positions in relationship with others during interactions, in particular through talk, that make claims about who people are within particular social contexts" (Langer-Osuna & Esmonde, 2017, p. 639). Within the positioning theory framework, we draw on Gee's (2014) discourse analysis, which asserts that language is used for seven building tasks. Specifically, this study attends to the language used for the tasks of building significance and communal practices. In the context of small groups working on a mathematical task, discourse analysis together with positioning theory offers a lens to examine how language is used by individuals to position members' mathematical thinking in relation to each other and how—or perhaps whose—language is responsible for maintaining communal practices. Positioning theory also considers the role of broader societal norms and expectations that may manifest in local contexts, discerning "how power and privilege are distributed, enacted, and taken up" (Davies & Harré, 1999, as cited in Langer-Osuna & Esmonde, 2017, p. 639).

Methods

The purpose of this study is to investigate discourse within a small group partnership while problem-solving to explore how collaborations take place. Specifically, we address the following research questions: How do partners working on a mathematical task use language and actions to: (1) position others' thinking as significant, and (2) establish a collaborative environment?

Setting and Participants

Data for this study come from a larger study investigating the relationships between student engagement and emerging mathematical development. The larger study had six preservice teachers participating in a teaching experiment focusing on concepts of logarithms. Participants were recruited from the elementary and secondary mathematics education majors taking mathematics courses during the semester of data collection. Participants attended 5 one-hour sessions, held weekly, which were not affiliated with any course. For this study, we focus on the interactions of one small group: Uma and Sean.

All participants were in their junior year of a secondary mathematics education program. Sean identified as a White man and was a "non-traditional" student with previous military experience. Uma identified as a White woman and was a "traditional" undergraduate student, who had recently changed majors from elementary education. Of the six participants, Uma was the only participant who was not enrolled in a course taught by the teacher-researcher.

Each of the student groups formed a heterogendered pair, and Uma and Sean self-selected to work together. During the study it came to our attention that across all groups, it appeared that the ideas of the men were held in higher regard than the ideas of the women, and that the men had authority to decide which—if any—of the women's ideas were pursued. The rationale for selecting Sean and Uma was twofold. First, the themes identified in the group interactions were the most salient with this pair. Second, the contrasting identities of Uma and Sean speak to the role that student identity plays in group interactions.

Background from Previous Study

Additional aspects of the larger study also informed this secondary analysis and discussion of our results. The larger study included semi-structured post interviews with participants in conjunction with the teaching experiment sessions. Individual interviews with Uma and Sean shed light on their experiences. Specifically, Uma expressed the important role Sean played in her ability to fully engage with the mathematical tasks. Uma explained, "without [Sean], I probably would have just sat there like staring… I would have picked some points and put them on there, but I wouldn't be very confident… I didn't necessarily know what to put on my own papers, I was like before I do anything I wanted to see where [Sean] was going with it." On the other hand, Sean described the nature of their partnership as, "I tend to work alone very well… and I don't think we were necessarily working together, we may have agreed on some things, but I don't think we were truly, you know, working in unison." In the context of this study, we take this aspect of their individual experiences to suggest that Uma and Sean may have had contrasting desires for establishing a collaborative working relationship.

Data Collection & Analysis

The teaching experiment sessions were recorded using a Swivl. This technology allowed for each small group of students and the teacher-researcher to have designated microphones, one main camera to capture the entire room, and one hand-held camera carried by the teacher-researcher. Cloud-based software allows viewers to specify microphones and cameras on playback, allowing us to listen to group conversations, and toggle between two cameras to view participant actions. We transcribed all of the small group interactions involving Uma and Sean.

Data analysis of the video and audio data took place in four stages. First, we identified every meaningful interaction between Uma and Sean, which became our unit of analysis. We define a "meaningful interaction" as an exchange of one or many talk-turns around a common on-task topic, idea, or subject. Interactions may contain one or many brief intervals of silence as long as subsequent talk-turns continue to concern the same subject and no changes to interlocutors occur. We considered instances when the teacher-researcher entered or left the conversation to constitute new interactions. Next, we transcribed every interaction and coded talk-turns using a codebook of verbs. Due to space constraints, our codebook can be viewed as an external document.

