POWER AND RELATIONAL EQUITY IN GROUP WORK: A CASE STUDY FROM A MIDDLE SCHOOL MATH CLASSROOM

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The aim of this descriptive case study is to identify and illustrate social processes, such as power dynamics based on the exchange and distribution of information, that affect student participation within groups. Collaborative group work continues to be extremely challenging for students (Barron, 2003; Borge & White, 2016; González & DeJarnette, 2015; Hofmann & Mercer, 2016). One source of challenge is the uncertainty that arises from trying to solve a new problem while simultaneously coordinating with others in the group. By analyzing interactional patterns during moments of uncertainty, I illustrate that power is related to who participates in group work and the ways in which students participate. Asymmetrical power dynamics can shape the interactional landscape in ways that limit opportunities for some students to participate. Balanced power dynamics, on the other hand, may promote relationally equitable participation. In addition, I show that students' perceived mathematical ability in problem-solving did not help to explain their level or form of participation in group work. The findings highlight the importance of the interactional context in collaborative group work. In the discussion, I present the implications for teacher support of group work interactions.

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PREFACE

I began the dissertation process with a broad question: what happens in social interactions? It was not a novel question nor did it address a gap in the literature. It was a question of self-reflection. The question stemmed from my desire to make sense of the social interactions I had seen and experienced in my personal life. After analyzing classroom interactions using the tools and frameworks I had learned during my graduate school career, I wanted to know what conclusions I would arrive at if I analyzed interactions from the ground up. What would I see? What would I delve into? What would puzzle me? This dissertation represented a journey into my own mind. I felt compelled to articulate the emerging ideas and unresolved questions floating in my head. In many ways, this dissertation was a way to start describing the way I see the world.

I would be remiss to not thank everyone who influenced and encouraged me in my journey of self-reflection. I am thankful for all the people who have shared with me their thoughts, especially those who have challenged me or were straight with me. I want to thank my parents, who have made sacrifices to provide a better life for their children. I also want to thank my sister, Victoria, whose developing perspectives amaze and move me. I am thankful for my partner-in-life, Matthew, who has been by my side through difficult times and who always helps me see the other side of things. I wish to thank my friends and colleagues, especially Jasmine Williams and Calli Shekell, who have helped me think through difficult concepts. I also want to

acknowledge Quentin King-Shepard, whose feedback during one of my presentations, particularly his phrase “hub of information,” inspired me to reanalyze classroom interactions in terms of power.

Finally, I would like to express my deep gratitude to my dissertation committee. This dissertation would not have been possible without the support, encouragement, and mentorship of my advisor, Dr. Tanner LeBaron Wallace, as well as the expertise, feedback, and time of Dr. Charles Munter, Dr. Timothy Nokes-Malach, and Dr. Ellice Forman. I have learned so much from listening to their perspectives.

I owe my growth as a thinker to all the people in my life. Since I am my mind, I would not *be* without them. Thank you.

1.0 INTRODUCTION

Collaboration or teamwork has become a highly valued skill in today's society. Despite attempts to foster collaborative spaces in classrooms, from physically removing barriers to cultivating a positive climate, supporting productive collaborative work remains a huge challenge. This is, in part, due to our limited knowledge of how collaboration happens. Though prior research has identified important social features of group activity systems, such as managing joint attention and negotiating perspectives (Barron, 2000; Borge & White, 2016; Nokes-Malach, Richey, & Gadgil, 2015), we do not yet know how certain groups are better at joint attention or negotiating perspectives than other groups. In other words, the underlying social processes that shape collaborative group work are still unknown.

One underlying social process may be students' use of power to influence the course of group work and group work interactions. If students in a group share power, joint attention and negotiation of perspectives among students may be more likely. Conversely, if power is concentrated within only one or two students, other group members may feel excluded from problem-solving. For example, during group problem-solving, a student may express uncertainty about whether a solution makes sense. In one scenario, the other group members may try to convince the student with explanations and justifications, attending to differing perspectives. In another scenario, the other group members may pressure the uncertain student to adopt a particular solution. In the latter situation, the uncertain student may feel dismissed or

marginalized and withdraw from participating. Thus, the ways in which students exert power in critical moments may have implications for students' group work participation over time.

To provide a more concrete illustrative example of what I mean by underlying social processes, I will make an imperfect but useful analogy to Einstein's concept of General Relativity. Let me first say, I do not fully comprehend complex physics theories. However, I find the differences between Newtonian and General Relativity's conceptualizations of gravity helpful for describing the differences between social features of activity systems that have been examined in detail within the education field and underlying social processes which I hope to highlight here. Let me also say that Einstein's theory is not necessarily more accurate than Newton's theory. Each conceptualization of gravity can be used to examine different aspects of the same phenomena. In much the same way, examining activity systems and exploring underlying social processes are two different ways to understand social phenomena.

We often perceive gravity as a "pull" between objects – almost like invisible threads that connect distinct things together. One way to conceptualize gravity is to examine the relation of one object to another, for example the orbit of the Moon around Earth. In this Newtonian view, the Moon and Earth are interrelated parts in a system, situated in the larger solar system. Similarly, we can picture social interactions as the many dynamic, invisible threads between individuals participating in a situated activity system (Greeno, 2011; Greeno & Van De Sande, 2007). To understand social interactions, then, we can examine the actions or talk of one participant in relation to another participant and over time. In investigating what occurs between the two objects, two participants, or two things, we can make inferences about relationships and predictions about future actions. But, how is it occurring? What is the source behind the

gravitational “pull” between the Earth and the Moon? Likewise, what is the source behind the invisible connections in social interactions?

Einstein’s theory generated one possible answer for the motions of planets and moons in the solar system that may also apply to social interactions. What we perceive as force, or a “pull” between objects, is the result of the curvature of spacetime. As Professor Brian Greene explained on the Late Show with Stephen Colbert, imagine that the spacetime plane is a sheet stretched flat and suspended in air. A round, heavy object representing the Sun, if placed on that sheet, will create a curve – a warp in spacetime – which is what creates the orbit of the planets around the Sun. In other words, the objects appear to be exerting forces on each other *not* because they are invisibly connected to each other but because they are creating an *effect* on a *shared plane* within which objects are situated. In much the same way, what we perceive as social interactions may be indications of changes in the interactional plane. Participants in social interactions may not be connected to each other by invisible threads formed, maintained, or broken through actions or talk. Rather they may influence others or be influenced by others simply by occupying “space” on a shared interactional plane. For example, just as the orbit of the Earth around the Sun may be due to the curvature that the Sun creates in spacetime, one participant’s actions may align with another participants’ actions if the interactional plane is tilted in favor of the latter.

Social relationships or patterns of interactions can then be understood as the consequence of shifts and changes in the interactional plane. The dynamics of the interactional plane is what I call underlying social processes. Such social processes on the interactional plane may be the means by which particular interactional patterns are formed. Of course, the interactional plane can be warped in many and irregular ways that can create patterns of interactions within patterns of interactions, form counterintuitive relationships, or even isolate participants from others.

There may also be multiple interactional planes: parallel, complementary, or clashing interactional planes. This study does not attempt to unpack the idea of interactional planes in any philosophical way. I use it as a guiding analogy to understand what is happening in group work. Specifically, viewing participants in group work as occupying and sharing an interactional plane helps me more deeply examine social interactions within the group.

By viewing social interactions as occurring on a shared plane, I can incorporate into my analysis the concept of power – fundamental in any social interaction in any context (Berger, 2008). Power is difficult to describe and explain in social interactions. The terms used to illustrate power are often fuzzy; Researchers and educators often say participants can "give power" or "take power away." In the literature, "feeling empowered" is also a common phrase. It is unclear, however, what those terms and phrases mean in interactions. They become clearer if one views social interactions as occurring on an interactional plane. In the theory of General Relativity, the mass of an object helps to explain the degree to which spacetime is warped. In social interactions, power may be one way to think about how much of an effect a participant has in the interactional plane. So, "giving" power can be conceptualized as exerting power in the interactional plane in a way that tilts the plane in a favorable way for other participants to change the course of interactional patterns. Though, to be clear, I define power not as an inherent characteristic of the participant but a capability that emerges through social interactions (Ford, 1993) which can, in turn, shape interactional patterns.

In terms of group work, exerting power can create a positive or negative effect on an interactional plane. Individuals who are perceived to have greater or valuable information – which can change depending on the situation – may be able to exert more power. More intense effects of power can create larger warps or curves in the interactional plane. If the interactional

plane is consistently unbalanced, interactional patterns may revolve around one dominant participant, making it harder for other participants to change the course of interactions or to feel they are equal contributing members of the group. On the other hand, a balance of power can create an equilibrium where each participant has equal opportunity to change what happens in the interactional plane. It is important to note that power can be exerted in many ways – through action, talk, and even silence.

In this descriptive case study, I analyze groups of middle school students from a mathematics classroom to illustrate examples of how students interact in group work and how power may play a role in interactions. In terms of power, I focus on *who* exerts power and *how* power is manifested in groups. Specifically, I analyze how information is shared in student groups. Asymmetrical distributions of information may indicate power differentials that can shape what group interactions look like and how the group behaves. Through analysis of video, I describe group work social interactions specifically during moments of uncertainty. Moments of uncertainty may be critical events to analyze in order to gain a sense of how power dynamics emerge. To describe social interactions in moments of uncertainty, I use concepts of intersubjectivity, social metacognition, psychological safety, and belonging to understand social interactions. I also use relational equity as a lens to determine whether all group members have opportunities to collaborate in group work.

This dissertation is divided into five chapters. In the second chapter, I review some challenges of group work presented in the current literature and key concepts that are relevant to the analysis of group work social interactions. In the third chapter, I delineate my methods and analyses as well as provide an ethnographic background of the case classroom. Then, in the fourth chapter, I describe my findings focusing on specific groups and themes related to power.

Finally, in the last chapter, I highlight key findings, relate my findings to concepts of relational equity and status that have been discussed in mathematics education, and provide implications for teacher support of student group work relationships.

2.0 REVIEW OF THE LITERATURE

Collaborative group work has become a common instructional tool to promote student participation and learning in math classrooms (Barron, 2000; Cohen & Lotan, 2014; González & DeJarnette, 2015; Hofmann & Mercer, 2016; Horn, 2012; Palinscar & Brown, 1984; Webb et al., 2009). Here, I define collaborative group work as "the synchronous activity that occurs as individuals engage in collective thought processes to synthesize and negotiate collective information in order to create shared meaning, make joint decisions, and create new knowledge" (Borge & White, 2016, p. 324). In secondary classrooms, one important goal of collaboration is active participation of all group members. Group work may be beneficial if all group members have equal opportunities to engage in problem-solving (Boaler, 2006).

Another important goal of collaboration is to challenge students by introducing uncertainty. In mathematics education, uncertainty is a key feature of mathematical struggle that affords students the opportunity to learn mathematics concepts (Anthony & Walshaw, 2009; Hiebert & Grouws, 2007). Mathematical struggle invites reasonable confusion, doubt, or challenge and can be defined as the effort expended to grapple with and make sense of a mathematical problem or task (Hiebert & Grouws, 2007). Research shows that when students encounter a "hitch" during problem solving activities, they may reevaluate what they know and fill in gaps in their knowledge (Granberg, 2016), and experimental studies show that students who attempted to solve mathematics problems without being taught a procedure first performed

better than students who were given solution paths (Jonsson, Norqvist, Liljekvist, & Lithner, 2014; Kapur, 2008). Thus, uncertainty is an opportunity for student learning, but there are cognitive and social challenges involved.

2.1 CHALLENGES OF COLLABORATION

Group work continues to be extremely challenging for students (Barron, 2003; Borge & White, 2016; González & DeJarnette, 2015; Hofmann & Mercer, 2016). Students find difficulty in trying to solve a novel problem while simultaneously coordinating with others in the group. As Kieran states:

> …bridging the individual and the social in mathematical problem solving can be extremely difficult to put into practice, especially when it involves novel problem situations. Making one's emerging thinking available to one's partner is such a way that the interaction be highly mathematically productive for both may be more of a challenge to learners than is suggested by the current mathematics education research literature (Kieran, 2001, p. 220)

The quote alludes to the ambiguity and complexity of coordinating cognitive and social processes in collaborative activity. In that coordination, students may have difficulty formulating their own thinking, communicating their ideas, understanding others' ideas, or regulating work within the group (Borge & White, 2016; Nokes-Malach, Richey, & Gadgil, 2015). Moreover, student uncertainty in group work can potentially create social issues between students. Anecdotally, a student may feel apprehensive about revealing their emerging ideas and other

group members may interpret a lack of communication as demonstrating unwillingness to participate.

According to mathematics education literature, unclear social norms and social status differences may contribute to group work challenges (Barron, 2003; Cohen & Lotan, 2014; González & DeJarnette, 2015; Horn, 2012). Students may not know how to share their thoughts constructively or how to respectfully respond to others' ideas. They may have different conceptions of what it means to listen or help others (Cohen & Lotan, 2014; Horn, 2012). In addition, students who are perceived to have high ability may dominate group conversations. Social status differences can be especially problematic for students who are not perceived as "smart" as they may be excluded from mathematical discourse (Hand, Kirtley, & Matassa, 2015; Horn, 2012).

Yet another challenge may be establishing and maintaining social relationships. Students often work within the same group for more than a single session or task. Working in groups, then, not only entails problem-solving together but figuring out how to build relationships that will sustain group work. More effective and constructive group work can evolve from building relationships (Boaler, 2008). In addition, positive group relationships can boost cognitive processes, which can then, in turn, foster better relationships (Good, Mulryan, & McCaslin, 1992; Tolmie et al., 2010). However, adolescent students are still developing their social and emotional competencies (Collins & Steinberg, 2006) and may need supports and guidance to learn how to interact with others in mutually beneficial ways.

Consequently, collaboration involves navigating and managing social interactions. Groups may fail or succeed depending on how well they interact with each other. In the next

section, I present key concepts related to social interactions that are associated with successful group problem-solving.

2.2 SOCIAL AND INTERACTIONAL FEATURES OF GROUP WORK

Group work is an inherently social context. The way group members interact with each other may indicate what they see as doing group work or what it means to collaborate. Even a lack of interactions between group members indicates something about the interpersonal context within a group. For this study, I focus on four social and interactional features of group work that are relevant for understanding social relationships among group members: intersubjectivity, social metacognition, psychological safety, and belonging. These four features are major concepts that have been used to understand group work in the fields of cognitive psychology, educational psychology, and mathematics education. As I have suggested, the concepts also help to identify interactions that promote social connections or relationships. I conceptualize intersubjectivity and social metacognition as features that indicate prosocial and shared group interactions whereas psychological safety and belonging help describe the "climate" of social relationships.

2.2.1 Intersubjectivity

Collaborative interactions involve intersubjectivity, or having a shared meaning and mutual knowledge of having a shared meaning, rather than the transmission of information from one person to another (Esmonde, 2009a; Mortimer & Wertsch, 2003). Though it is difficult to know whether two or more people truly have shared understanding, students move towards

intersubjectivity by acknowledging each other's ideas, checking to see if they understand what others are saying, and attempting to repair the conversation when they are misunderstood. Intersubjectivity in group work is not only necessary for agreement but also to disagree on a presented idea (Nathan, Eilam, & Kim, 2007). *Joint attention*, or focusing on an action or thought together, is central to intersubjectivity (Barron, 2000). Establishing and maintaining joint attention can help to build a knowledge base for group members (Hmelo-Silver & Barrows, 2008). Importantly, joint attention also relates to social processes and is itself a prosocial behavior that demonstrates interest in other's thoughts and actions or desire to construct a shared experience (Tomasello & Carpenter, 2007).

2.2.2 Social Metacognition

Intersubjectivity overlaps with social metacognition, particularly related to joint attention. Social metacognition involves planning, monitoring, and reflecting on other's work or the activity of the group as a whole (Borge & White, 2016). In collaboration, joint attention is integral to each part of the social metacognitive process. The joint regulation of activity among students has been shown to be important for group problem-solving (Goos, Galbraith, & Renshaw, 2002). Unsuccessful groups show a lack of critical thinking around others' contributions. On the other hand, successful groups discuss, question, or test out ideas from group members. In high-level collaborative processes, social metacognition involves generating a shared understanding of justifications and explanations rather than merely the exchange of information without integration of different perspectives (Volet, Summers, & Thurman, 2009). As such, *reciprocity* – where there is evidence of corroboration, transformation, or even disagreement of other's ideas – may be foundational for social regulation (Iiskala, Vauras, Lehtinen, & Salonen, 2011).

2.2.3 Psychological Safety

Intersubjectivity and social metacognition play a role in psychological safety. Psychological safety is the shared understanding among students that the group is safe to take risks (Edmondson, 1999). Lack of intersubjectivity around what it means to interact in the group or poor regulation of group work processes can make it difficult to create a psychologically safe space. However, the presence of intersubjectivity and social metacognition in a group does not imply that all group members will feel they are able to propose new ideas, new ways of interacting, or take other risks. In some groups, there may be a "top-down" approach where more knowledgeable or confident students drive group work. Less knowledgeable students may not feel psychologically safe enough to speak up or contribute. Though psychological safety is not necessary for a group to be able to complete tasks or engage in deeper cognitive thinking (Curşeu, Schruijer, & Boroş, 2012), psychological safety, built on interpersonal trust and mutual respect, helps to sustain positive group work interactions (Edmondson, 1999, 2004). Low psychological safety can strain group work interactions over time.

2.2.4 Belonging

Lastly, feelings of belongingness may also help to maintain social relationships over time. Belonging, or relatedness, is a sense of connection and feeling respected or valued in a community (Goodenow, 1993; Juvonen, 2006; Ryan & Deci, 2000). By definition, belonging focuses on social bonds rather than mere social contact (Baumeister & Leary, 1995). Social contact refers to moments of interpersonal interactions (e.g., saying hello or engaging in conversation) whereas social bond refers to social contact that is accompanied by some level of

constancy, concern for well-being, and a sense of continuation in the future (Baumeister & Leary, 1995). Feeling belongingness, particularly in collaborative contexts, can promote motivation (Juvonen, 2006) and mathematical discourse (Boaler, 2008). Disengagement from group work may occur if students feel alienated or isolated (Juvonen, Espinoza, & Knifsend, 2012). Belonging results from multiple interactions over time. A finer-grained way to look at belonging is the degree to which students are included or excluded in group work. Although inclusion and exclusion do not encompass the whole concept of belonging, they indicate students' social orientations towards one another. Such orientations may influence students' future interpersonal behaviors (Juvonen, 2006). Consequently, who is included and who is excluded has implications for belonging and what may happen interpersonally in group work.

2.3 RELATIONALLY EQUITABLE PARTICIPATION

The concepts described in the prior section mainly help to characterize particular kinds of interactions between or among students. Relational equity is a relevant framing concept for understanding group work interactions as a whole. Boaler (2008) describes relational equity in terms of democratic ideologies of having an equal standing and focuses on the ways students treat each other rather than attending to achievement or learning. There are three components to relational equity: (a) respect for other's ideas, (b) commitment to the learning of others, and (c) ways of communicating that support or help others.

Using a relational equity lens allows me to examine how the interactions in a group are shaping each group member's "standing" that, in turn, affords or constrains individual group member's opportunities to participate. By participation, I mean collaborative actions where

students share their ideas, propose new strategies, ask for other's justifications or explanations, offer opinions, or disagree with other's thoughts. Thus, adapting Boaler's definition, relationally equitable participation entails having equal opportunities to engage in collaboration. This is different from other forms of participation, for example legitimate peripheral participation. In legitimate peripheral participation, more novice members become part of a community by observing and learning from more expert members (Lave & Wanger, 1991). Therefore, less mathematically knowledgeable group members may be peripheral to but a legitimate part of the activity of group work. On the other hand, relationally equitable participation emphasizes respecting and incorporating students' diverse funds of knowledge or different ways of interacting in doing mathematical work (Boaler, 2008).