Depending on whether we were considering positioning mathematical thinking as significant or establishing collaborative environments, we categorized verbs based on the level of participation or whether the interaction was open or closed. For example, one student *agreeing* with another's mathematical thinking without offering an explanation for their agreement, indicates a low participation in positioning the other's thinking as significant. Moreover, *stating* claims without data or warrant is a closed form of collaborating because it does not offer opportunity for continued interaction. On the other hand, *revoicing* a partner's thinking indicates a higher level of participation in positioning the other's thinking as significant, and offers the opportunity for a continuation of the conversation. We discuss our codes further as we unpack transcripts presented in the results.

Then, for each interaction we created summaries surrounding how each student used language and actions to position other's mathematical thinking as significant and establish a collaborative environment. We analyzed these summaries to identify patterns of language that Uma and Sean tended to employ for each of the two discourse tasks (Gee, 2014).

Results & Discussion

We will discuss how each partner, Uma and Sean, used language to (1) position the other's thinking as significant, and (2) establish a collaborative environment during the study.

Positioning Other's Thinking as Significant

As the group worked through the mathematical tasks in the five sessions, each member made mathematical contributions which moved the group forward. However, how each member positioned the other's thinking as significant differed substantially. Generally, Uma's strategy for elevating Sean's thinking as mathematically significant was to agree with his ideas, ask clarifying questions, and revoice Sean's ideas in her own terms. In contrast, Sean seldom outwardly positioned Uma's thinking as mathematically significant. Instead, if Sean viewed Uma's ideas as significant, he would either immediately begin implementing Uma's idea (without agreement or acknowledgement), promptly make a mathematical statement building off of her idea (again, without explicit agreement), or provide a simple acknowledgement of Uma's speaking.

Interactions 1 and 2 below highlight how each student used these strategies. In Interaction 1, Uma contributes an idea to the group, in the form of a question posed to Sean. Her question is met by Sean asking a clarifying question, so he can immediately begin implementing her idea, punching numbers into his calculator. In Interaction 2 we see an example of how Uma responds to Sean's ideas by agreeing and revoicing his ideas in her own language. Meanwhile, Uma's ideas are met by Sean either solely acknowledging that he was aware of Uma speaking, or with a mathematical statement, neither of which suggest Sean engaged with any of Uma's arguments.

Uma: Would it help to change these...so that they are all in the same [notation]?
Sean: So, write it like, 5 times 10--squared [concurrent with Uma below]
Uma: --to the second. Yeah.
Sean: 1 times 10 to the 3 [head down, saying what he is writing]. 1 point 8 [trailing off, punching numbers into calculator]

Interaction 1: Uma presents a mathematical idea in the form of a question, which Sean then implements

Uma: Um, so, like the concerns for too much paper? Is that what the concerns that we were, like the space?
Sean: Yeah. So, either the two concerns were either the clustering or having to extrapolate that line out so far. And, you know, our model and the student's model are really similar, right?
Uma: Mmmhmmm.
Sean: [looks at cell phone while Uma is talking]
Uma: It's just the different interval, kind of yeah. I mean, it makes it so that you can get an idea of the whole thing on one sheet of paper, so it doesn't feel like too much. [Uma looks at Sean and realizes he is looking at his phone]
Sean: I think, um…
Uma: I think if it were, if it was linear and was on a whole thing, it might look a little bit more overwhelming with how long it would have to be.
Sean: I think it, it's kind of important…the thing that drives you to use our model is that there are so many dates that are recent, right? So, that allows us to spread some things out, and towards the end they are kind of compressed.
Uma: Yeah, it kind of puts them back.

Interaction 2: Uma presents an open mathematical argument, which is met with a (closed) mathematical statement.

As seen above, the interactions between Uma and Sean during the group collaboration have very different tones. Uma presents mathematical arguments as a way of inviting Sean to interact with her reasoning, whereas Sean makes statements about his mathematical thinking, which are closed for further conversation. Uma accepting and revoicing Sean's ideas demonstrates a wish to reach a consensus on another's ideas, reiterating her desire to build a collaborative community.

Building a Collaborative Environment

Analogous to the strategies by Uma and Sean when positioning the other's ideas as significant, each student had vastly different approaches to building a collaborative community. In general, the ways Uma used language to build a collaborative partnership with Sean were open, whereas Sean's language was relatively closed. Each student relied on two primary strategies for building a community. Uma posed direct invitations to Sean for him to explain his reasoning, or phrased her ideas as questions, as an invitation for collaboration. Sean, on the other hand, frequently made statements or simply answered Uma's questions without offering further explanation unless asked. Sean invited Uma to share her mathematical thinking in noticeably few interactions. Yet, when he did, he used the same strategy, but its intention depended on whether he was confident in his thinking or not.

Interaction 2 provides an example of how these two used one of their strategies. Uma initiates this interaction by inviting Sean to engage with her idea of what concerns their solution took into account—which was actually revoicing Sean's ideas from a prior interaction. This invitation is then met by Sean asserting his ideas in closed statements. In Interaction 2, we see an example of how Sean poses questions that outwardly appear to be invitations but are not open for Uma to voice her thoughts. Instead, Sean's statement, "Our model and the student's model are really similar, right?", only allows for Uma to agree or disagree with his idea—with a clear expectation of agreement.

Alternatively, in the moments where Sean was unsure of his mathematical thinking, he posed genuine invitations for Uma to engage with his thinking. In Interaction 3, we see both Sean and Uma working through a task which has them both stumped. Again, Uma begins the conversation by inviting Sean to explain his thinking. Sean then provides a closed statement, which Uma uses as another starting point for an invitation. During their conversation, it becomes clear that Sean is unsure of how to approach the problem. However, Sean's actions change after he voiced his confusion, as he began to pose genuine invitations for Uma to engage with his thinking.

Uma: So, now the question is, when you take in the overlapped time, does this still preserve the same amount?
Sean: As that 10 to 1? That is the question. I don't think that it is.
Uma: Mmmhmm. Do you have any thoughts leaning you more towards why it's not...
[15 seconds of silence]
Sean: If we graphed them longer, we would end up with something like that.
Uma: Mmmhmm.
Sean: We're saying then that is equal with that, or this is 10 times that, but I think this.
Uma: That overlap takes away from it being able to be 10 times that?
Sean: Yeah, I just don't know how to…
Uma: Yeah, how to explain…
[Sean states what he is thinking, Uma agrees]
Sean: You know what I mean? If I keep overlapping more and more, then they become the same time period. So, I don't think any overlapping is…
Uma: It conflicts. I guess, yeah, that is a good way to…
Sean: Does that make sense?

Interaction 3: Uma invites Sean to explain his reasoning, Sean and Uma voice their confusion, Sean invites Uma to engage with his idea.

Discussion & Conclusion

This study outlines discourse patterns emerging within small group partnerships while solving mathematical problems. The themes identified illustrate how interactions within a group can elevate or diminish other's thinking, as well as build or demolish collaborative environments. Furthermore, these results illuminate the role a student's identity plays in these interactions.

Throughout the study, Uma actively sought out a collaborative community, while Sean appeared ambivalent in their collaboration. Uma used language as a tool when attempting to create the collaboration she desired, consistently inviting Sean to share his ideas, posing questions about the tasks, and clarifying his ideas. Meanwhile, Sean voiced that he viewed their collaboration as simply "working in the same space," and thus appears to have paid little attention to the environment his actions produced. Rarely does Sean provide Uma with a genuine invitation to share her thinking about mathematics. Instead, the "invitations" Sean provides Uma are followed by a statement of his thinking, disregarding any argument or question Uma made. The few instances that Sean acknowledges Uma's thinking, he does not probe her thinking any further, whereas Uma repeatedly asks Sean questions about his thinking. Notably, how Uma cultivated collaboration simultaneously positioned Sean's mathematical thinking as significant.

While Uma repeatedly invited Sean to share his thinking, she also constantly agreed with the statements Sean would make. Hand in hand, these actions positioned Sean's thinking as significant. Moreover, Uma would often pose questions to Sean to which she appeared to know the answer, implying that Uma positioned Sean's thinking above hers. Yet, Sean never elevated Uma's thinking in the same way. Rather, if Sean agreed with Uma's argument, he would respond with another statement. It is important to note that some of the questions Sean posed to Uma position his own thinking as significant. As seen in Interaction 2, Sean often posed questions to Uma seeking agreement with his ideas. Additionally, these questions would frequently occur after Uma had a discussion with the teacher-researcher about her own mathematical ideas. Sean would undercut the ideas Uma had voiced to position his own thinking as significant. For example, after the teacher-researcher checked in on the pair's progress in the first session and Uma explained her reasoning for their work, Sean asked Uma, "But we do agree that this block has more time in it than this block, right?"—repositioning his own thinking over the ideas she had voiced.