2.4 INFORMATION AND POWER

Participation in group work involves negotiation of power (Berry, 2006). There are many definitions of power; I define power here as the ability to influence the interactional plane, or "terms" of activity and direction of group work. Following Foucault, I view power as an inherent aspect of social interactions and discourse (in Ford, 2003). Thus, power does not come from authority or prescribed roles but emerges from interpersonal interactions. In addition, power exists on a balance scale and flows between or among students (Cornelius & Herrenkohl, 2004). Power, then, is not a thing that one student possesses more of and another holds less. To use Berry's (2006) argument, the question is not whether students have more or less power but rather who exerts power and by what means.

The concept of power has been discussed and explored previously in mathematics education (Hand, 2012; Martin, 2009; Nasir, Hand, & Taylor, 2008; Oppland-Cordell & Martin, 2015). Generally, studies conceptualize power in relation to the larger discourse around racial, cultural, or linguistic inequities. For example, Hand (2012) frames power in relation to broader cultural hierarchies and dominant discourse that exist in society. Without attending to culture and power, teachers may reproduce and perpetuate dominant discourses within their classrooms. Hand (2012) suggests ways teachers can support dialogic space, blur distinctions between mathematical and cultural activity, and reframe the system of mathematics education to promote equity in the classroom. In another study, Oppland-Cordell and Martin (2012) discuss power as it relates to race and language. The authors examined how Latin@ students navigated social spaces and their expressions of identity in a White, English-speaking classroom. They suggest instructors can support Latin@ students by empowering the students in their identity development.

In this study, I explore moment-to-moment flows of power that emerge within group work apart from the larger, societal discourse. Though power relationships in terms of race, culture, and language are undeniably and inextricably linked to interactions within classrooms, I highlight here a different form of power and the subtle ways in which students "take" or "give" power in group conversations. One of the means by which students exert power or empower others is through using information. Information is a form of power and, in mathematics classrooms, some types of information may be privileged over others (Nasir et al., 2008). Information may also be used to give others ownership of an idea, to create partisanship or promote solidarity, and to persuade others (Cornelius & Herrenkohl, 2004).

Here, I extend the relation between information and power described in previous studies and focus specifically on group work interactions. First, as stated above, certain kinds of information may be privileged over others. Second, information coming from particular students, such as students with perceived high ability, may be privileged over information contributed by other students. Third, information can be selectively exchanged or equally distributed. Fourth, information can be withheld from others. Fifth, information may be attributed or credited to others or the group. Sixth, information can be used to create alliances or show support. Seventh, information can be used as a means to convince others or give directives. The ways in which information is shared or exchanged helps to reveal power dynamics within groups and has implications for students' participation in collaborative group work.

3.0 RESEARCH AIMS AND QUESTIONS

The aim of this descriptive case study is to identify and illustrate social processes, such as power dynamics based on the exchange and distribution of information, that affect interactional contexts and student participation within groups. I examine social interactions during moments of uncertainty as they represent key moments that can reveal how students do or do not attempt to coordinate activity with each other. For example, in moments of uncertainty, students may disregard each other or they may try to create a shared understanding. Such student actions may be related to expressions of power. The broad research question for this study is: **How do students socially interact with each other during moments of uncertainty in group work?** The second, emergent research question is: **How does power play a role in student group work interactions?**

4.0 METHODS AND ANALYSES

This case study describes and analyzes the social activity of group work in one 6th grade mathematics classroom. I define group work as two or more students engaging in collaborative work or "synchronous activity that occurs as individuals engage in collective thought processes to synthesize and negotiate collective information in order to create shared meaning, make joint decisions, and create new knowledge" (Borge & White, 2016, p. 324). Specifically, the analysis involved describing student-to-student interactional events generated from video recordings of naturally occurring classroom practices. I use interaction analysis outlined by Jordan and Henderson (1995), primarily focusing on student talk and nonverbal actions (e.g., pointing, writing, and gesturing) that accompany talk. Through interaction analysis, I examine student-to-student interactions situated within social ecologies and, thereby, describe emerging social coordination problems within group work as well as *local meanings* of what students see as doing group work (Erickson, 2011; Jordan & Henderson, 1995).

4.1 CASE STUDY JUSTIFICATION

A case study design involves generating in-depth descriptions of a phenomenon in a real-life context (Creswell & Poth, 2017; Yin, 1994). The phenomena of interest in this study are student-to-student interactions that occur during moments of uncertainty in group work. Here, the

purpose of the case study is to describe how students socially interact and how power shapes interactional patterns, particularly in moments of uncertainty. Thus, the case (student-to-student interactions) is my unit of analysis bounded in multiple layers of context (Miles, Huberman, & Saldaña, 2014).

For this study, I purposefully selected group work in Ms. Ellis's 6th grade classroom for four main reasons. First, Ms. Ellis's teaching resembled reform-oriented mathematics instruction where she encouraged students to propose and discuss strategies with each other to solve open-ended tasks. Importantly, she did not provide mathematical procedures for students to memorize and practice. Thus, the nature of work in this classroom required students to share and negotiate information and ideas, generating rich interactional events to analyze and creating opportunities for students to encounter uncertainties. Second, in my initial observations of the classroom, I sensed that Ms. Ellis's students interacted with each other in mutually beneficial ways (e.g., talking about ideas and listening to others) that seemed to facilitate group work. Though students at times expressed frustration towards other students, overall, students appeared to show investment in working together to complete tasks, providing instances of potentially collaborative interactions to examine and describe. Third, Ms. Ellis grouped her students as heterogeneously as possible in terms of ability and did not provide a script or specific roles for students, creating conditions for group work to emerge relatively organically. This was important for my analysis as it allowed for variability within groups as well as variability between groups in how students interacted with each other.

Finally, I believe many teachers may identify with Ms. Ellis. Initially, Ms. Ellis struggled with teaching more conceptual math. In an interview, she stated, "I've always been strong with math but I came from not conceptual. I came from where everyone comes from…You know,

skill and drill, memorize…And I tried to transition into that [conceptual teaching] my first year here and I think I struggled with it. I was a little resistant to it." Since then, Ms. Ellis has learned to "love it" but also recognizes that she is still learning, especially from her students, each year: "I mean it's interesting…I've taught it three years in 6th grade and every year at, you know, every lesson, I find a new way to do it because…what the students bring to me." Ms. Ellis's classroom embraces practices that are thought to enhance students' learning but is still a work-in-progress. Describing group work that occurs in this classroom may be instrumental in providing rich examples of group work interactions and understanding group work interactions in other, similar classrooms.

4.2 DATA SOURCES

During the 2012-2013 academic year, I observed and video recorded 10 lessons of the same classroom taught by Ms. Ellis. The timeline of data collection can be seen in Figure 1. The data collection effort was part of a larger project conducted by the Youth Development Lab team at the University of Pittsburgh to investigate and identify teacher supports associated with high quality relational climates. Six middle-grade teachers from the one urban school system in the Pittsburgh area were selected based on recommendations from the assistant superintendent. Prior to video data collection, in-class observations completed by the primary investigator validated the nominated classrooms had high quality relational climates. The teachers and students from selected classrooms were consented prior to video-recording. The research team video-recorded non-consecutive, full lessons for each teacher. In addition to video recordings, the team conducted interviews with teachers (in July and May) as well as student focus groups (in April).

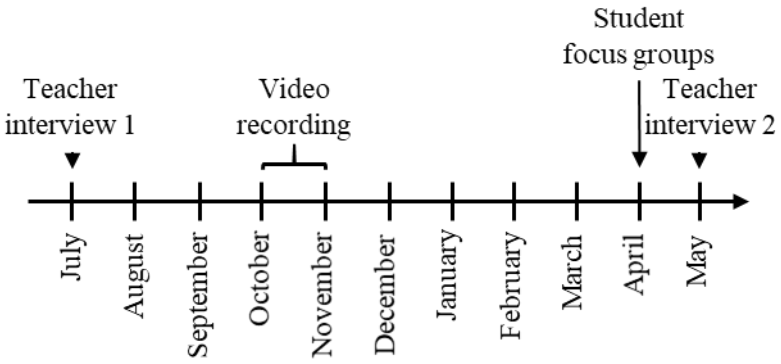


Figure 1. Timeline of data collection efforts during the 2012-2013 academic year

The research team used the data for three research papers. The first paper involved examining teacher autonomy-supportive classroom management strategies. The second paper examined teacher behaviors and students' understanding around provision of choice in classrooms. The third paper explored students' interpretations of teacher autonomy support and whether their interpretations aligned with motivational theory. Prior analysis was not used or incorporated in this study.

4.2.1 Classroom videos

From October 2012 to November 2012, I video recorded one of Ms. Ellis's class periods for 10 non-consecutive days. Video recording days depended on my availability and whether there were school events (e.g., school assembly, practice fire alarm) that changed the scheduling that day. The video recordings captured lessons from the beginning of the class period to the end when students were dismissed. Two stationary cameras captured the lesson and classroom interactions. One camera faced the front of the room where the Smart Board was located. The other camera

had a wide-angle lens and encompassed all group tables within its shot from the corner of the room. A boom microphone and sound mixer helped to get cleaner audio of the entire classroom. Ms. Ellis also had a portable microphone on her person, and the audio of the portable mic fed into the non-wide-angle camera. The video and audio recordings were minimally edited and stored in their original file format.

After each video recording, I created a content log briefly noting details of what had occurred that lesson. Content logs are rough summaries that are not analytical in nature and provide a quick overview of what occurred within and across the videos (Jordan & Henderson, 1995). Sometimes, after the students were dismissed, I had the chance to converse with Ms. Ellis and ask her questions about things I noticed or wanted to know more about. I documented the content of those conversations in the content logs as well. As a note, heretofore, when I write that Ms. Ellis said something in conversation, I am obtaining the information from the content logs.

In all but one of the videos, Ms. Ellis's students (n = 24) worked in groups to solve mathematical tasks. One video-recorded day showed her students working in pairs to complete a quiz. During a quiz, the expectation for student interactions are likely to be different than in regular classroom lessons. Thus, for analysis, the partner quiz day was removed. In addition, the first two video-recorded lessons contained audio recording errors that made it highly difficult to hear student-to-student talk. I removed those two videos from the sample as well. As a result, 7 out of 10 video-recorded lessons were qualitatively analyzed.

4.2.2 Teacher Interviews

Ms. Ellis completed two interviews: an interview before video-recording began and an interview towards the end of the school year. The first teacher interview was an introductory interview that

asked questions such as how the teacher came into the profession, what qualities make a teacher effective, how teachers can maximize student growth, etc. The second interview asked more targeted questions related to teaching practices such as how the teacher provides choice in the classroom, promotes student understanding and interest, and encourages independent thinking – all components of autonomy support. In addition, the teacher was asked to reflect on video clips of autonomy-supportive interactions in her own classroom. Importantly, the researcher conducting the interview did *not* name autonomy support as a main construct or direct questions in a way that limited the teacher's responses to only ideas around student autonomy.

I used transcribed interviews in this study to support my descriptions of the classroom context. Though the interviews were not focused on supporting group work interactions in the classroom, Ms. Ellis's responses provided a window into how she structured her classroom, what she believed students should learn, how she believed students should participate, what she attended to, and what she found challenging. The interviews helped support my characterization and interpretation of the classroom context of group work that may have affected how students engaged in groups.

4.2.3 Student Focus Groups

Selected students from Ms. Ellis's classroom participated in two student focus groups (n = 5-6 for each group) towards the end of the school year. In each of the focus groups, students commented and elaborated on 6 video clips of autonomy-supportive interactions that occurred in their classroom. Again, the researcher conducting the focus group did not prompt students to think about autonomy support specifically and asked students open-ended questions similar to "What is happening in the video?" and subsequent questions based on students' responses, like

"Why do you think the teacher did that?" Though parts of the student focus group data have been analyzed previously, none of the prior codes or coding schemes were used in this study. Like the teacher interview data, the student focus group transcripts provided support for my descriptions of the classroom context. More importantly, the focus group transcripts revealed students' perspectives on the context of group work and social interactions in the classroom.

4.3 ETHNOGRAPHIC BACKGROUND

4.3.1 Math Classroom Context

As mentioned previously, the classroom setting for this study was a 6th grade math classroom in an urban, public school located in the Pittsburgh area. At the time of the study, Ms. Ellis had a Master's in Education and 8 years of teaching experience in middle school math. In her classroom, around 58% of her students were female, 54% were students of color, 69% qualified for a free or reduced lunch program (a proxy for socioeconomic status), and 15% were identified as special needs. Her classroom was a full inclusion classroom, meaning that students with learning disabilities or special needs were part of the regular class full time and did not receive separate instruction outside of the classroom. An instructional assistant or teacher aide was present in the classroom to provide additional assistance to students, particularly students with special needs.

The classroom that I video recorded was the last period of the school day, and the lessons were approximately 60 minutes long. The lessons were structured on a cycle consisting of three main phases based on the Connected Mathematics Project (CMP) curriculum (Lappan, Fey,

Fitzgerald, Friel, & Phillips, 2009; Stein, Engle, Smith, & Hughes, 2008): *launch* (i.e., introduction to the task), *explore* (i.e., problem-solving in small groups), and *summarize* (i.e., strategy-sharing and discussion with the whole class). Figure 2 shows the three phases of the lesson.

Ms. Ellis introduced tasks by projecting the task in the student workbook to the Smart Board and reading the scenario and directions. After reading the directions, she often rephrased the task to facilitate student understanding of the context and posed questions for students to think about. This was also a time for students to ask clarifying questions. Ms. Ellis generally gave very few ideas or suggestions beyond what the task provided. During the explore phase, Ms. Ellis expected students to discuss strategies in their table groups to solve tasks. As students solved tasks, Ms. Ellis walked around from group-to-group, answering questions, reminding students of what they had learned, and suggesting new strategies. In most lessons, group work took the bulk of class time (an average of about 49% of class time across videos; see Figure 3). After students had the opportunity to work on a task in groups, in the summarize phase, students either volunteered or Ms. Ellis selected students to write and explain their strategies on the Smart Board. Following student presentations, students in the audience asked questions to the student presenters about the strategies employed or suggested different strategies. During strategy-sharing, the students and the teacher often talked about multiple ways the task problems could be solved.

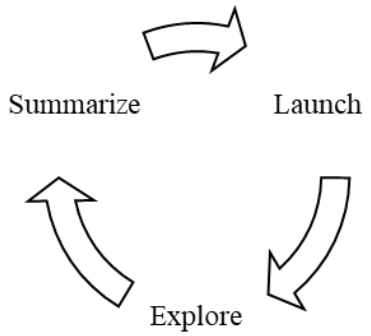


Figure 2. CMP cycle of lesson phases

Figure 3 below shows that group work was a regular feature of Ms. Ellis's classroom (see the green bars). In some lessons, the task was split into different group work sessions. If towards the end of class students needed more time to finish group work, Ms. Ellis gave students time the following day to work together. Students rarely did individual work or had time to think quietly by themselves. Out of the seven lessons, Ms. Ellis provided "private think time" once (in Video 2, Figure 3). Private think time allowed students to bring possible solutions to the table, but for most tasks students were expected to come to a solution together.

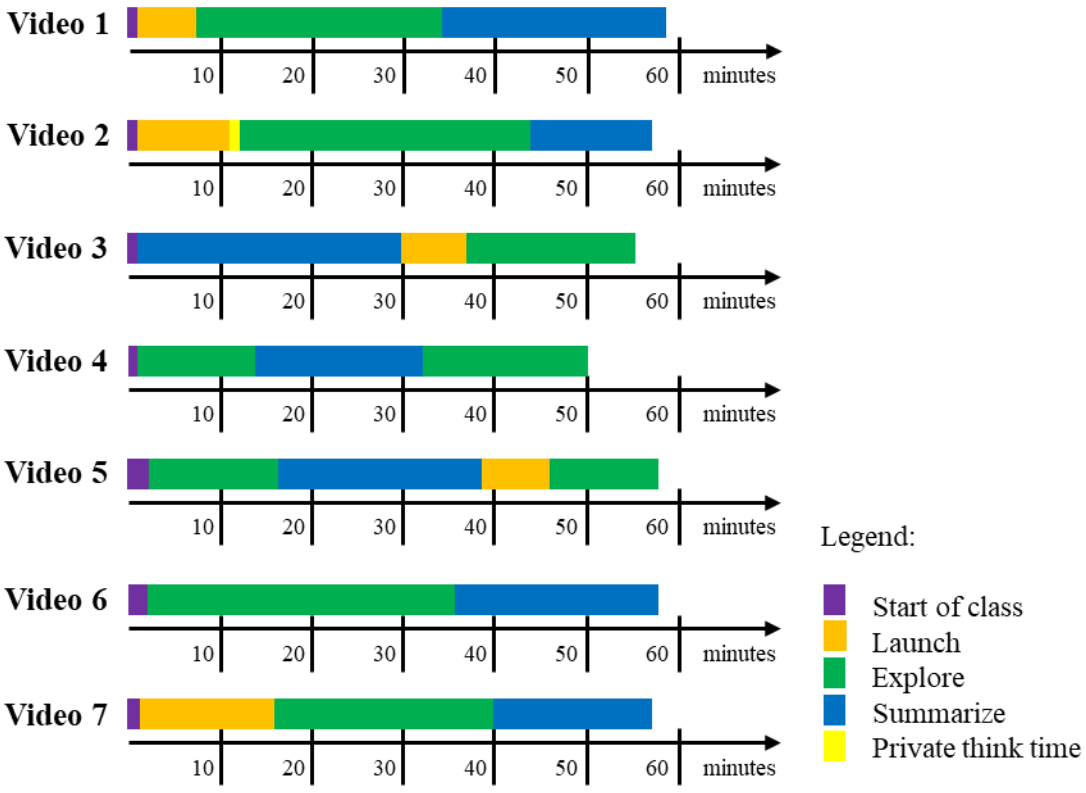


Figure 3. Lesson components within each classroom video

In her lessons, Ms. Ellis frequently provided opportunities for students to lead in finding strategies and presenting mathematical work. “In my classroom I’m the facilitator,” Ms. Ellis said in her first interview, “The students take over.” Ms. Ellis continued, “I’m observing everything they’re doing and I see from that point, okay, how do I challenge you more? How do I make this harder?” Her statement suggests that she viewed challenge as part of the learning process. Ms. Ellis’s responses were reflected in the way she structured her lessons, where she provided opportunities for students to discover strategies and share their thinking with their group and the whole class.

4.3.2 Tasks

Ms. Ellis's mathematical tasks came from the Connected Mathematics curriculum workbook. The Connected Mathematics curriculum was developed through the Connected Mathematics Project (CMP) by Michigan State University and funded by the National Science Foundation (see for more information: https://connectedmath.msu.edu/). The curriculum aligned with the Common Core State Standards for Mathematics and the Standards for Mathematical Practice. As implemented in Ms. Ellis's classroom, the curriculum focused on building mathematical understanding through a sequenced set of tasks. The tasks were problem-centered, meaning the they were contextualized within interesting mathematical situations or real-world situations. Ms. Ellis believed the Connected Mathematics curriculum supported the school's vision of mathematical learning. In her second interview, she stated, "We have a curriculum resource that we follow that supports our vision of what we believe math should look like…we're a school that believes in the conceptual understanding and the why behind the math." Ms. Ellis's response showed her personal alignment with the goals of the Connected Mathematics as not all math teachers within the school system used this particular curriculum.

The Connected Mathematics workbook contained tasks related to understanding fractions, decimals, and percents. At the start of video recording, students in Ms. Ellis's classroom began learning about fractions and equivalent fractions and then progressed through the workbook to decimals. The tasks consisted of multiple parts or problems and often involved graphs, charts, number lines, or other visual representations. For example, in one task, students created fractions by folding strips of paper. In another task, students used fractions to compare fundraising "thermometers" of different classrooms in a hypothetical context. In most of the

lessons (4 out of 7 videos analyzed for this study), students generated number lines to solve problems.

Ms. Ellis generally planned to complete one task per lesson but adjusted the schedule if students needed more time on a task. Importantly, Ms. Ellis left the task open-ended and did not preemptively provide solution paths for students to follow. She stated in an interview, "We never just say okay [there's] one way to do it…We question the task. Who's done it differently? Who thought about this problem differently?" If needed, she provided guided, individualized support to students during group work time if students were having difficulty understanding problems or finding strategies to solve problems. Though, typically, Ms. Ellis encouraged students to figure out problems within groups first without teacher input.

4.3.3 Group Work

Students sat in table groups of 4 seats. There were six table groups in total, arranged symmetrically in two rows (see Figure 4). For the purposes of this study, I designated a color to each group (Red, Orange, Yellow, Green, Blue, and Purple). Ms. Ellis determined the seating within the groups. Seating within groups was relatively consistent throughout the video-recorded lessons, except Ms. Ellis had two students switch seats sometime in the middle week of video-recording.

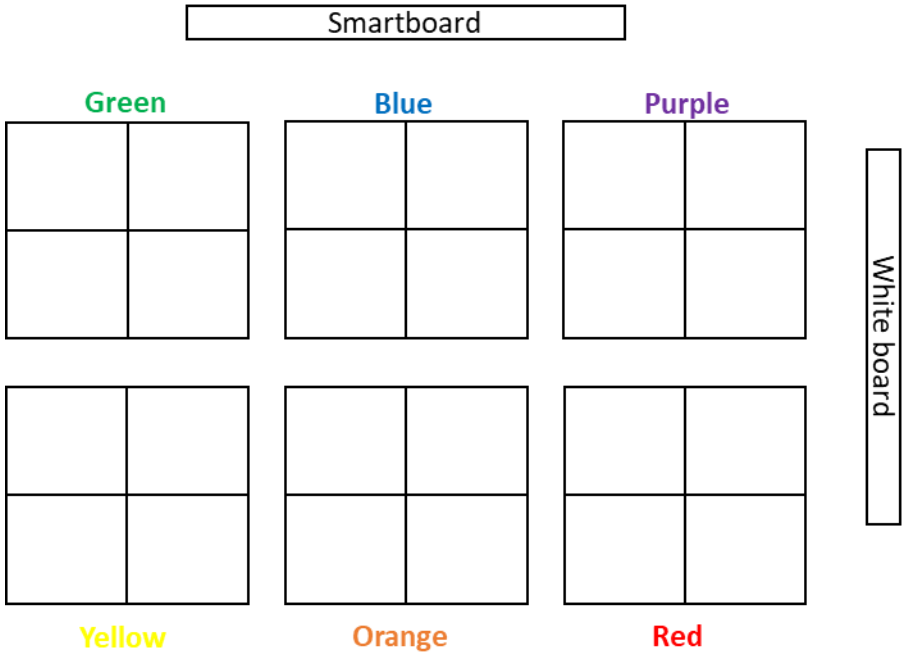


Figure 4. Group layout within the classroom

Ms. Ellis intentionally assigned students to each table. After the third day of video recording, I asked Ms. Ellis if she grouped students in a particular way. She informed me that she assigned and reassigned seats depending on the personality and skill of the students, which she assessed through students' work. Students were heterogeneously mixed, as much as possible, so that groups did not consist of students with all high or low ability. Group composition was heterogenous not only in terms of mathematical skill or ability but also in terms of race and gender. Ms. Ellis also mentioned that she coordinated with the Science teacher so that students were not "stuck" with the same classmates for two classes. This indicates that Ms. Ellis not only attended to students' mathematical abilities but also the social dynamics between students.

Group work was a regular and essential feature of the classroom. Students engaged in group work in every video recorded lesson (except the partner quiz day), and group work was the means through which students learned to solve mathematical tasks. In her interview, Ms. Ellis

stated that she emphasized "collaboration amongst peers" and worked to monitor and reinforce positive "discussion norms." In addition, Ms. Ellis stated that she worked with students at the beginning of the year to become familiar with working in groups by co-constructing group work expectations with students and periodically grading group work skills based on those expectations (see Appendix A.2). Group work expectations included being respectful in communication, engaging in accountable talk by listening and building on each other's ideas, constructively disagreeing by explaining ideas and not shutting peers out, and making sure all group members are participating. Each lesson, Ms. Ellis randomly selected a group to assess – using a rubric (see Appendix A.3) – how well students were meeting expectations. Besides group work expectations, Ms. Ellis did not – based on my observations of videos – provide specific direction on who should speak when, who has what roles, who should do what work, whether or how to divide work, or how to use and allocate and resources. As Ms. Ellis did not provide a script or structure for how to participate in group work, the way students organized and managed themselves emerged relatively organically in group work activity.

4.3.4 Student Uncertainty

Based on interview responses and observations, student uncertainty seemed to be a major part of the learning process in Ms. Ellis's classroom. In her interview, Ms. Ellis stated that "we're taught here that you ask questions when you don't understand someone's strategy…What don't you understand about it, or why don't you think it would work?" Her response suggests that students' lack of understanding were not situations to be corrected but rather explored with or explained to others. Raising confusion or doubt through questioning was an important tool for learning. Ms. Ellis stressed, "we rely heavily on questioning to advance students."

Ms. Ellis described that she approached questioning differently for different students. She noted, “You have students who are confident with math and students who aren’t. And I think with the students who aren’t confident in math, they’re the ones that tend to struggle, because they don’t have a belief that they can do it.” Ms. Ellis supported not-confident students and confident students differently. For not-confident students, Ms. Ellis explained, “You’re giving them [not-confident students] one question with a lot of wait time… you know they [confident students] might get three questions done and this one [not-confident student] got this one question done, but it was so rich and detailed [for the not-confident student] that that’s okay.” While Ms. Ellis let not-confident students grapple questions at a slower pace, she tried to challenge confident students and (re)introduce doubt: “when it comes to students who do know…you’re pushing them like, oh, you think you have this. Okay, what if I threw this into it?”

Though Ms. Ellis believed it was important to provide the space and time for students to ask questions and explore uncertainty with peers, she recognized that students may disengage because “they don’t a) want to do the work or they don’t understand what’s happening with the math…and some students just would rather be on their own. They’re having a bad day.” Depending on the situation, Ms. Ellis provided more direct support or allowed students to work alone at a back table. Like many teachers, Ms. Ellis worked within the constraints of her classroom and endeavored to balance her teaching with the unique circumstances brought by her students.

4.4 VIDEO VIEWING DISCUSSIONS

Prior to selecting and analyzing video clips, I viewed and discussed videos of Ms. Ellis's classroom in multiple interdisciplinary research team meetings. Before analyzing video, it is imperative to understand what the video contains or represents, ideally from multiple perspectives (Erickson, 2006; Jordan & Henderson, 1995). For this study, I worked particularly closely with a colleague, Calli Shekell, from the Department of Instruction and Learning at the University of Pittsburgh who investigates mathematics education. My colleague, Calli, and I viewed videos together and discussed events that we thought were noteworthy, related to teaching practices or student participation patterns. The discussions helped me articulate what I was noticing, explain why I thought something was important to note, ground my observations of the classroom in concrete details of the videos, and gather alternative explanations or counter interpretations of the same event. I also viewed video clips with faculty members from mathematics education, cognitive psychology, and educational psychology departments who helped me gain clarity around the language I was using to describe events, understand what Ms. Ellis's classroom represents, and build concepts related to student-to-student interactions.

4.5 SELECTION OF EVENTS

I selected the final set of video clips through a multi-step process. Prior to selecting video clips, I quickly viewed video-recorded lessons and documented the seating arrangement of students, the general activity of the lesson, the specific tasks assigned to students, the lesson components (i.e., introducing the task, problem-solving in group work, and strategy-sharing with the whole class),

and idiosyncrasies in the data. I excluded 3 videos that contained faulty video/audio or did not capture a "regular" lesson (i.e., partner quiz day), which resulted in 7 video recorded lessons for analyses.

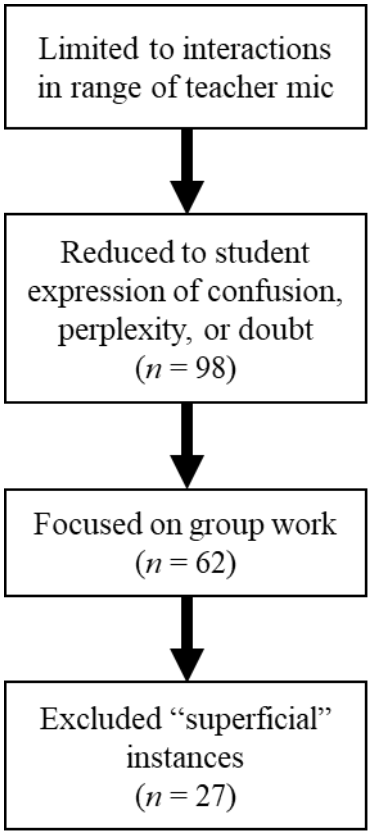


Figure 5. Flowchart of the selection of video events

After a quick pass through all the videos, I began the data reduction process to create a collection of clips where students expressed uncertainty (see Figure 5). First, carefully viewing videos from start to end, I time-marked all instances where students explicitly indicated perplexity, confusion, or doubt. I adapted Warshauer's (2015) coding of student struggle, paying particular attention to "what", "how", or "why" questions and comments initiated by the students. As there were no microphones at each table group and audio was difficult to hear

outside the range of the portable microphone attached to Ms. Ellis's person, I only marked instances that were in the presence of the teacher or clearly apparent to the teacher, visually or audibly. Thus, these instances, from which the final sample of uncertainty clips are derived, represent the teacher's observation of student perplexity, confusion, or doubt and not students' personal experiences of them.

In reviewing all the remaining instances of perplexity, confusion, or doubt (n = 98), I decided to further select instances that occurred during group work as I expected, based on the structure of the lessons, that moments of uncertainty would likely occur as students figured out ways to solve tasks together and try to communicate ideas to one another. Instances within other lesson components were not as rich or clear-cut. During the introduction of the task, students directed clarifying or procedural questions to the teacher with little student-to-student interaction. While, during the strategy sharing portion of the lesson, I found it difficult to clearly determine whether students' "why" or "how" questions and comments were expressions of uncertainty or students' attempts to ask good questions to their fellow peers. Though my decision of focusing on group work emerged from the data, it also aligns with prior studies which show that collaborative group work may be potentially beneficial for student learning but may also be challenging, ambiguous spaces to navigate (Blatchford, Baines, Rubie-Davies, Bassett, & Chowne, 2006; Nokes-Malach, Richey, & Gadgil, 2015).

From the instances of perplexity, confusion, or doubt during group work (n = 62), I removed instances where students asked clarification questions to the teacher about contextual features of the task (e.g., what the abbreviations "kg" and "g" mean) or of questions that arose from simple, procedural mistakes (e.g., transferring numbers wrong from the task) that were easily resolved. With the remaining instances (n = 49), I attempted to further reduce the instances

to video clips of uncertainty about mathematical concepts and strategies but realized that, due to the limitations of the data and my own mathematical knowledge, I could not identify and describe struggle instances without making tenuous claims and inferences. Instead of trying to assess whether an instance was mathematically substantive, I directed my attention to how the teacher responded in the instances that either did or did not provide time for students to explore their uncertainty in figuring out the task.

I returned to the Warshauer (2015) article and, using the author's coding of teacher responses, categorized teacher responses as one of the following: telling (i.e., supplying information), directed guidance (i.e., break down problem into smaller parts), or probing guidance (i.e., ask for reasons and justifications). The article describes a fourth category, affordance (i.e. ask for detailed explanation and afford time for students to work), but it was difficult to differentiate between probing guidance and affordance in these videos. Therefore, I combined the categories and considered all instances that were *not* telling or directed guidance as probing guidance. Notably, Ms. Ellis had no responses of telling. For directed guidance, I further categorized whether the teacher's responses resolved students' perplexity, confusion, doubt or let it remain open. I then removed instances where the teacher responded with directed guidance *and* resolved a problem for the students. In other words, I selected only instances where the teacher responded with probing guidance or open directed guidance that indicated the problem was left unresolved and students were given time to think through their uncertainty.

Subsequently, I expanded the selected instances (n = 29) to events that incorporated interactions before and after students' expression of perplexity, confusion, or doubt. The movement of the teacher in and out of the group space or the changing content of the conversation determined the time boundaries (i.e., start and end times). In two cases, there were

video clips from the same lesson where the teacher revisited and followed-up a previous interaction. I stitched those clips together, using video editing software, and considered them as one event showing a continuation of students' uncertainty. The remaining events (n = 27) were an average of 1 minute and 44 seconds (min. = 19 seconds, max. = 3 minutes and 49 seconds).

To recapitulate, the final 27 video clips from this process comprised events of student uncertainty during group work that were (a) apparent to the teacher and (b) specifically related to solving the task. Moreover, in these events, the teacher responded to the students in a way that provided them some opportunity to explore uncertainty (with facilitation from the teacher) rather than removing uncertainty.

4.6 DATA CONSTRUCTION AND ANALYSES

As video recordings – even short clips – can contain an overwhelming amount of information (Erickson, 2006), I used data processing techniques (Graue & Walsh, 1998; Jordan & Henderson, 1995) and ethnographic techniques (Emerson, Fretz, & Shaw, 2011) to construct workable, text-based data records. In short, I transcribed talk in each of the clips, adding nonverbal actions (e.g., writing or gestures) when necessary and paying particular attention to student-to-student talk. Qualitative analysis resources suggest that the level of detail and accuracy in the transcripts should depend on the goals for analysis (Graue & Walsh, 1998; Jordan & Henderson, 1995). Because I planned to focus on the content and subtext that is communicated between students, I did not document more micro features of talk, such as pace, intonation, or emphasis.

Transcribing talk within group work was challenging due to the simultaneity of actions across multiple participants. In order to accurately depict scenes and document concrete details in a more systematic way, I organized my transcripts by columns: teacher-student (T-S) talk, student-student (S-S) talk, and student personal (SP) talk. The columns denoted the participants engaged in a particular exchange and the direction of the talk. Student personal talk signified talk that appeared, from the video, to be directed to the self and not others. Transcribing in this way helped me to focus on student exchanges within each group. To help illustrate the exchanges, I supplied the transcripts with nonverbal actions or situational information – enough to create an appropriate representation of events.

Analysis of data initially began with attempts to dive into open coding of transcribed events, or inductively create categories to "name, distinguish, and identify the conceptual import and significance of particular observations" (Emerson et al., 2011, p. 175). Such attempts failed because, even after multiple video viewing sessions, I had limited concrete understanding of student interactions within the selected video clips; and, thus, I had no systematic way of identifying specific, student interactions to code. For example, at this initial phase, it was difficult to articulate or justify why some interactions felt prosocial while other seemingly similar interactions did not. After receiving advice from my advisors, I took a step back from coding and grounded my observations in the data by creating analytic memos. Analytic memoing allowed me to break down interactions at a finer grain size and identify specific, concrete interactional features to code. Thus, continuing the previous example, instead of interpreting interactions as prosocial, I identified moments where students established joint attention.

4.6.1 Phase One of Analyses

Interaction analysis, specifically focusing on participation patterns and meanings conveyed in conversation (Jordan & Henderson, 1995), began in earnest with analytic memoing. This type of preliminary analytic writing allows the researcher to pay close attention to moment-to-moment interactions and construct richer, more interpretive descriptions (Emerson et al., 2011). In my analytic process, I described what was occurring in a particular event, moving conversational turn-by-turn (or, in the transcript, line-by-line) as well as watching the video clip. I also embedded my analytic insights into the descriptions and connected insights to theoretical concepts in the literature, particularly related to intersubjectivity (Nathan, Eilam, & Kim, 2016; see also, Esmonde, 2009), joint attention (Barron, 2000; Borge & White, 2016), and social metacognition (Borge & White, 2016). Non-prosocial interactions also emerged from the data, which I related to concepts such as disaffiliation (Goodwin & Heritage, 1990; see also, Stevens, 2000). Analytic memoing also entailed constant comparison across video clips. Common themes emerged from the data, which I later transformed into qualitative codes.

4.6.2 Phase Two of Analyses

The coding process described here reverses the coding sequence described in typical qualitative methods books (Miles, Huberman, & Saldaña, 2014; Saldaña, 2009). I intentionally did the more fine-grained coding prior to the broader, higher-level coding for two reasons: (1) in moving from analytic memos to coding transcripts, I wanted to keep as close to the data as possible, and (2) I wanted to reduce bias of higher-level codes influencing my decisions of finer-grained codes.

From the emergent themes in the analytic memos, I created interactional codes and applied them to specific, student-to-student interactions in the video clip transcripts. Using NVivo software, I labeled observable behaviors between two or more students as demonstrating (a) prosocialness (i.e., establishing or maintaining joint attention in a way that is generally respectful, positive, safe, or helpful), (b) distancing (i.e., dismissing or rebuffing another student's attempt to establish joint attention), (c) teacher-like scaffolding (i.e., taking a "teacher-like" role to scaffold or elicit another student's thinking), or (d) defining or negotiating roles (i.e., suggesting how students should act as group members). Some codes, like prosocial and teacher-like scaffolding, co-occurred. After viewing the prosocial interactions as a collection, I determined that the prosocial category was too broad. I inductively generated sub-codes that were more specific, like reinforcing the conversation, recovering or repairing conversation, exchanging thoughts or information, or making the conversation exclusive. The codes mentioned in this paragraph will be described in more detail in the findings chapter.

Table 1. Categories and definitions of interactional codes

Student-to-student interactional codes	**Definitions**
Prosocial	When two or more students establish or maintain joint attention in a way that is generally respectful, positive, safe, or helpful
Reinforcing conversation	Student(s) agrees with another student or backs the statement of another student
Repairing/recovering conversation	Student(s) attempts to restore or continue the conversation after a miscommunication or disruption/pause in turn-taking
Exchanging thoughts/information	Student(s) verbalizes their thinking or provides information to another student
Making conversation exclusive	Student(s) selectively focuses attention on and engages with another student in an exchange, leaving out another member of the group
Distancing	When a student(s) dismisses or rebuffs another student's attempt to establish joint attention
Teacher-like scaffolding	When a student(s) takes on a "teacher-like" role to scaffold or elicit another student's thinking
Defining/Negotiating roles	When a student(s) suggests how students should act as group members

Finally, I applied attribute codes and descriptive codes at the clip level. Attribute codes provide details about the setting or context of the data – information that is not embedded within the data (Saldaña, 2009). These included the specific group involved in the event, the number of students in the group, and the task the group was working on. Descriptive codes, which are more content-related (Saldaña, 2009), marked whether the group requested help from the teacher and whether there was disagreement between students. I also categorized clips – based on my interpretations of interactions – by "types" of uncertainty (see Table 2). These types consisted of uncertainty about (a) general mathematical terms, processes, or ideas; (b) varying interpretations of the task or problem; (c) strategies that could not be applied to a new problem; (d) convincing or communicating to group members; and (e) making sense of another student's work. Furthermore, I clarified the location of uncertainty within the group. For example, I noted whether student uncertainty was between students, within a student, or shared among students.