In these interactions we see inequities for both how students build a collaborative space and how they position another's thinking as significant. While Sean spent little to no effort building a collaborative space, Uma used a myriad of different methods to do so. Impressively, Uma managed to position Sean's thinking as significant even though he provided very few openings for her. Uma created and maintained a collaborative environment by posing direct invitations to Sean and regularly applauding Sean's mathematical contributions—actions which were never reciprocated. We discourage readers from ascribing a lower mathematical ability to Uma based on her actions. Instead, we believe Uma is an inspiration—single handedly building a collaborative environment, while also demonstrating her effort in thinking about the mathematical tasks.

Inequities in a group collaboration could arise from a variety of factors, not least of which are the identities of the students involved. Uma and Sean's identities differed in three notable ways: (1) their age, (2) major, and (3) gender. Uma was a "traditionally" aged undergraduate student and Sean was an older, "non-traditional" student. The differences in their age could have led Uma to view Sean as more of an authority figure than a peer, and thus defaulted to his thinking over her own. Second, Uma had just changed her major from elementary education, while Sean had been in the secondary program since he started. Because of this, Uma and Sean had not interacted previously. Additionally, Uma was the only student in the study who had not taken a course with the teacher-researcher. Each of these factors could have left Uma feeling like an outsider, not having established an identity with the group prior to the study. Finally, Uma identified as a woman and Sean as a man. In addition to the other factors, this difference in gender holds the potential to explain a large part of Uma's interactions, as they align with societal expectations for women and the identities women in mathematics are known to inhabit.

Although the members of the other groups did not share as substantial of differences in backgrounds as Uma and Sean, the impetus for this investigation came from interactions of *all* groups participating in the study. Every group shared one common characteristic: heterogendered pairs. It is well documented that, compared to the men in their major, women in STEM experience a lower sense of belonging (e.g., Good, Rattan, & Dweck, 2012; Holmegaard, Madsen, & Ulriksen, 2014), confidence (e.g., Ellis, Fosdick, & Rasmussen, 2016; Fennema & Sherman, 1978; Steel & Ambady, 2005), and self-efficacy (Dweck, 2008). However, society also dictates that women should be polite, accommodating, and reassuring. These "desirable" characteristics substantially impact the way women engage in discourse in the mathematics classroom. As evidenced by Uma's hesitancy to share her own ideas, these societal expectations suggest that women should not be overly confident, as that can be seen as assertive. Instead, Uma sought reassurance of her ideas by posing them to Sean as questions, inviting him to engage, and more frequently positioning his thinking above her own.

A student's ability to learn in a [mathematics] classroom should not be tied to any aspect of their identity. Our research has demonstrated the inequities that can arise from group collaborations, both in whose ideas are acknowledged as significant and the effort that is placed on building a collaborative environment. Additionally, we have explored the role a student's identity plays in these collaborations, and the expectations placed on the ways students interact.

These findings hold broad implications for the mathematics education community. First, the inequity in Uma and Sean's collaboration, and the remainder of the groups in the study, necessitate the thoughtful inclusion of group work by mathematics teachers. As teachers, we cannot blindly assume that group work will increase student learning, when the cognitive lifting required of some students in these spaces may inhibit their ability to learn. While Rowe's (1988) study saw a dramatic increase in student confidence with same-sex pairs, we do not believe there is a quick "fix" to this issue. Students' identities are multifaceted and each component impacts the way they walk through the world and through a mathematics classroom.

This lack of understanding of how to build equitable group collaborations in an undergraduate mathematics classroom demands attention from the mathematics education community. The findings of this study came from a larger study which was not designed to investigate discourse patterns in group collaborations. Yet, our insight into how language was used in these collaborative spaces is poignant. Research on building group norms for collaborations that value *all* mathematical contributions as significant and create spaces for *every* student to share their thinking is of utmost importance to the field. Moreover, equitable group collaborations at the undergraduate level have yet to be explored and are of critical importance to increasing diversity and inclusivity in mathematics.

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