Table 2. Categories and definitions of types/location of uncertainty

Category	**Definition**
Type	
Understanding mathematical ideas	Student(s) uncertain about the mathematical terms, strategies, solutions, or ideas related to the task
Interpreting the task or problem	Student(s) uncertain about what the task is asking or the context around the task
Rethinking a strategy for a new problem	Student(s) uncertain or encounter difficulty in applying a strategy to a new, related problem
Making sense of a group member's work	Student(s) uncertain about what another student is doing or saying
Convincing or communicating to group member(s)	Student(s) uncertain in how to approach, convince, or communicate their ideas to another student
Location	
Within a student	uncertainty about the task lies within one student where a student may be confused or find difficulty in the task or what other students are saying/doing
Among students	uncertainty about the task lies between or among students where students are not sure of each other's thinking or behavior
Shared as a group	students are uncertain about the same thing related to the task, or are aligned or in consensus about something they are not sure of

4.6.3 Phase Three of Analyses

To find patterns in the data, I created display matrices (see Appendix B.2; Miles, Huberman, & Saldaña, 2014) by descriptors and codes to summarize themes across video clips. In doing so, I noticed that student-to-student interactions appeared to differ mainly by group. In other words, the six groups (Red, Orange, Yellow, Green, Blue, and Purple) varied in number of uncertainty events, types of uncertainty, and categories of student-to-student interactions. For example, certain groups were associated with more positive, prosocial interactions while other groups demonstrated negative, distancing interactions. Pursuing this observation, I viewed video clip collections by group (e.g., all video clips pertaining to the Purple group) and across groups, comparing and contrasting interactional patterns. I hypothesized that interactional patterns may help explain why some groups displayed more collaborative behaviors than others. Following the work of Kieran (2001) who created interactivity flow charts for dyads, I sketched simplified visual representations of each group's interactional patterns that were in the presence of the teacher.

Because my selected video clips were a very specific kind of event, I checked to see if the group interactional patterns held across other interactions. I watched video clips from the initial, larger pool of group work instances and referenced notes from my observations of the classroom. I found similar patterns across uncertainty events and other group work instances, which suggests that the interactional patterns I saw were not specific to moments of uncertainty but applied to general group work interactions. Though the interactional patterns were similar, the types of student-to-student interactions differed in some groups. For example, certain groups

(mainly the Blue and Red groups) displayed more distancing behaviors during moments of uncertainty than other group work moments.

After reviewing group work interactions as a corpus, I further defined interactional patterns as the flow and direction of task-related information between students. I attended to students exchanging or sharing information as it is central for collaborative group work. I also sensed that the way in which students exchanged or shared information may be related to how students socially interact with each other. For example, who shares information with whom may have implications for who is included or excluded in group dialogue.

Interactional patterns produced interactional structures that were distinct for each group. Below is an example of an interactional structure composed of particular interactional patterns:

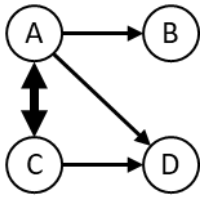


Figure 6. Example interactional pattern

The circles represent different students and the arrows show the direction of task-related informational talk. Double-headed arrows represent reciprocity in talk while thicker arrows show greater frequency (>2 instances) in providing or sharing information. The idea of reciprocity relates back to social metacognition in which there is evidence of a shared understanding of justifications and explanations rather than merely an exchange of information (Iiskala, 2011). So, A and C above share more information with each other than A provides information to B or D. The diagram also shows that B and D do not talk to each other about the task.

Two distinguishing categories emerged across interactional structures: *balanced* and *asymmetrical*. Feedback from colleagues at the University of Pittsburgh helped me to differentiate between the two structures. Balanced interactional structures comprised of a relatively even distribution of information and reciprocity among students, indicated by double-headed arrows, whereas asymmetrical interactional structures were defined by a "hub of information" or centralized nodes that showed information emanating from some and not all students in the group. In the example above (Figure 6), the interactional structure is asymmetrical and student A is a centralized node. I realized that interactional structures resembled gravity diagrams and showed the "push and pull" of social interactions between students. Pursuing that analogy, I conceptualized the interactional structures as two-dimensional representations of interactional planes, where more "powerful" students could create a greater impact or "curve" in the plane.

The interactional structures helped me to visualize power dynamics – who produces information, who shares information with whom, and how information is taken up. For example, student A in the figure may be exerting more power in the interactional plane than B, C, or D. In addition, C may be aligning with A by reciprocating information. I began to understand my previous interactional codes (prosocial, distancing, etc.) in terms of concepts related to power, particularly as outlined by Cornelius & Herrenkohl (2004) who discuss power as (a) giving ownership of an idea, (b) creating partisanship or showing solidarity, (c) and persuading others. The three conceptualizations of power became sub-codes to the interactional codes. I then explored whether interactional structures afforded or constrained certain kinds of student-to-student interactions within groups. The findings of these analyses are described in the next chapter.

4.7 ENSURING TRUSTWORTHINESS

Ensuring *trustworthiness* in qualitative research involves demonstrating (a) credibility, (b) transferability, (c) dependability, and (d) confirmability (Miles et al., 2014; Toma, 2006). Overall, generating rich descriptions of the context and student-to-student interactions through transcribing, memoing, coding, and writing contributed to trustworthiness. To ensure credibility, I triangulated my findings with teacher interviews, observational notes, and, importantly, student focus groups. After the main analysis described above, I conducted quick, descriptive coding of student focus group data, noting students' perceptions of group work or interactions with other students, and juxtaposed student interpretations with mine. In the findings chapter, I incorporated data from student focus groups, particularly in places where student interpretations offer greater insight or provide a contradiction. To ensure transferability, I described the boundaries of the setting and context (the class, task, group work, and moments of uncertainty) and connected qualitative codes and findings to important constructs in prior literature. By connecting to prior constructs, I contextualized this case study within broader research around group work and mathematics education. To ensure dependability and confirmability, I examined student-to-student interactions within multiple groups over multiple lessons and actively looked for negative or disconfirming instances. Moreover, throughout the data analysis process, I discussed video clips with several other researchers that allowed me to examine my own assumptions and gather alternative interpretations of events.

5.0 FINDINGS

The main research questions for this study were: (1) how do students socially interact with each other during moments of uncertainty in group work? and (2) how does power play a role in student group work interactions? As mentioned in the Ethnographic Background section in Chapter 4 (Methods and Analyses), group work was the main activity by which students did mathematical work. The teacher, Ms. Ellis, established and maintained a positive climate for group work by co-constructing group work norms and expectations with her students and reinforcing those expectations. Ms. Ellis emphasized respectful communication, constructive dialogue, and participation from all students. Despite clear group work norms and expectations in the classroom, groups varied in social interactions from somewhat collaborative to highly collaborative (described in more detail in later sections). However, group work consistently involved social coordination, navigation, and negotiation across all groups.

Students' statements in focus groups echoed my observations about the social nature of group work in Ms. Ellis's classroom. In response to a video clip where the teacher was helping a student think through a problem, a student – unprompted – noted that students were "figuring out problems with their group and helping each other out." When asked about group work expectations, one student said expectations involved "respecting your peers, not getting into arguments, um, respectable language, and accepting everybody's ideas." Another student added, "also, like trying to come to one agreement…sort of like put both of your ideas together to come

up with one." Rather than focusing on finding solutions, students highlighted the importance of good communication and reaching a shared understanding. In the same focus group, one student said, "When we do teamwork it's all about trying to not even just like find the answers but basically working together to find how we can like make a way to solve the answers." Thus, to some students, the social process of group work was as (if not more) important as getting an answer to a problem.

Respect seemed to be a particularly important part of group work, as one student in a different focus group expressed, "If you're not respectful to other people on the whole like things might just go wrong and everybody just starts working alone." The quote suggests that student interactions could have consequences for the way participation looks like in groups. For students across focus groups, working alone appeared to be a behavior that should be avoided. Students seemed to conceptualize group work as sharing thoughts and ideas. The importance of exchanging ideas and coming to an agreement transcended group work in the classroom. One student explained:

> "I think it's [group work's] important because if you're sitting at the table and maybe one person has an idea but the other person disagrees and then when everybody sort of puts their information together they can really come to an agreement and put there both of their strategies…when you get older and you actually get a job, the job you might need to like work with each other and if you don't do it while you're younger, you're not going to be able to communicate and work with others."

Other students articulated that knowing how to interact in groups was a beneficial skill for future work situations.

In the focus groups, students also acknowledged that group work was not always successful. When asked if students felt safe in the classroom to take chances, one student replied, "I feel welcomed," while another student gave a lukewarm answer saying, "Kinda…because there are kids that will make fun of you a little and will stay stuff behind your back." Another student added, "Yeah, the last group I was in, I didn't really feel that comfortable." The quotes suggest that there could be a lack of psychological safety or belonging in some groups. A student from a different focus group stated, "…we don't do a lot of independent work in our classroom. We just like all work together and sometimes it might not work out all the time." In both focus groups, students underscored the social challenges of working together.

Generally, students appeared to be invested in doing group work, though students encountered difficulties interacting with peers. I use the above quotes from student focus groups to highlight the social nature of group work and provide a backdrop for the social interactions that will be described in the sections below. Following an overall description of findings, I will explore what social interactions looked like in two groups, how social interactions may have affected group participation, and why certain groups may have been more "comfortable" – as the student stated above – than other groups.

5.1 UNCERTAINTY EVENTS

Across 7 video-recorded lessons, there were 27 events of student uncertainty (an average of 3.9 uncertainty events per lesson). Those events were in the presence of the teacher, and so it is possible that student uncertainty occurred more frequently in the videos than captured here. As I mentioned in the Methods and Analyses chapter, the video and audio limits of the data affected

my decision to focus only on student-to-student interactions when the teacher was present. However, I also believe that such moments are important to investigate as teachers assess group work based on the interactional clues they gather when they visit and observe groups. In other words, the events I analyzed would have been what the teacher had directly seen and heard. In-depth descriptions of such events may help teachers gain a deeper understanding of student-to-student interactions and identify critical moments to provide social support.

Figure 7 shows that there were different types of uncertainty. The greatest source of uncertainty was *making sense of a group member's work*. The figure also shows that uncertainty could come from one student, result from communication between students, or be shared among all group members. Most of the uncertainty arose between students. In other words, uncertainty in Ms. Ellis's classroom was social in nature. Students expressed uncertainty in the process of working with group members and communicating ideas. There was no clear pattern in uncertainty types/location by group or student interactions. For the sake of space, I do not describe in detail the nature of uncertainty itself in the excerpts below.

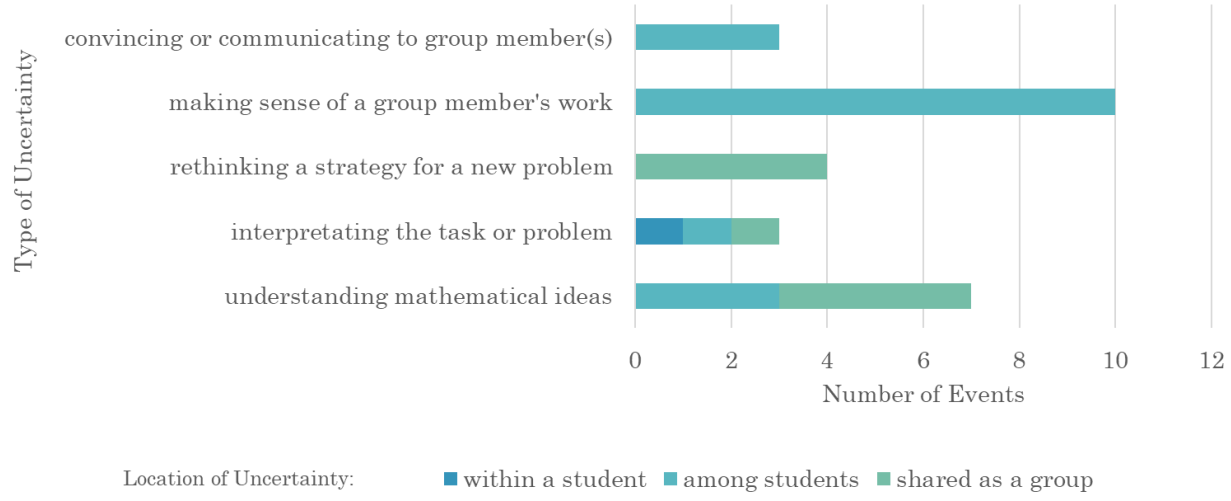


Figure 7. Type and location of uncertainty across uncertainty events (n = 27).

5.2 STUDENT-TO-STUDENT INTERACTIONS

Overall, within the events of uncertainty, there were 8 times as many events with *prosocial* interactions among students than events with *distancing*, which speaks to the positive relational climate of the classroom (see Figure 8). There were 24 uncertainty events that contained *prosocial* interactions and, across those events, 44 instances where students demonstrated an effort to establish or maintain joint attention in problem-solving across those events. There were 3 events where *distancing* occurred between students and 2 events with *teacher-like scaffolding* and *defining or negotiating roles*.

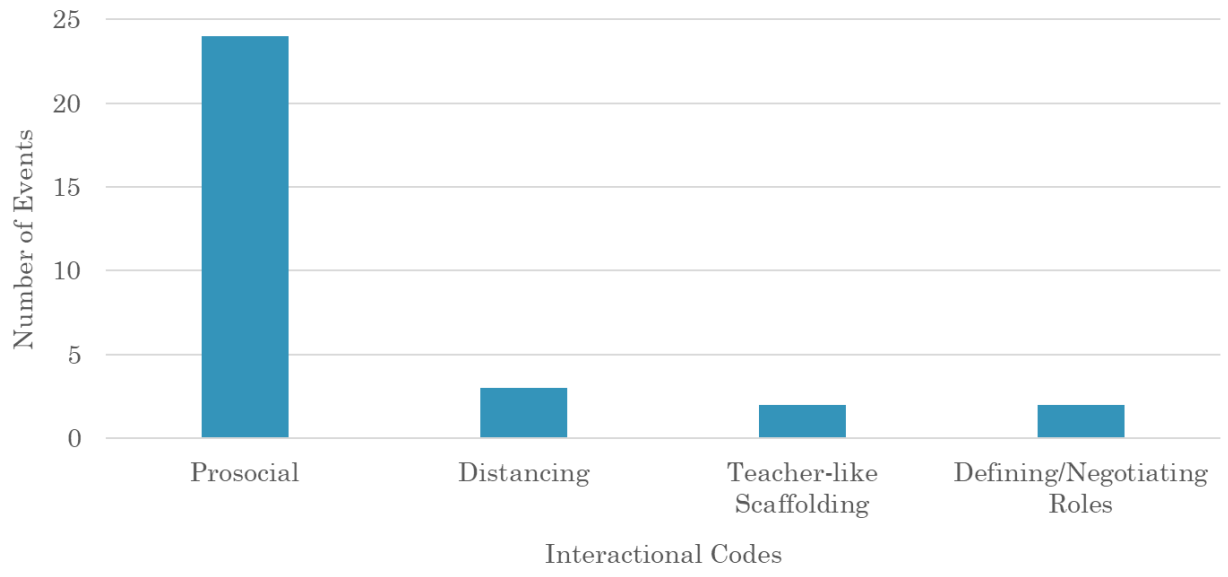


Figure 8. Number of video clip events by interactional codes

Student-to-student interactions differed by group. Figure 9 shows that the Purple and Yellow groups exhibited the most prosocial behaviors. Notably, only two groups demonstrated distancing behaviors: Red and Blue groups. As mentioned in the Methods and Analyses chapter, viewing interactional codes by group prompted me to examine interactional patterns within each group to explore what may explain, for example, distancing behaviors only happening in certain groups and how those interactions occurred.

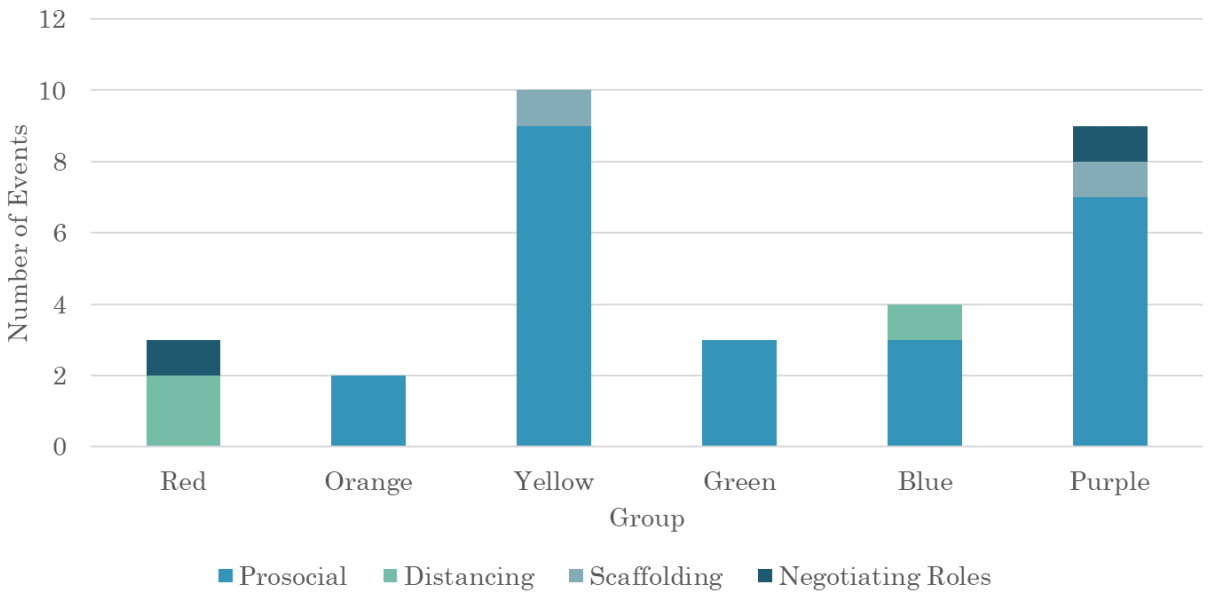


Figure 9. Interaction coded video clip events by group

5.3 INTERACTIONAL PATTERNS

Interactional structures, or aggregated interactional patterns over multiple interactions, showed that three groups (Purple, Yellow, and Green) showed a *balanced* structure, where information was reciprocally shared and relatively evenly distributed (see Figure 10). The remaining three

groups (Red, Blue, and Orange) showed an *asymmetrical* structure, where only certain students were involved in exchanging information or where the source of information was skewed towards certain group members. The interactional patterns served as organizing mechanisms as well as a proximal context or framework to understand, interpret, and describe specific student-to-student interactions. As mentioned in the previous chapter, interactional patterns can be conceptualized as two-dimensional representations of an interactional plane, where each arrow represents "curves" in the plane. Importantly, interactional patterns allowed me to illustrate social relationships between students in terms of power.

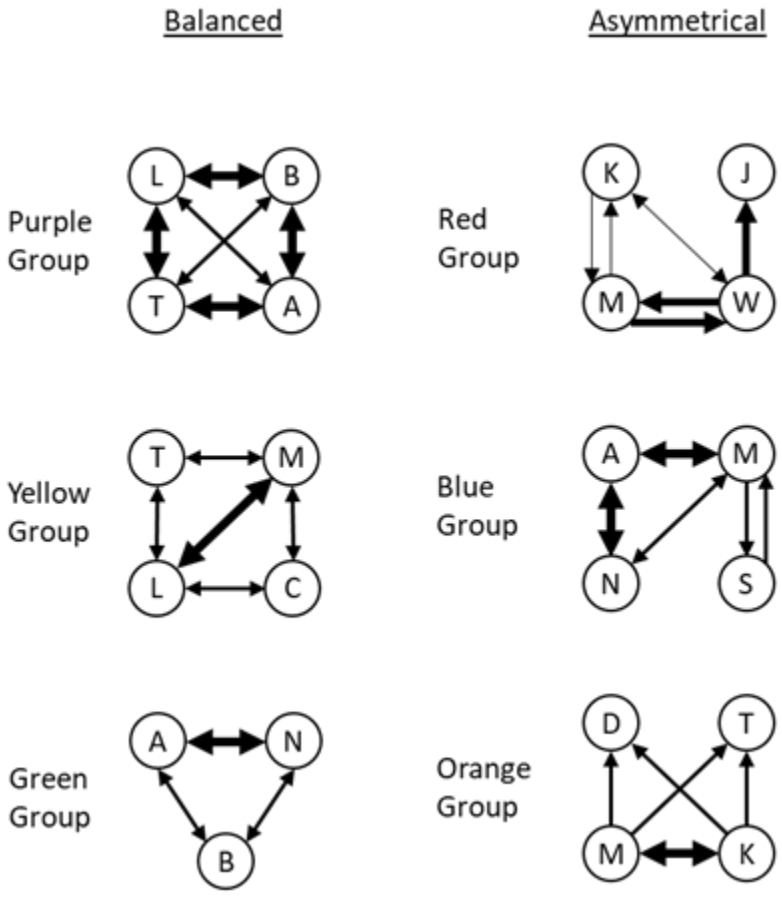


Figure 10. Balanced and asymmetric interactional patterns aggregated across videos

It is important to note that interactional patterns may look different for different exchanges between students. Meaning, the figure above shows aggregated patterns and does not suggest that patterns were the same for all interactions in this group. I describe interactional patterns in greater detail in the subsequent sections.

5.4 POWER DYNAMICS WITHIN GROUPS

As collaborative group work depends on the exchange and discussion of information, who is involved in information sharing and how information is shared provides keen insights into social dynamics, particularly related to power, within groups. It is possible for productive learning in group work to occur without informational input from all students. For example, students may be peripheral but legitimate participants if they are able to engage in the cultural activity of group work and learn from more knowledgeable peers (Lave & Wanger, 1991). However, if one goal of collaborative group work, from a relational equity perspective, is respecting and incorporating different kinds of knowledge to facilitate meaningful participation of all group members, then it becomes important to understand whether or how students are privileging information coming from certain students over others. Over multiple interactions, privileging information from select students may result in hubs of concentrated information that marginalizes information from other group members.

Diagramming interactional patterns helped me to visualize whether there were unequal distributions of shared information among group members, which may indicate asymmetry in power. In some groups, all students were involved in the co-construction of information, meaning students were able to influence the knowledge produced. In other groups, certain

students refrained from or were excluded from information-sharing. The interexchange of information is largely invisible and, thus, visualizing interactional patterns allowed me to make explicit the interactions between students and gain insight into the interactional group context to more accurately describe and interpret student interactions.

To describe in rich, concrete detail which group members were involved in information-sharing and the ways in which information was offered or received, I selected excerpts from two groups: the Purple group and the Red group. I selected the two groups for communicative and conceptual reasons. First, some video information – like tone of voice or gesturing – is lost when events are transcribed to text. I felt the excerpts from the Purple and Red groups were easier for readers to picture through transcribed text. Second, I focused on the Purple and Red groups because they represented opposite ends of the spectrum in terms of interactional structure and social interactions. The Purple group showed a *balanced* interactional structure, and students in the group demonstrated prosocial and pro-learning behaviors. In contrast, the Red group had an *asymmetrical* structure, and students exhibited mainly aloof or distancing behaviors in response to other students' ideas. The contrast between groups draws attention to how different social dynamics within groups can be and the ways in which power is tied to how group members socially interact each other.

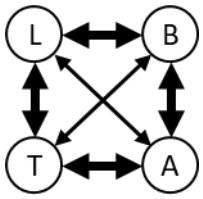
5.4.1 The Purple Group

The Purple group consisted of four students: Brad, Leona, Terrell, and Aliyah. The group was (as were all the groups) heterogenous in terms of mathematical ability. To avoid problematic, static characterizations of students based on ability or knowledge (as the teacher, Ms. Ellis, mentioned in an interview, students could be more knowledgeable on certain topic or tasks and less

knowledgeable in others), I will borrow Ms. Ellis's categorizations and refer to students as mathematically-confident or less mathematically-confident. To be clear, Ms. Ellis did not label or assign each student in her classroom as mathematically-confident or less mathematically-confident. She used those terms generally to explain how she supports students who are struggling. For this study, I adopted Ms. Ellis's terminology and used each student's prior state math test scores as well as mathematical talk in group work as evidence to differentiate mathematically-confident from less mathematically-confident students.

Based on my observations, Aliyah appeared to be the most mathematically-confident of the group. She was advanced in math, according to her previous year's state math test scores, and, based on my observations, demonstrated fluency in articulating her thinking using mathematical terms. Brad and Leona were the most vocal of the group. They frequently asked questions and expressed opinions. Terrell was quieter, though he had few reservations about participating in the group. He often showed less mathematical confidence in problem-solving. He tended to encounter more difficulties in solving task problems than his group members, and he – at times – asked for one-on-one guidance from the teacher. Previous state test scores show Terrell came in with the lowest math score out of all the students in his classroom.

Although Terrell was generally less mathematically-confident, he had strong social relationships with his group members. He shared information with all his group members, and, importantly, his group members shared information with him. The figure below shows that across video clip interactions of group work, the Purple group showed reciprocal relationships among students in terms of sharing task-related information:



Over time, all students in the group shared information with each other about the task and the shared information was acknowledged and taken up by other group members. Students did not consistently exclude a member of the group. Said another way, students were not selective about with whom they shared task-related information, though students seemed to prefer to share information with certain group members over others. Considering that the group was heterogenous in terms of ability, the interactional patterns suggest that, regardless of ability, all students actively participated in group problem-solving. Thus, there was no concentrated hub of information in this group, suggesting that all students in this group had influence in shaping group work.

Even during moments of uncertainty, when communication between students can breakdown, students in this group consistently shared information to solve tasks together and maintained joint attention. For example, students in this group voiced strategies that they thought may be worthwhile to explore (Brad: [to his group] I have an idea.), rephrased each other's ideas (Aliyah: [in response to Brad's thinking; looking at Brad] So, we have eight in group…in part C – we're going to have to split it again in half?), asked for explanations (Brad: [to Aliyah] Wait, but how is that possible?), assessed each other's work (Leona: [gets out of her seat and leans over Brad's notebook] Wait no. That's one, two, three, four [referring to labeling on a number line].), and checked to make sure group members were on the same page (Leona: [to Terrell] Which one [referring to which problem] are you on?). Through such interactions, students engaged in accountable talk, where students listened and built on each other's ideas (Michaels,

O'Connor, & Resnick, 2008), and social metacognition, where students observed and regulated each other's work and thinking (Borge & White, 2016). In these ways, students in this group established and maintained intersubjectivity, or shared understanding, that is critical for mathematical participation and discourse (Nathan et al., 2007).

What did these student behaviors look like in interaction? More importantly, who were involved in these interactions and how were they involved? Interactional patterns may show balanced relationships, but the nature of those relationships may be titled in direction of particular students. For example, one could imagine highly vocal and mathematically-confident students occupying more primary roles in initiating information-sharing while other group members having more secondary roles in responding to or taking up information. Excerpts from the Purple group show that this was not always the case.

5.4.1.1 Excerpt 1: "He said do nine divided by four"

The following excerpt illustrates how information was shared between less mathematically-confident and highly mathematically-confident peers in respectful and constructive ways. In this particular interaction, students were working on a multi-part task that involved using their understanding of fractions and number line representations to answer a series of questions related to a hypothetical volunteer highway clean-up situation. The first problem of the task asked students to write nine-fourths (9/4) miles as a mixed number. Students had difficulty understanding what nine-fourths miles represented and how to show the fraction on their number lines. In a prior interaction, the teacher visited the group and asked group members what they thought represented a whole or one mile. Students tried to determine whether nine-fourths miles meant nine miles split into fourth-sized sections or nine fourth-sized sections where four-fourths was one mile.

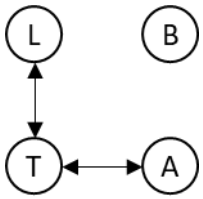
The teacher visited the group again to check on their thinking:

	T-S talk	S-S talk	Student personal
1	**Teacher**: [walks over to the group and stands next to Aliyah] So, what did you all go with?		**Brad**: [writing in his notebook] **Aliyah**: [looking towards the group]
2	**Leona**: [body leaning towards Terrell] He [Terrell] said do nine divided by four.		
3	**Teacher**: Well, if I said right now to you, "Hey, you four, let's go outside for community service purposes – let's go ahead and make sure our area is clean – we'll clean up the highway. We work, we work…		
4	**Teacher**: [talks to the assistant teacher who asks a question on behalf of another group]	**Terrell**: [sits up straighter, looks towards Leona and then Aliyah] Oh, couldn't you split it up (inaudible) improper fractions (inaudible) like one fourth – no, yeah, nine (inaudible) and you split it up again, you know what I'm talking about?	**Leona**: [looking at Terrell] **Aliyah**: [looking at Terrell]
5		**Aliyah**: [looking at Terrell] (inaudible response)	
6		**Terrell**: Yeah, do that. Let's do that.	

In response to the teacher's question, Leona said Terrell had an idea of dividing nine by four. Terrell's idea was mainly computational and seemed to be related to creating a mixed number, which was directly related to the task problem. The teacher began to reiterate the context of the task but was interrupted by the assistant teacher. While the teacher's attention was elsewhere, Terrell shared a different but related idea on representing nine-fourths using a number line to

Leona and Aliyah. Aliyah responded to Terrell, and Terrell replied positively to Aliyah's response.

The diagram below shows the information-sharing interactions in the excerpt:



Evidence for the reciprocal arrow between Leona (L) and Terrell (T) came from line 2 in which Leona indicated that Terrell shared an idea about what to do with nine-fourths ("nine divided by four") with at least Leona in the group. In other words, Terrell shared information with at least one group member and he was heard by a group member, Leona, who gave Terrell credit and repeated his idea to the teacher.

Cornelius and Herrenkohl (2004) suggest power is constructed, in part, by perceptions of who has ownership of ideas. In the above interaction, Leona gave ownership of an idea to Terrell. By doing so, Leona gave weight and influence to Terrell's idea. Moreover, Cornelius and Herrenkohl (2004) state that perceptions of who owns an idea are inextricably linked with relationships between the owner and others. In this excerpt, Leona's body language (leaning towards Terrell) and her relaying of Terrell's ideas to the teacher demonstrated prosocialness, which indicated that Leona was aligning with and not disassociating from Terrell's ideas.

The reciprocal arrow between Terrell (T) and Aliyah (A) was generated by lines 4-6 where Terrell presented an idea about what to do with the number line. Terrell looked at both Leona and Aliyah as he shared his thoughts. While Terrell was speaking, both Leona and Aliyah's attentions were directed toward Terrell. After Terrell indicated that he had finished his thought ("you know what I'm talking about?"), Aliyah responded to Terrell. Though it was

unclear what Aliyah said, it appeared that Aliyah's response was related to and perhaps built upon Terrell's idea because Terrell indicated that he understood what was said ("yeah, do that") and suggested that the group try out what was discussed ("let's do that").

Persuasive discourse is another aspect of power dynamics (Cornelius & Herrenkohl, 2004). In discourse, students may need to convince other students that that they have something valuable or helpful to contribute and convince others to listen to them. Students with higher status, who are perceived as smart, may have little trouble persuading others. Students who are less confident about a particular task may have greater difficulty persuading others to listen to their emerging ideas. In this excerpt, however, the status differential appeared to be minimal. Aliyah was the most mathematically skilled group member while Terrell often had difficulty communicating mathematical ideas. In the above instance, Terrell tried to convince Aliyah, and Aliyah appeared to respect Terrell's ideas – enough to listen and respond to him. Aliyah's response also appeared to empower Terrell so that Terrell felt more confident to suggest that the group should pursue the shared idea.

I highlighted Terrell's participation because, unfortunately, for students who often lack mathematical confidence, the barriers to participation are high (Horn, 2012). As one focus group student mentioned in the beginning of this chapter, students may feel apprehensive about taking chances because some students may "make fun of you." The excerpt was noteworthy because, again, Terrell did not demonstrate that he was certain about how to solve the problem. Yet, within the group, he shared and explained his idea to his more mathematically-confident peers. More importantly, his ideas were heard by all his group members. Even Brad, who was not shown to be interacting with Terrell in the excerpt above, in a later interaction, acknowledged and took up Terrell's ideas (Brad: [to the teacher] So, so, he [referring to Terrell] came up with

the idea of making ninths only actually it's fourths. [Brad is referring to how Terrell thought of making divisions in the number line to represent nine fourth-sized sections.] So, like (inaudible)). Similar to Leona, Brad gave Terrell ownership of an idea. Thus, group members not only included Terrell in the sharing of information but also explicitly noted that their own thinking was influenced by Terrell.

5.4.1.2 Excerpt 2: "Sorry, I'm still trying to figure it out"

To present a counter-example, I describe an excerpt below where Terrell had difficulty with the task and did not engage in sharing information with his group members. This excerpt occurred two lessons after the previous excerpt. The excerpt shows that students in this group did not always show reciprocity in sharing information during moments of uncertainty. Yet, even when students were not exchanging or taking up each other's ideas, students demonstrated prosocial behaviors.

The task for this excerpt involved understanding decimals as fractions and ordering decimals from least to greatest. The first part of the problem asked students to write the heights of two students, shown as decimals 1.52 and 1.5, as fractions. The second part of the task involved ordering students' heights in a chart from the shortest to the tallest. Leona and Aliyah were looking back and forth from the chart in their workbook and writing in their notebooks. Terrell sat sideways in his chair, looking at his notebook and flipping through pages. He placed his notebook on his desk but did not write. (As a note, Brad was absent this day.)

The teacher walked over to the group as Leona looked at Terrell's notebook and made a comment in a surprised tone:

	T-S talk	S-S talk	Student personal
1		**Leona**: You weren't writing	

		it down the whole time?
2		**Terrell**: Sorry, I'm still trying to figure it out.
3	**Terrell**: I'm trying to ask her a question and she won't answer.	
4	**Teacher**: What's your question? Well, let's go ahead and talk about it now.	
5		**Aliyah**: I asked you what you think it will be.
6		**Terrell**: Yeah, and I said [inaudible]
7		**Aliyah**: And I asked you why and you said your brain was turned off [smiles]

Terrell had difficulty with the first part of the problem, writing decimals as fractions, and had not been ordering decimals. He noted to Leona that he was "still trying to figure it out," and he then turned to the teacher, saying that attempted to elicit help from a group member but did not receive a reply or was perhaps dismissed. After the teacher suggested that the group talk about Terrell's question, Aliyah addressed Terrell directly to say that she had asked Terrell what he thought of the problem (line 5). From Terrell and Aliyah's exchange, it appeared that Terrell had provided Aliyah with a response, but, when pressed by Aliyah for an explanation, Terrell gave an indifferent response ("brain was turned off").

In this excerpt, there were two strands of miscommunication. The first was between Leona and Terrell. Leona clearly expressed that she thought Terrell was not doing what she thought he should be doing, implying that Terrell was behind in group work. Terrell seemed to justify his lack of work by indicating that he was genuinely uncertain about the task, suggesting perhaps that he was not purposefully slacking. The second strand of miscommunication was between Terrell and Aliyah. Terrell had expected help from Aliyah but, from his point of view,

had not received the requested help. Aliyah, on the other hand, believed she was helping Terrell by eliciting his thinking on the problem ("I asked you what you think it will be") and asking him to justify his answer ("I asked you why").

In particular, the miscommunication between Terrell and Aliyah revealed their different perspectives on what it meant to be a group member and how group members should provide help. Terrell viewed his group members as resources who could provide information when it was requested. In this instance, Terrell appeared to want a specific answer from Aliyah. Aliyah also saw group members as potential resources, not as sources of information but rather as peers who promote learning by questioning. Thus far in the transcript, there was no clear resolution to Terrell and Aliyah's attempts to define or negotiate group member roles.

As shown in Excerpt 1, in other group moments, Terrell showed willingness to participate in exchanging information and explaining his thinking to group members. In this excerpt, Terrell seemed less eager to talk and engage in the work. In fact, earlier in the lesson, the teacher commented on the group's unusual lackluster mood, noting Leona and Terrell's silence. Perhaps Terrell was having an "off" day. Terrell's purported comment of "[my] brain was turned off" may be interpreted as "I don't want to think about this right now." Perhaps Terrell wanted Aliyah to tell him key information so that he could move on in the task. It is then noteworthy that Aliyah did not comply with Terrell's request and instead asked for his thoughts and explanations. In other words, Aliyah interacted with Terrell in pro-learning ways that suggested Terrell was a contributing group member. Moreover, Aliyah added a smile to her statement at the end (line 7), indicating that she was not attacking or being negative towards Terrell.

Following the interaction, Aliyah's comment prompted the teacher to tap Terrell on the shoulder and suggest that he be more specific about what he did not understand:

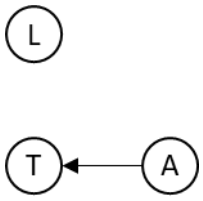
	T-S talk	S-S talk	Student personal
8	**Teacher**: [taps Terrell on the shoulder] Hey, see that's not a good response. Why – what don't you understand? Be specific.		
9		**Terrell**: [points to his notebook and mumbles something]	
10		**Aliyah**: [sits up a little straighter and looks at Terrell] Okay what we did –	
11		**Leona**: [looks at Terrell] Are you talking about that fractions part? **Aliyah**: We know that fractions –	
12		**Aliyah**: We just took (inaudible; talks about something related to the chart of decimals)	
13	**Teacher**: [walks away from the group]		

Terrell turned to his group members and pointed to his notebook but appeared uncertain in how to articulate his confusion (line 9). Aliyah followed to where Terrell was pointing to and started an explanation of what she (and possibly Leona) had done. Leona then included herself in the conversation and asked Terrell and Aliyah to confirm the part of the problem about which they were talking (converting decimals into fractions).

Here, it seemed Terrell and Aliyah reached a compromise in defining or negotiating group member roles. Aliyah may have sensed that Terrell was having difficulty articulating his thoughts. Or, perhaps, now that she knew – from Terrell pointing at his notebook – what the confusion was about, she could provide information. Whatever the reason, Aliyah did not press

Terrell again with a question but instead began explaining the relationship between fractions and decimals. She still refrained from telling Terrell the answers, or what the fractions would be. In addition, Leona demonstrated investment in the conversation by establishing joint attention, or ensuring that she was on the same page as her group members. As the teacher walked away, Aliyah continued her explanation. Aliyah's willingness to provide an explanation is important as "successful collaboration…depends on a commitment to a form of discourse that values argument and relies on explanation" (Kieran, 2001, p. 214).

The diagram below shows the information-sharing interactions above:



Though Leona, Aliyah, and Terrell talked to each other, information was only elicited and offered by Aliyah. Particularly, at the end of the excerpt, Aliyah started to explain how to turn decimals into fractions. When Terrell and Aliyah were describing what had happened (lines 5-7), Terrell seemed to suggest that he gave an answer to Aliyah, but there was not enough evidence to know if Terrell offered his thoughts or if he, for example, repeated an answer that was agreed upon by his group members.

The interaction diagram for this excerpt was very different from the interaction diagram from the first excerpt. In the first excerpt, Terrell reciprocally shared information with his group members. In this excerpt, a group member provided information to him. What did this suggest in terms of power? Terrell was not as empowered as he was in the prior excerpt. This may be due to the fact that he was the only one who was uncertain about the task whereas, in the first excerpt, all group members were uncertain about how to represent nine-fourths in their number lines.

Terrell's lack of understanding in this particular task put him in a vulnerable position. But, instead of ignoring or dismissing Terrell, Aliyah attempted to explain the process of converting decimals into fractions. In fact, when the teacher visited the group again about a couple minutes later, both Leona and Aliyah were breaking down each part of the decimal number and associating it to a specific part of a mixed number fraction. Thus, Leona and Aliyah persisted in explaining mathematical ideas to Terrell.

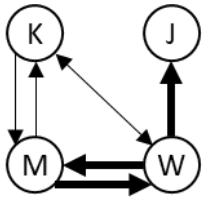
Power can be exercised to build relationships (Berry, 2006). Excerpt 2 was an example where power could promote positive interactions. The interactional plane was initially tilted towards the direction of Aliyah and Leona, who appeared to have no trouble solving the task. Aliyah and Leona could have kept their knowledge to themselves, thereby excluding Terrell. Instead, by using their knowledge to help a struggling group member, Aliyah and Leona not only redistributed the information and included Terrell but also tried to facilitate a shared understanding. Thus, Terrell's future opportunities for participation in the group were not jeopardized.

5.4.2 The Red Group

The Red group operated very differently from the Purple group. The Red group consisted of four students: Wendy, Mary, Kate, and Jamal. Talk in the group was dominated by two very mathematically-confident and mathematically-knowledgeable female students: Wendy and Mary. They were articulate in explaining their mathematical ideas and solved tasks with ease. For example, in one task related to fractions, Wendy commented that the task was "easy as pie." The group reached part E of the task while other groups were grappling with part B. Kate was also mathematically-confident but generally quiet. In one instance, when the teacher tried to

elicit Kate's thinking and noted her silence, Wendy commented, "She's always quiet." The girls' previous year's state math test scores showed that all three were advanced in mathematics. Jamal, who was identified as a special education student, appeared to show little mathematical confidence. He rarely spoke in the group and often asked the teacher for help.

Across group work, interactional patterns for the Red group looked drastically different from the Purple group:



Single-headed arrows indicate that information was often presented to other students but ideas were not acknowledged or taken up by other students. For example, Mary and Wendy exchanged information frequently, but they talked over each other about different ideas and rarely acknowledged each other's ideas. The same was true between Mary and Kate. There were a couple of instances where Kate and Wendy shared information where the other student took up the idea, but it was not common. The interactional pattern also shows that Wendy frequently shared information with Jamal but Jamal did not share information with Wendy or any other group member. In fact, Wendy appeared to be central to the flow of information. Wendy frequently offered information to all other group members. Yet, despite the multiple arrows shown in the figure, group members often worked independently. There were three lessons in which they did not interact at all with each other in the presence of the teacher. No other group exhibited a lack of interaction to the degree of the Red group.

5.4.2.1 Excerpt 1: "Use tenths"

Unlike the Purple group, during moments of uncertainty, students in the Red group demonstrated distancing behaviors. In the following excerpt, students were working on a task that involved finding at least two fractions that fit in between a given pair of fractions. For example, students had to find two fractions in between one-fifth and two-fifths. The task itself was not the source of uncertainty for students in this group. Mary was uncertain about her group members' thoughts, particularly Wendy's ideas, around which fractions to choose. Later, Mary also had difficulty convincing her group members to use fraction denominations she thought worked well.

Contributing to the uncertainty was the miscommunication between Mary and Wendy. Mary was speaking about the second problem of the task: finding fractions between one-fifth and two-fifths. Wendy, however, assumed that Mary was talking about the first problem of the task: finding a fraction between three-tenths and seven-tenths.

	T-S talk	S-S talk	Student personal
1		**Wendy**: [talking about something related to tenths]	**Kate**: [working in her notebook]
2		**Mary**: [speaking in the direction of Wendy] How – What number would we put in between the tenths? Like – since we only have…	**Jamal**: [looking at group and at his notebook]
3		**Wendy**: [looks up at Mary and refers to the first problem which is not the problem Mary is on] We have three options. We can use four tenths, five tenths, six tenths.	

Mary essentially asked Wendy what other fraction denominations besides tenths could the group use to find a fraction between one-fifth and two-fifths. Mary seemed to want to hear Wendy's thoughts on the problem as, shown later in the interaction, Mary clearly had another fraction in

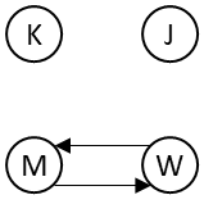
mind. Wendy, not understanding Mary's question, offered Mary three fractions that fit in between three-tenths and four-tenths. In other words, Wendy provided answers to the first problem when Mary was asking for Wendy's thoughts about the second problem. The exchange between Wendy and Mary indicated that group members were unaware of where other group members were in the task.

The teacher stepped in but also assumed that Mary was speaking about the first problem, likely because of Wendy's statement. The teacher asked Mary a series of questions about the first problem which only seemed to confuse Mary more. After a few lines between the teacher and Mary, Wendy interrupted the conversation:

	T-S talk	S-S talk	Student personal
12	**Teacher**: Well, can another fifth fit in between there?		
13	**Mary**: In between wh –		
14		**Wendy**: [looks at Mary] Use tenths.	**Kate**: [working in her notebook]
15		**Mary**: [no pause; quickly] Yeah, but if you did that then…if we're only working with one fifth and two fifths, then how would –	
16	**Teacher**: [talks to the assistant teacher about another student]	**Wendy**: [interrupts Mary] They don't have to be the same (inaudible). So you could do one tenth and something else. (inaudible)	
17		**Mary**: [looks toward her notebook] I was thinking that we should do three tenths and six twentieths because three tenths is in between one fifth and two fifths and six twentieths is equal to three tenths, so…	**Wendy**: [looks at Mary briefly and then writes in her notebook]
18			**Wendy**: [writing in notebook]

It was unclear if, at this point, Wendy knew Mary was referring to the second problem. In any case, Wendy provided a solution that sounded like a directive: “use tenths.” Mary started to explain that if tenths are used then only three-tenths fits in between one-fifth (two-tenths) and two-fifths (four-tenths). So, using tenths would only provide one fraction between the given fractions when the task asked students to find two. Mary did not finish her explanation as Wendy interrupted her again. Though Mary named the fractions of the second problem, it was still unclear whether Wendy knew which problem Mary was on. However, Wendy’s suggestion that Mary could use tenths or another denomination could indicate that Wendy was talking about the second problem as well. Mary continued her explanation and proposed another possible fraction (six-twentieths), but no one responded to her or appeared to acknowledge her.

Below is a diagram of the information-sharing interaction in the excerpt above:



Not only did Kate (K) and Jamal (J) refrain from sharing information, but they did not talk during the interaction. As mentioned previously, Kate and Jamal rarely spoke to the group. Mary (M) and Wendy (W) offered ideas to one another but did not acknowledge or take up one another’s ideas. In lines 2, 15, and 17, Mary attempted to share information with Wendy. However, Mary’s ideas were dismissed, in part because there was a misunderstanding around which problem was being discussed. However, even if Mary and Wendy had been talking about the same problem, there was no indication that Wendy even acknowledged Mary’s ideas. In lines 3, 14, and 16, Wendy told Mary what to do and did not respond specifically to the content of

Mary's statements. Similarly, Mary bypassed Wendy's statements and continued to talk about her own idea. Even in line 15, when Mary responded to Wendy's "use tenths" statement, there was no pause as Mary almost immediately began her thoughts, indicating a lack of shared understanding between the two students.

Interestingly, students in this group did not press pause, so to speak, in the conversation to reassess the situation and make sure they were on the same problem. One could argue that Mary and Wendy were each assuming that they were talking about the same fractions. However, it could suggest that this group did not engage in social metacognitive behaviors to check each other's understanding or work. In contrast, students in the Purple group regularly checked-in on each other to make sure group members were working on or talking about the same problem. Students in the Red group appeared to be working separately and were unaware of each other's work, which meant there was little opportunity for intersubjectivity between group members.

The conversation was dominated by Mary and Wendy, two mathematically-confident students. Notably, Mary's comments were directed towards Wendy. During the exchange, Mary did not look at or orient herself towards Kate or Jamal. Neither Mary nor Wendy included Kate and Jamal in the conversation. Moreover, Kate and Jamal did not say anything, and they mostly wrote in their own notebooks. Kate and Jamal's lack of participation in group could suggest that they either (a) did not feel like they were part of the conversation or (b) were more interested in completing their work than engaging in dialogue with their group members. Either scenario would situate Mary and Wendy as influential players who drive group talk.

Though both Mary and Wendy conversed with each other, they engaged in different ways of communicating information. Mary attempted to use persuasive speech. She initially posed questions (line 2, "What number would we put in between the tenths?"), problematized using

only tenths to find two fractions (line 15, “Yeah, but…if we’re only working with one-fifth and two-fifths, then how would –”), and provided an explanation for her idea of using twentieths (line 17, “I was thinking that we should do three-tenths and six-twentieths because…”). Thus, Mary’s contributions contained elements of promoting discussion within her group, particularly as she tried to problematize the issue of using tenths and made an effort to consult with a group member (Engle, 2012). In response to Mary, however, Wendy used authoritative language. Wendy responded in curt sentences (line 3, “We have three options”; line 14, “Use tenths”; line 16, “So you could do one tenth and something else”) that closed the conversation rather than building on Mary’s thoughts. Wendy also provided answers without explanations and displayed distancing behaviors by interrupting Mary and not acknowledging her ideas.

Mary and Wendy, then, held conflicting ideas of how group members should talk to one another and how group work should be done. Mary wanted to discuss possible solutions with Wendy whereas Wendy seemed to be concerned with reaching the correct solutions and seemed to want Mary to determine solutions on her own. In this interaction, the conflicting ideas of group member roles remained unresolved. There was no compromise, as there was between Aliyah and Terrell from the Purple group. Wendy rebuffed Mary’s attempts to generate dialogue, and, in doing so, Wendy exercised her power to limit Mary’s attempt at generating group discussion, putting Mary in an awkward position. At the end of the excerpt, Mary’s statement trailed off (“so…”). She appeared uncertain about how to proceed given that Wendy and her other group members were unresponsive. Mary continued to engage with Wendy in subsequent interactions, but her role as a group member became more tenuous over time, as shown in the next excerpt.

5.4.2.2 Excerpt 2: "Erase all this"

The following excerpt further revealed group dynamics, in particular Mary and Jamal's relationship with the group. Though one student was mathematically-confident and the other was less so, Mary and Jamal both experienced marginality in the group, albeit in different ways. Importantly, the commonality between Mary and Jamal's exclusion was Wendy. In other words, Wendy was at the center of what happened interactionally in this excerpt.

The task for this excerpt involved the same highway-clean up situation as mentioned previously with the Purple group. One part of the task required students to find the distance that was cleaned after day two if students cleaned one and two-thirds miles each day and, at that rate, how many days it would take to clean ten miles. To find the solution, the task required students use a number line to represent their thinking.

As the teacher arrived at the group, Mary was trailing off in her explanation of how she represented her number line when Wendy expressed confusion:

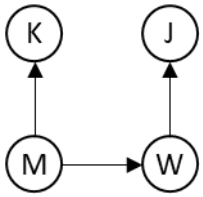
	T-S talk	S-S talk	Student personal
1		**Wendy**: [looks at Kate] She's confusing me. [Her tone has a hint of annoyance.]	**Jamal**: [writing in his notebook]
2		**Kate**: I know. [She says it as if she is commiserating with Wendy.]	
3	**Teacher**: What are you all confused about?		
4	**Mary**: I'm trying to explain to them how –	**Wendy**: [softly but succinctly] Mary!	
5		**Kate**: [looks at Wendy and makes a small laughing sound]	
6	**Mary**: [looking at her notebook] I was saying (inaudible) she was saying that she was confused. I'm trying – what I was doing		**Kate**: [leans over to look at Mary's notebook] **Wendy**: [looking at her own notebook] **Jamal**: [not looking at

	right here is – I started with zero. The halfway mark equals number one. And the end number equals two. So, I split each of the halves into three to get sixths. And I (inaudible) to the middle as three-thirds – we get one (inaudible).		anything or anyone in particular then adjusting in his seat]
7		**Wendy**: [leans over towards Jamal] So, actually, split it in half. [indicated something in Jamal's notebook] Erase all this. Erase all this.	
8			**Jamal**: [erases something in his notebook and starts writing]

Wendy expressed her confusion about Mary to Kate. Wendy did not seem to be eliciting help from Kate to resolve the confusion. Instead, Wendy seemed to be making a statement about Mary in a way that suggested she was irritated. Wendy's statement could be interpreted as a nicer way to say "She's frustrating me." Kate's response ("I know") further indicated that Wendy was not noting the confusion but that she was seeking consolation of sorts. Kate's response also showed solidarity with Wendy but at the expense of Mary. Kate and Wendy appeared to be sharing an exclusive moment, though they were loud enough that other group members would have heard. Then, shortly after Mary began telling the teacher what she tried to explain to her group members, Wendy appeared to show disapproval by saying Mary's name (line 4). Kate, again, seemed to share the moment with Wendy by laughing lightly. Mary continued to explain her idea to the teacher, perhaps eliciting the teacher's help to communicate with her group members. Kate looked at Mary's work, though she did not say anything else. Wendy turned her attention to her own work. Later, Wendy gave orders to Jamal, who interacted

minimally with his group members. Jamal initially wrote in his notebook, but, during Mary's explanation, he looked around into space.

The diagram below shows the information-sharing interactions of the above excerpt:



Mary attempted to share information with her group, mainly Wendy and Kate. Neither Wendy nor Kate explicitly acknowledged Mary's thoughts or ideas. Though Kate's body language suggested that she was, at least, listening, Wendy disassociated herself from Mary by exhibiting distancing behaviors and focusing on her own work.

As shown in the previous excerpt, it was not unusual for Wendy to ignore Mary. What was different was that Wendy expressed annoyance. Wendy generally spoke matter-of-factly, even during instances where she disagreed with her group members. In this excerpt, Wendy appeared to take Mary's actions on a more personal level, particularly evidenced by her soft but disapproving exclamation of "Mary!" Wendy not only expressed her feelings but also openly involved Kate, which had not occurred in previous interactions. Kate, in turn, aligned herself with Wendy. Mary could very well be a frustrating group member, and her careful, but long explanations could be tiresome for her peers. However, considering that Mary was the only group member who consistently endeavored to ask her group members questions and explain her thinking, more negative interactions could weaken Mary's relationships with group members which could simultaneously lead to fewer opportunities for group intersubjectivity.

Cornelius and Herrenkohl (2004) describe a third conceptualization of power (in addition to ownership of ideas and persuasive discourse): partisanship. Though the authors describe

partisanship in relation to mathematical arguments, students can also be divided in terms of how they believe group work should occur. The ways in which group members socially align themselves can tilt the power dynamic towards one conception of group work over another. As I described in the previous excerpt, Mary and Wendy held contrasting ideas about group member roles. Mary demonstrated one way group members could interact with each other, through persuasive speech, while Wendy exhibited more authoritative behaviors and provided solutions. In this excerpt, Wendy's expression of annoyance to Kate and Kate's alignment with Wendy subtly shifted the power dynamics away from Mary's way of interacting in the group.

Wendy's approach to group work dominated group work interactions. This was also evident in the way Wendy interacted with Jamal. Wendy, in line 7, provided information to Jamal and told Jamal exactly how to split his number line and what to erase from his notebook. Like in the previous excerpt, Wendy's directives were not followed by an explanation. Again, Wendy was authoritative in her communication. Jamal did not question Wendy or exhibit frustration at having to re-do some of his work. He appeared to comply with Wendy's statement, and there was little indication that he was interested in why Wendy wanted to split part of the number line in half.

Jamal's participation was starkly different than Terrell's participation in the Purple group. Terrell actively participated in his group whereas Jamal displayed passive behaviors. But, to call Jamal a "freeloader" or "disengaged" would be to mischaracterize him. He frequently worked in his notebook and asked the teacher task-related questions. In fact, he directed his questions mostly to the teacher. Across all group work interactions for this group, Jamal asked the teacher questions five times (for example, "Is this two-thirds and one whole?" or "So, it says 475 apples, what are the kg for that?"), but I had no evidence of him asking questions to his group members.

It was noteworthy that Jamal's questions could have been easily answered by his group members, but he chose not to ask them. This suggested that Jamal was invested in working through tasks but refrained from engaging in group work – possibly because his group members did not provide him opportunities to contribute.

Looking at this group's interactional patterns and the way that group members interacted (or did not interact) with him, Jamal could have been withholding his consent (Erickson et al., 2008) to engage in group work. It was also possible that Jamal felt that he could not say anything to the group. His only person of contact with the group was Wendy, and Wendy did not seem interested in helping him understand how to solve problems or his thinking. Moreover, if even mathematically-confident students like Mary were shut out by Wendy, the barriers for participation could seem higher for Jamal. Thus, Jamal had very little influence in shaping group work interactions, in part, because he was not included in group conversations and had no clear role in a mostly authoritative discourse structure driven by the one mathematically-confident student who was his only connection.

5.4.3 Summary

The excerpts from the Purple group and Red group illustrated how power dynamics were produced through social interactions. In the Purple group, where interactional patterns showed that information-sharing was balanced among group members, mathematically-confident students gave ownership of ideas to a less mathematically-confident group member, Terrell, and included him in conversations. Moreover, students in the Purple group fostered intersubjectivity by explaining their thinking to one another and building upon each other's ideas. In contrast, power relationships were asymmetrical in the Red group. Mathematically-confident students

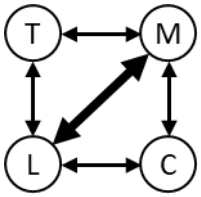
rarely shared information with a less mathematically-confident group member, Jamal, or provided information in an authoritative manner. In addition, students ignored or dismissed more persuasive forms of discourse, embodied in one mathematically-confident student, Mary. Power dynamics in groups provided insight into how students participated these groups and their future participation group work.

5.5 GROUP PARTCIPATION: INCLUDED AND EXCLUDED STUDENTS

In the previous section, I suggested that student participation may be related to group social relationships and power dynamics. Here, I explore that relation by focusing on less mathematically-confident students. Less mathematically-confidents students may be in vulnerable positions within groups, particularly if they do not understand the material and are unsure of how to contribute. Jamal from the Red group, for example, rarely interacted with his group members and was told, by his group member, what to do in the problem and how to do it. Yet, students like Terrell from the Purple group actively participated in group discussions, and his group members elicited his thinking. What about the group dynamics could help explain differences in participation between less mathematically-confident students? Were there other students like Terrell? Or was Terrell an unusual case?

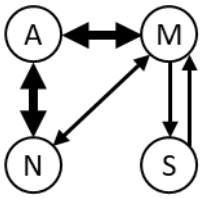
The answer to the last question was no. Tiana from the Yellow group, like Terrell, came into the classroom with a low score on her previous year's math state test, was identified as a special education student, and encountered difficulties in solving task problems. Yet, again like Terrell, she was an active participant in group work. Tiana's group also had a balanced

interactional structure, similar to the Purple group but with one fewer connection (between T and C) and not as strong relationships:



As the interactional patterns show, Tiana shared information with Lyla (L) and Molly (M). In the highway clean-up task, she shared her representation of the number line (Tiana: [counting the tick marks on her number line] One whole and two-thirds. One whole and two-thirds. And two whole and four-thirds. And then…). In another task involving finding decimal equivalents for benchmark fractions, Tiana shared her thoughts on what six-fifths would be as a decimal (Tiana: It would be one and twenty hundredths.). In response, Lyla and Molly attempted to gain clarity around Tiana's thinking (Molly: So wait, Tiana, that's four-thirds. Wouldn't that be three wholes and…yeah) or asked Tiana to explain her work further (Lyla: Why did you write point two zero?). Though there was no clear instance where Lyla and Molly gave ownership of an idea to Tiana (as students did with Terrell in the Purple group), Lyla and Molly worked to establish intersubjectivity by explaining their thinking and eliciting Tiana's thinking. Thus, Tiana's participation appeared to be fostered by her group members who included her in the exchange and construction of information.

However, in another group, students included one less mathematically-confident student while simultaneously excluding another. The Blue group had an asymmetrical interactional structure, though more connected than the Red group:



Nya (N) and Steve (S) were both special education students and often received help from the assistant teacher. As shown by the interactional patterns, Nya was more involved in the sharing of information with the group than Steve. Interestingly, Nya demonstrated prosocial behaviors towards group members while ignoring or dismissing Steve. In one instance, Nya displayed distancing behaviors towards Steve by calling him out (Nya: [makes a buzzer noise to Steve] Wrong!) for responding inaccurately to a teacher's question and, later in the same interaction, by expressing frustration that Steve was not listening (Nya: [to the teacher] He won't believe us…I had Max tell him but he won't listen). Steve, over time, participated less and less in the group. In fact, in two separate lessons, Steve told his group members to move on to the next problem without him. The teacher voiced concern that Steve was not working with his group members (Teacher: You told them [his group members] to move on, Steve?) but allowed him to work independently with help from the assistant teacher.

The above interactions involving Terrell, Jamal, Tiana, Nya, and Steve demonstrated the complexity of social dynamics and student participation in groups. Each student encountered difficulties in solving math tasks. Yet their mathematical ability or their confidence in solving problems alone did not explain their level or form of participation in group work. Students' social status also lacked explanatory power to explain differences in participation, as status differentials appeared to be greater or smaller depending on the group. Somehow, the dynamic interactional processes between students within groups recursively influenced students' participation patterns over time. The group social dynamics appeared to be based on the unique

composition of group members. The unique interactional patterns, over time, seemed to lead to the inclusion or exclusion of students. There was some evidence of this as a student in one focus group stated, “It [group work] also has something to do with who you are, like how we have like our own groups with a certain amount of people, and I think it has to do with the people that you are sitting with and how you can work with somebody.”

5.6 AN INTERESTING CASE: GROUP DYNAMICS

As I mentioned, group social dynamics could be the result of group composition and the unique interactional characteristics that students bring to the group. Here, I want to dispel two notions: (1) that students’ personalities accounted for why some students were more vocal and active and (2) that the group context accounted for student interactional and participation patterns. In other words, I want to avoid the conceptualization that either student factors or group factors were singularly driving the group interactions described above. Instead, I propose that the driving factor is the social dynamics itself – the interactions between individual students with other students in the group context.

The dataset provided a unique opportunity to explore this idea. In the middle of video-recording Ms. Ellis’s classroom (sometime between video-recorded lesson 5 and 6), the teacher had Terrell and another student, Darnell, switch seats. Terrell was a member of the Orange group prior to becoming a member of the Purple group, while Darnell was a member of the Purple group prior to joining the Orange group. In their initial groups, both Terrell and Darnell appeared to be less engaged in group work (described below). Perhaps noticing that the two students were

struggling in their respective groups, the teacher decided to intervene, and Terrell and Darnell's participation improved upon joining their new groups.

I have already described Terrell's interactions with his group members in the Purple group. In the Orange group, Terrell's participation looked very similar to Jamal's participation in the Red group. Terrell rarely interacted with his Orange group members and, like Jamal, asked the teacher questions rather than asking his group members. Group work in the Orange group was directed and coordinated by two mathematically-confident female students, Makayla and Keri. The two students typically consulted one another about a problem – exchanging ideas and asking questions almost exclusively to one another. Once an acceptable strategy or solution was reached, they then helped other group members.

Though Makayla and Keri did not use authoritative language and took time to explain their thinking to Terrell and another student in the group, Tyrone, the girls did not ask for input from either student. Tyrone was soft-spoken but did not seem to struggle with the math, and, in a video showing a partner quiz which was not analyzed here, he demonstrated that he had good strategies to solve problems. Yet, both he and Terrell did not participate in conversations between Makayla and Keri. Not only did Terrell refrain from sharing his thoughts to the group but he asked the teacher if she could help him with a problem at the back table (Terrell: [raised his hand and said to the teacher] Can I have some help at the back table, please?). In this classroom, it was very rare for students to ask to work apart from the group. (Only one student, part of the Green group, worked outside, away from his group; The student worked on tasks outside the classroom for personal reasons.) Terrell's behaviors in the Orange group showed that his participation in the Purple group was not because he was inherently sociable or outspoken.

On the other hand, there was nothing magical about the Purple group that helped to promote student interactions. Darnell, the student who switched seats with Terrell, was initially part of the Purple group. He and the Purple group members had trouble getting on the same page and getting along. Darnell displayed behaviors that suggested he was not enjoying group work. He infrequently looked in the direction of his group members, and he often laid over his desk with his cheek on his notebook, facing outside of the group. A couple times, he stood his binder up like a barrier between him and his groupmates. There was one incident where students of the Purple group called the teacher over to tell her that Darnell was not participating in group work (Brad: And also, he's not following along. He's just copying.). Darnell became defensive, saying that he did not know what the group was discussing (Darnell: I have no clue!). Darnell did not seem to understand what his group members were doing and why they were doing extra work. When the teacher noted that he "should never just want to do the bare minimum," Darnell shrugged and replied: "I've always wanted to do the bare minimum. Just get it over with." Darnell's idea of group work did not seem aligned with what his group members wanted to do.

Darnell's interaction was much different in the Orange group. He did not collapse over his desk or use his binder as a barrier. He appeared to be more engaged, writing in his notebook and looking at his group members. Overall, Darnell exhibited less resistance to work. The Orange group, which seemed unhelpful for Terrell, seemed to be less stressful for Darnell. Perhaps Darnell did not know how to engage in the kind of collaborative group work that the other Purple group members encouraged. Or, it could be that there was a prior event in the group that led to negative social relationships between Darnell and the other group members. Whatever the reason, being in the Purple group was not empowering for Darnell.

I do *not* highlight Terrell and Darnell's situation to show that there may be "right" or "wrong" configurations or compositions of groups. The case of Terrell and Darnell suggests that group dynamics are not the result of student-level factors or group-level factors but the interaction between both levels. Thus, to promote balanced power relationships between students and active participation in constructing information for all students, it may be important to examine and understand group interactions rather than focusing on only individual students or only group characteristics.

5.7 OVERALL SUMMARY

Group power dynamics were socially constructed over time through interactions. Power dynamics, related to information-sharing were different for each group. In some groups, like the Purple group and Yellow group, students engaged in the reciprocal exchange of information that contributed to a shared understanding of mathematical ideas. In other groups, like the Red group and Blue group, information was withheld by or concentrated around certain mathematically-confident students. The emerging balanced and asymmetrical power relationships had implications for student participation. Students were more likely to actively participate in groups where information, and therefore power, was mutually shared and less likely to participate in groups characterized by authoritative discourse or skewed power differentials.

6.0 DISCUSSION

Group work is socially complex, and uniquely complex for each group. This study suggests that the ways students socially interact with each other in a group can create vastly different learning contexts that shape how students participate. The statement may be seemingly obvious, but it highlights that there are different *interactional contexts* within the same setting of collaborative group work. Stevens (2000) states that a "finer-grained sense of context is, if nothing else, a tool for avoiding premature conclusions about what a setting is based on its name or official primary function" (p. 133). Thus, one cannot assume that a collaborative group work structure will entail wholly collaborative interactions. In addition, a finer-grained interactional context can be a tool to understand not only whether students are working together but *how* students are interacting with each other. For instance, within collaborative group work, some students may exercise power in a way that creates imbalanced, unequal social dynamics.

Power dynamics between students constituted the main finding in this study. Investigating power in the classroom is not new in mathematics education. Researchers and educators have generally examined power in relation to societal discourse around race and culture, such as classroom spaces constructing or perpetuating systemic inequities for students of color (Hand, 2012; Nasir et al., 2008). In this study, however, I have described power relationships between students. Though macro-level issues related to race and culture without a doubt shape students' interactions in the classroom, my analysis shows that power emerges from

micro, interactional contexts. Following Foucault, power exists through social interactions (see Cornelius & Herrenkohl, 2004; Ford, 2003), and asymmetrical power relationships may result in some students having greater opportunities to participate while others are excluded.

Power relationships among students – tied to the exchange or take up of knowledge and information in this study – can shape the interactional plane or landscape that, in turn, determines who participates in the group and what participation looks like. As in the case of the Purple group, students respected and valued each other's ideas even during moments of uncertainty. More importantly, they empowered a more vulnerable group member, Terrell, who struggled with solving tasks. Over time, all members of the Purple group equally contributed to the co-construction of information. In contrast, one student from the Red group, Wendy, exerted power in a way that limited discourse and excluded group members. Consequently, not all group members had the same opportunity to shape discourse. Over the course of the lessons, Red group members interacted with each other less frequently.

Though my findings are exploratory, I propose that understanding power relationships reveals key insights into why certain groups are more successful in collaborating than others. This study and prior studies have described power in relation to student participation (Cornelius & Herrenkohl, 2004; Wiebe Berry, 2006). Power may also affect social organization and management of group work. Particularly in moments of uncertainty, students with differing ideas of what it means to do group work may exert power to influence how group work happens. Like the Purple group, students may use persuasive language to reflect and evaluate other's ideas, thereby facilitating collective problem-solving. On the other hand, as in the case of the Red group, students may employ authoritative language that rewards "correct" answers and hampers

discussions. Ultimately, such modes of power may lead to different interactional patterns and different regulation of groupwork.

I further propose that power dynamics between students may be one way to look at relational equity and social status in the classroom. Power imbalances may undermine relational equity and increase social status differentials. Without an understanding of power dynamics, it may be difficult to diagnose why students are not collaborating in the ways expected or identify which interactional moments to intervene on to promote relational equity or equalize social status.

6.1 POWER AND RELATIONAL EQUITY

Power may be central to the concept of relational equity. As mentioned in Chapter 2, relational equity, as defined by Boaler (2008), relates to democratic ideals of having equal standing in a context. Boaler (2008) conceptualizes relational equity as respect for other people's ideas, commitment to the learning of others, and ways of communicating that support or help others. Achieving those facets may necessitate balancing power among students as asymmetrical power relationships between students can privilege certain students over others in discourse. More specifically, asymmetrical power relationships may make it more likely for certain students to determine what ideas get put on the table and what ideas get discussed, thereby driving the direction of discourse and potentially leaving out other students.

Another way in which power may affect relational equity is through student perceptions. Power differentials can affect individual students' mental states (Magee & Smith, 2013). Students who are able to exercise more power may exhibit less interest in other's perspectives

(Galinsky, Magee, Ena Inesi, & Gruenfeld, 2006) and even engage in more stereotyping of others (Fiske, 1993; S. A. Goodwin, Gubin, Fiske, & Yzerbyt, 2000). Moreover, larger differences in power can diminish feelings of psychological safety in the group (Curşeu et al., 2012; Edmondson, 2004). As a result, students on the low end of the asymmetrical power relationship may feel the group climate is not conducive to participation. These mechanisms may help explain why, for example, Wendy who was more "powerful" in the Red group appeared uninterested in group member's ideas and why other group members, like Jamal and Kate, generally refrained from sharing their thoughts.

Persistent power differentials may lead some students to feel like they do not belong in the group. Given that sense of belonging is an fundamental component of motivation (Furrer & Skinner, 2003; Goodenow, 1993; Ryan & Deci, 2000) and important for engaging in meaningful discourse (Boaler, 2006, 2008; Hadjioannou, 2007), threats to belonging can derail collaborative group work. On the other hand, feeling belongingness can elevate group work and create a space where students show solidarity even during moments of misunderstanding or disagreement, as in the Purple group. Students in the Purple group consistently interacted with each other in respectful and democratic ways, particularly in giving each other ownership of ideas and using persuasive language, that may have facilitated strong group membership. As Boaler (2006) states, relational equity depends on a culture of care and respect, including a sense of connectedness in a community of learners.

6.2 POWER AND SOCIAL STATUS

Power may provide a different perspective regarding social status. Because of the society that we live in, students carry with them their race, gender, social class, perceived ability, social desirability, and other statuses into the classroom. But, which statuses become salient and how they become salient depends on the interactional context (Stevens, 2000, p. 109). In other words, students' social statuses are extremely important to consider, but equally important is how those statuses play out in interactions. Depending on the interactional context, for example, students who are perceived as having low ability may become active, integral group members or become marginalized and excluded from group activities (Horn, 2012). Thus, status may be irrelevant in one context while highly differentiated in other. In one way, social status *differences* may arise from power differentials.

The statement may seem counterintuitive. Prior research has conceptualized it in the opposite direction: as social status differences giving rise to power (Cohen & Lotan, 2014; Horn, 2012). Yet, the manifestations of power through interactions could also produce differences in status. Meaning, who exercises power and how others respond can generate perceptions of whether group members have higher, lower, or equal status. For example, two students from the Blue group, Nya and Steve, both encountered difficulties in solving tasks and were less mathematically-confident, but one student was an included member while the other student was excluded. One could argue that their inclusion or exclusion depended upon their relative social status in the group. However, I propose that, by aligning with mathematically-confident group members and distancing herself from Steve, Nya created an asymmetrical power relationship that, over time, constructed a status difference between herself and Steve.

Statuses like perceived ability may not correspond with who has "control" in the group. Meaning, power in the group does not necessarily follow high status. For instance, mathematically-confident and articulate Mary occupied an increasingly tenuous role in the Red group. Wendy, on the other hand, appeared to grow in dominance, recruiting Kate to her side in distancing Mary and acting as an authority figure to Jamal. Again, one could argue that Mary had a lower status relative to Wendy and thus had less influence in group work. But, it is also possible that Wendy attempted to "take away" power from Mary to gain greater influence in the group. Though, that does not mean Mary was powerless. Mary seemed persistent in her efforts to convince Wendy to see things her way. Therefore, by exercising power, students can construct, define, redefine, reinforce, or resist perceptions around status. Understanding power, then, can allow teachers to see how students actively shape their own as well as others' social status in the group.

6.3 IMPLICATIONS FOR TEACHER SUPPORT

Power is inherent in social interactions. If power dynamics are ignored, teacher supports aimed at promoting relational equity and reducing status differentials may inadvertently reproduce or reinforce power relationships that potentially exclude members of a group or community. This may be due to the tendency for teachers to focus on providing supports for and assigning competence to all students without attending to how students on the higher end of asymmetrical power relationships may be influencing the interactional plane in ways that limit others' participation. Moreover, ignoring or justifying power differentials (e.g., by allowing mathematically confident students to direct group work) may decrease relatedness among

students (Magee & Smith, 2013) and, as mentioned, propagate stereotypic ideas around who belongs in the classroom (Fiske, 1993; S. A. Goodwin et al., 2000). Balancing power, then, is central to supporting social interactions. This has implications for teaching practice in the following ways:

First, teachers should consider providing different kinds of supports to students depending on power dynamics. For groups like the Purple group where power was relatively balanced and there was a strong sense of group membership, a teacher may focus their energy on elevating student discourse to support deeper understanding around the mathematics. Meanwhile, for groups like the Red group, a teacher may have to provide more targeted supports to shift power dynamics. A common support recommended by the current literature is assigning competence to less mathematically-confident students in order to highlight students' strengths (Cohen & Lotan, 2014; Horn, 2012). However, if social interactions are conceptualized as occurring on an interactional plane, simply providing supports to students with lower ability may not change the group dynamics. Teacher may also have to socially support mathematically-confident students to make them aware of how their behaviors are influencing group work and demonstrate ways to be more respectful "citizens" of the group community. Teacher support and guidance can involve encouraging students to constructively exercise power through respectful, persuasive exchanges of ideas and explanations rather than exerting power in authoritative ways. In other words, teachers can play an important role in disrupting asymmetrical power dynamics in groups.

Second, teachers should consider understanding power in addition to social status in the classroom to achieve equitable participation. In fact, looking solely at social status may result in problematic assumptions of how students are interacting or how they will interact with others. A

more helpful way to consider social status may be to observe how students attempt to construct status through power. By attending to power dynamics, teachers may be able to address problematic interactional moves early on, such as distancing or "othering" in response to a proposed idea, that could potentially create status differences over time. However, noting status differentials may be useful as they may indicate an imbalanced power dynamic among students. Teachers should recognize that discourse dominated by students of perceived high ability or other status may be symptoms of social interactions that reinforce status differentials. Teachers can then assess the patterns of interactions between students in discourse (e.g., who is giving information to whom, who decides who gets the information, who is taking up information, who decides which information is important, etc.) and how students are being included or excluded.

Third, as prior literature suggests, establishing a shared understanding of norms that provides a framework for how students should interact with each other is extremely important (Cohen & Lotan, 2014; Horn, 2012). However, building collaborative groups does not end with norms. Even in classrooms with high relational climate and a culture of caring, such as the classroom in this study, students may not have the same opportunities to participate if power dynamics tilt the interactional plane to favor certain students over others. As described above, teachers should also attend to how students exert power *in the moment*, especially during moments of uncertainty when social norms may become ambiguous. Teachers can also make power explicit in interactional moments – by identifying moves related to giving ownership of ideas, showing solidarity or partisanship, and using persuasive or authoritative discourse – to help students understand the consequences of their actions in relation to others and ways to facilitate group participation.

6.4 LIMITATIONS AND FUTURE WORK

The main critique of a case study design is the lack of generalizability to other contexts or situations. The critique not only questions the general relevance of the findings but also the validity of case studies. However, the in-depth analysis that a case study design requires can offer key insights into the features and processes that make up a real context (Creswell & Poth, 2017). Findings from case studies can inform future research by providing a more complex, nuanced view of a phenomenon and point to critical areas for development.

In this case study, a limitation is the inevitable uniqueness (in terms of personality or individual traits) that the students and teacher bring to the classroom which shapes the social interactions seen in group work. Consequently, particular interactions or interactional patterns may not be the same as in other classrooms. Another limitation is that this case study examines one form of teaching which affects what students do in the classroom and how students do mathematical work. As such, the findings cannot not speak to what happens in math classrooms broadly. To ensure relevance and trustworthiness, in my analysis process, I have continuously dialogued with prior literature regarding group work, specifically in mathematics education. I situate my work within central concepts and theories in educational psychology, mathematics education, and cognitive psychology. The rich detail of naturalistic interactions this work provides can be informative for researchers in those fields investigating or assessing group work in classrooms.

One major limitation of this study is the lack of student perceptions on specific group work moments. Though focus group data have provided me with students' overall perceptions of the classroom context, interviews with students about particular interactions or problem-solving processes would have provided greater insight into student power dynamics. Another limitation

of this study is, due to video and audio limitations, I could not fully track each group's progress over time. Though I have strived to be accurate in my characterizations of group interactions, capturing group work in greater detail – for example, including student work in video-recordings – would have allowed me to follow each group's thinking as it evolved over the lesson and, especially, whose ideas took hold. Such information could have provided greater support for my findings.

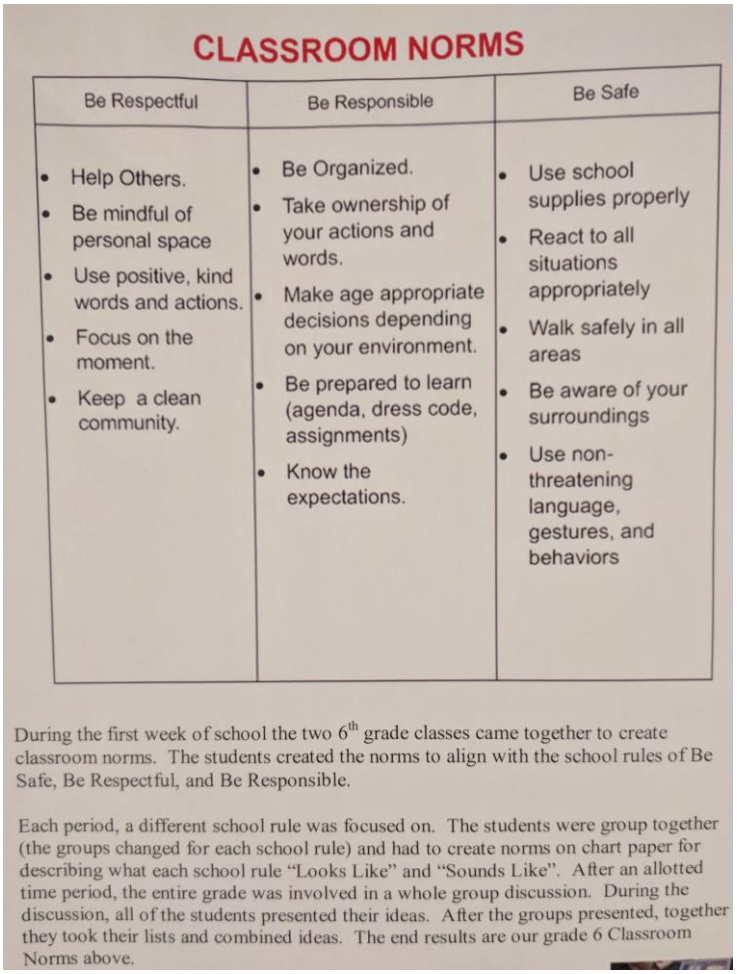
Future work on student collaboration should consider incorporating student perceptions of group work interactions and how students feel about interacting with each other. Future work can also focus on other forms of power, such as language use, in group work. For example, students may use ways of speaking and linguistic practices to promote social connections, challenge others' ideas, or resist dominant forms of talk (Malsbary, 2014; Moschkovich, 2010). Furthermore, future studies can investigate how interactional forms of power overlap with broader forms of power in terms of race, gender, or culture. One potential study may involve examining, using critical theories, the kinds of information exchanged in addition to the ways in which information is shared among students. Such analysis may reveal how subtle shifts in power within student interactions can produce what information becomes identified as relevant and whether the information deemed relevant is culturally inclusive.

Given that manifestations of power are present within all interactions (Berger, 2008), asymmetrical power dynamics have consequences for how successfully students will engage and learn in group work. In addition, examining power dynamics between students may help teachers better identify interactional moments to support equitable learning opportunities. I hope this study helps conceptualize the ways in which power arises from and affects social interactions so that teachers can see student power dynamics happening *in the moment* within their classrooms.

APPENDIX A

CLASSROOM ARTIFACTS

A.1 CLASSROOM NORMS



CLASSROOM NORMS

Be Respectful	Be Responsible	Be Safe
• Help Others. • Be mindful of personal space • Use positive, kind words and actions. • Focus on the moment. • Keep a clean community.	• Be Organized. • Take ownership of your actions and words. • Make age appropriate decisions depending on your environment. • Be prepared to learn (agenda, dress code, assignments) • Know the expectations.	• Use school supplies properly • React to all situations appropriately • Walk safely in all areas • Be aware of your surroundings • Use non-threatening language, gestures, and behaviors

During the first week of school the two 6th grade classes came together to create classroom norms. The students created the norms to align with the school rules of Be Safe, Be Respectful, and Be Responsible.

Each period, a different school rule was focused on. The students were group together (the groups changed for each school rule) and had to create norms on chart paper for describing what each school rule "Looks Like" and "Sounds Like". After an allotted time period, the entire grade was involved in a whole group discussion. During the discussion, all of the students presented their ideas. After the groups presented, together they took their lists and combined ideas. The end results are our grade 6 Classroom Norms above.

A.2 GROUP WORK NORMS

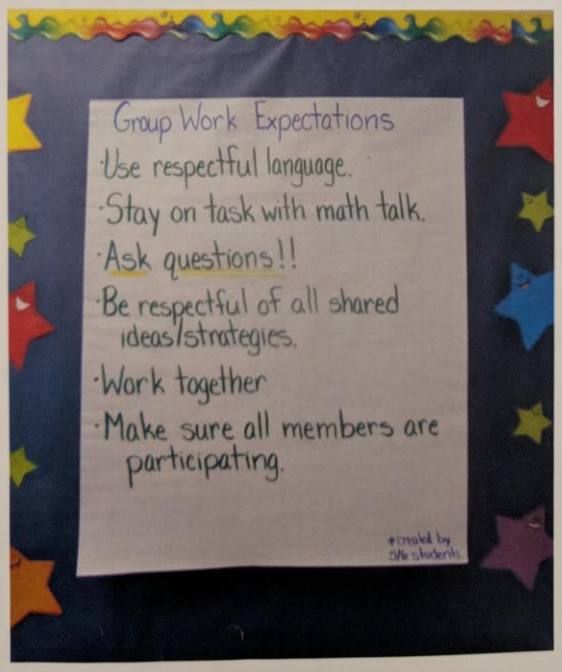
Group Work Norms/Expectations

This year, the students created their group work norms. We spent about 4 days completing various problem solving tasks where the students had to work together. During these days, respectful discourse was modeled from peer to peer and student to student. As a class, students created norms that should be seen and heard during all group work. After the norms were created, the students completed a "fishbowl activity". It was adapted from the following sight.

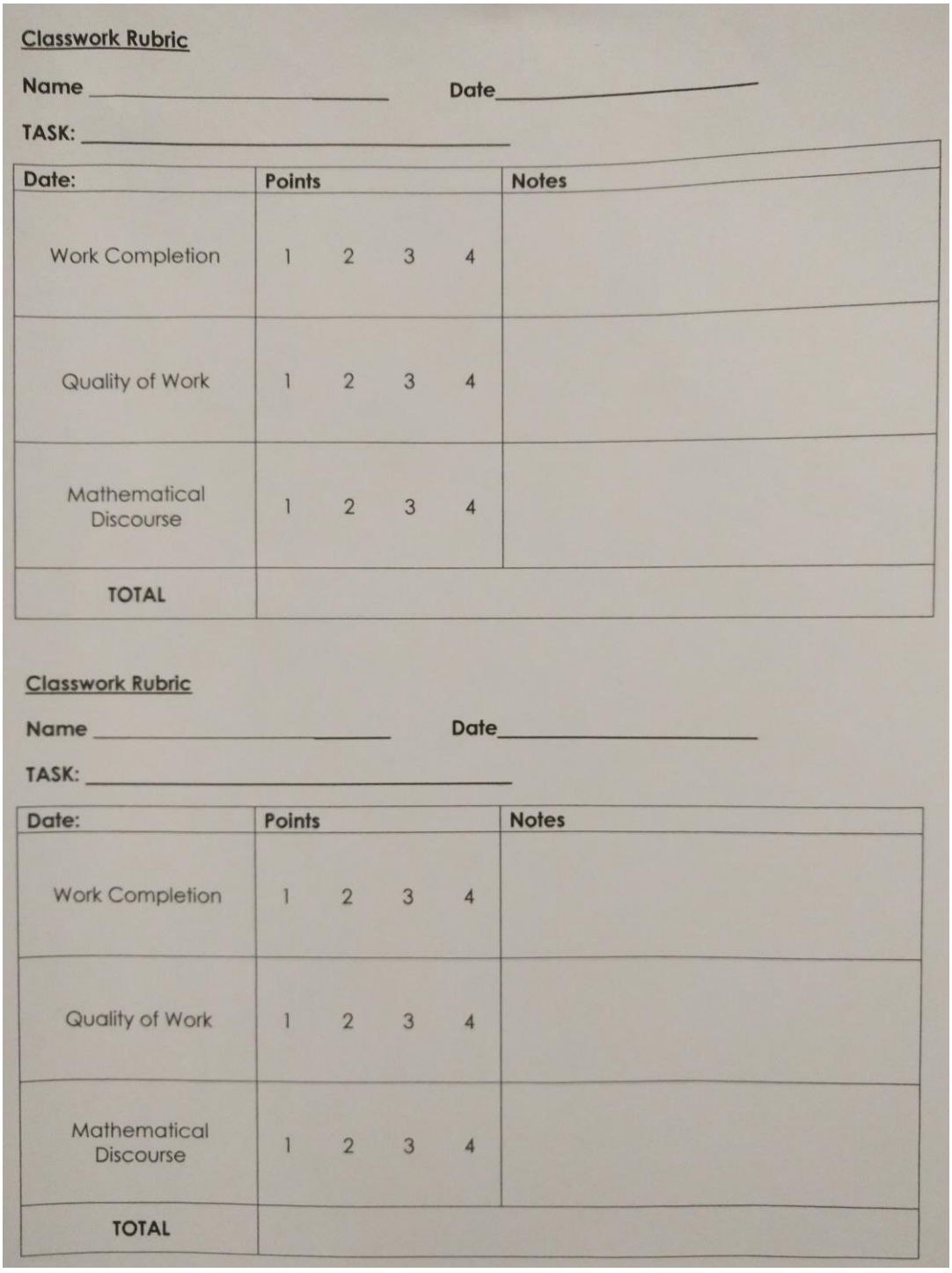
http://www.edutopia.org/math-social-activity-cooperative-learning-video

I had 4 students volunteer to be the "test subjects". They were given a task to complete as a group. As they completed the task, all the other students wrote down notes on what they noticed during their group work, being sure to focus on the group work norms that were created. After an allotted time, the students share their feedback with the "test subjects".

(I'm hoping to complete this activity various times throughout the year).



A.3 GROUP WORK RUBRIC



Classwork Rubric

Name _____ **Date**_____

TASK: _____

Date:	Points	Notes
Work Completion	1 2 3 4	
Quality of Work	1 2 3 4	
Mathematical Discourse	1 2 3 4	
TOTAL		

Classwork Rubric

Name _____ **Date**_____

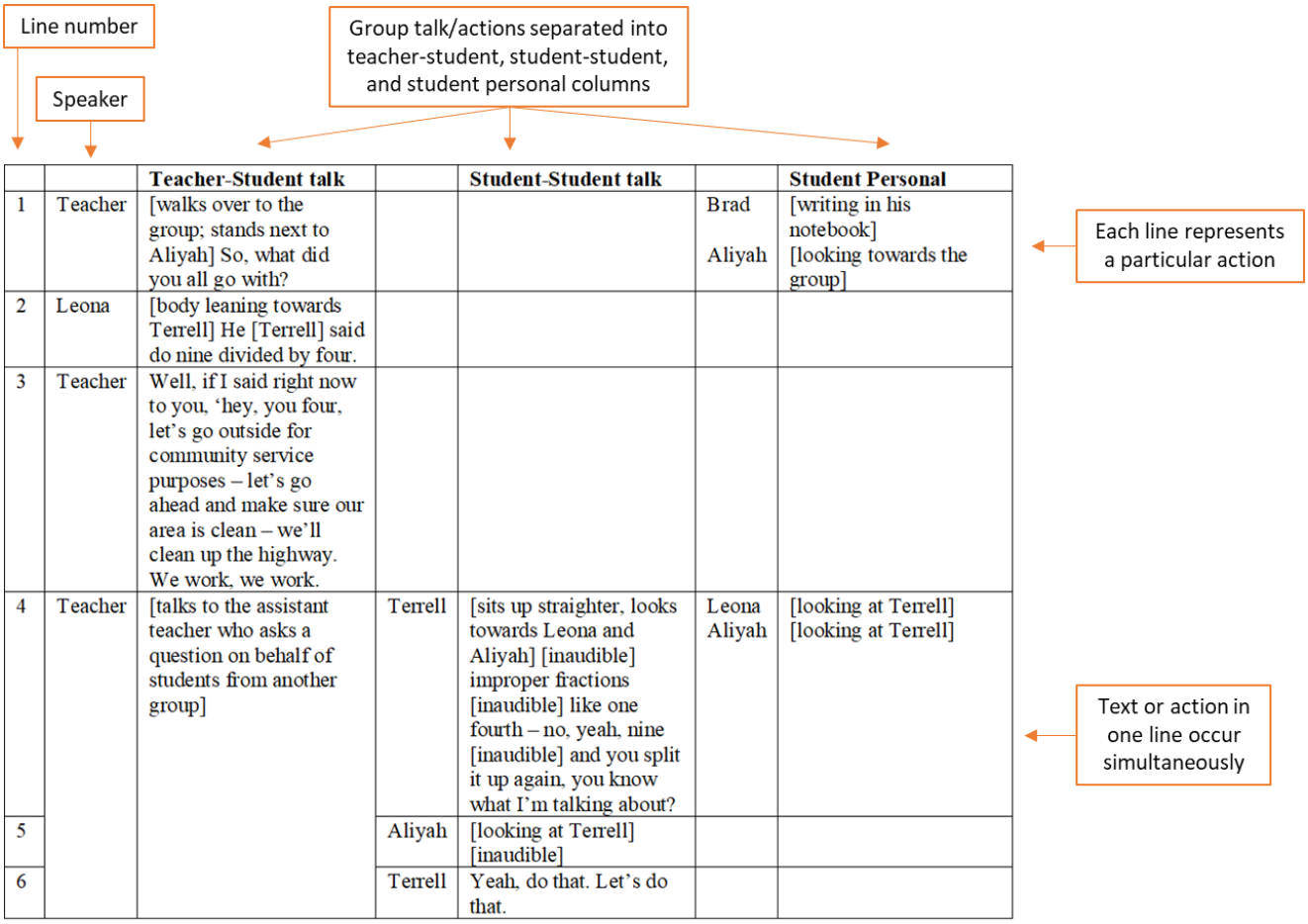
TASK: _____

Date:	Points	Notes
Work Completion	1 2 3 4	
Quality of Work	1 2 3 4	
Mathematical Discourse	1 2 3 4	
TOTAL		

APPENDIX B

EXAMPLE DATA RECORDS

B.1 ANNOTATED TRANSCRIPT



		Teacher-Student talk		Student-Student talk		Student Personal
1	Teacher	[walks over to the group; stands next to Aliyah] So, what did you all go with?			Brad Aliyah	[writing in his notebook] [looking towards the group]
2	Leona	[body leaning towards Terrell] He [Terrell] said do nine divided by four.				
3	Teacher	Well, if I said right now to you, 'hey, you four, let's go outside for community service purposes – let's go ahead and make sure our area is clean – we'll clean up the highway. We work, we work.				
4	Teacher	[talks to the assistant teacher who asks a question on behalf of students from another group]	Terrell	[sits up straighter, looks towards Leona and Aliyah] [inaudible] improper fractions [inaudible] like one fourth – no, yeah, nine [inaudible] and you split it up again, you know what I'm talking about?	Leona Aliyah	[looking at Terrell] [looking at Terrell]
5			Aliyah	[looking at Terrell] [inaudible]		
6			Terrell	Yeah, do that. Let's do that.		

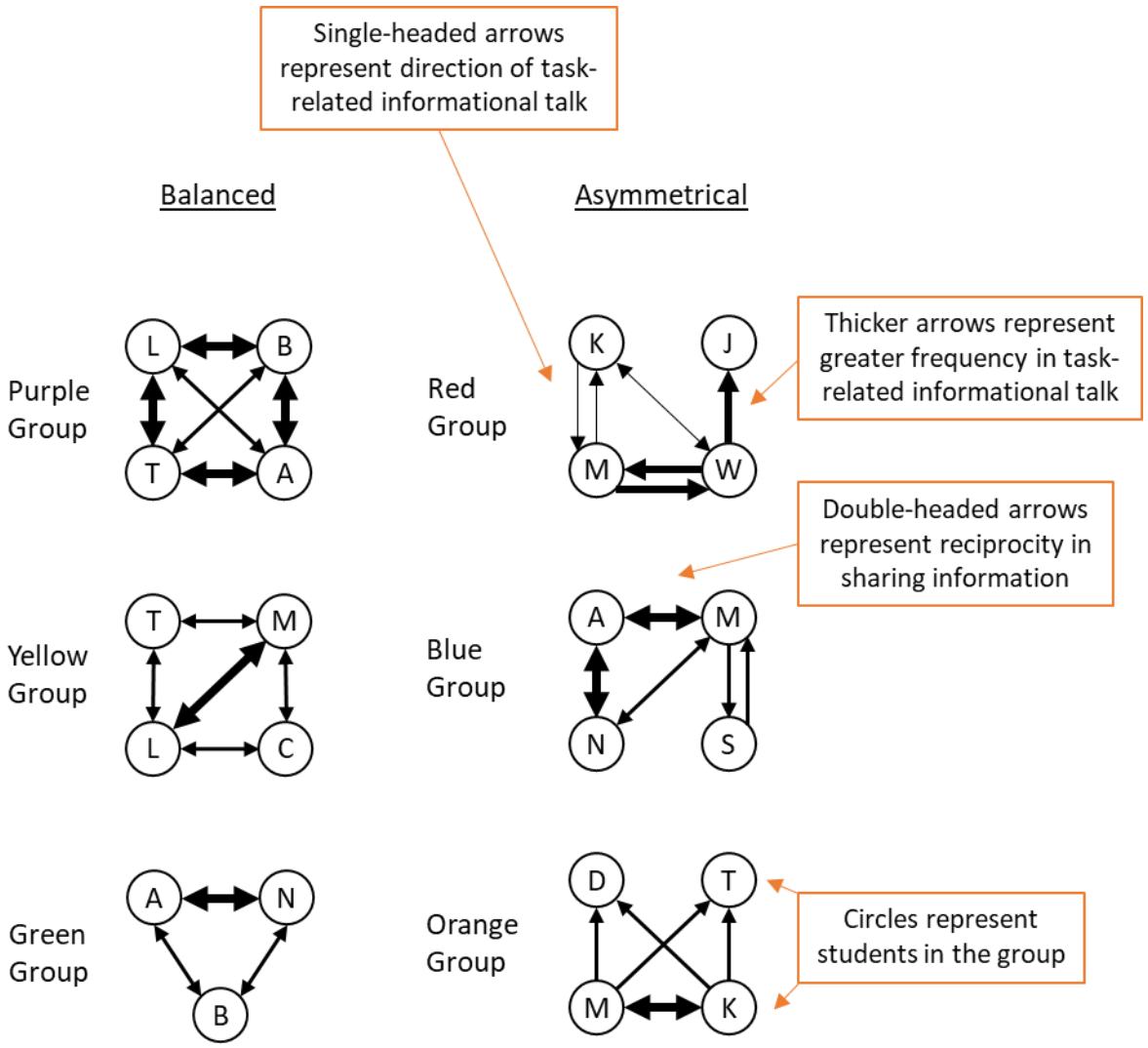
B.2 SAMPLE DATA MATRIX

Group	Prosocial	Distancing	Teacher-like Scaffolding	Defining/Negotiating Roles
Purple	Students in this group exchanged thoughts and ideas on how to solve problems and demonstrated respectful communication by repairing conversational turns.	---	Aliyah scaffolded Terrell's thinking by asking him about his ideas and then asking him to explain his thinking.	Terrell requested help from Aliyah, expecting her to provide information that would directly help him with the task; instead, Aliyah asked him to explain his thinking and suggested that the role of group members is to push each other's thinking rather than providing answers.
Blue	Nya, Max, and Audrey exchanged thoughts and ideas on how to solve problems but also made conversations exclusive by not including Steve into their dialogue.	Nya, Max, and Audrey distance Steve by dismissing Steve's attempt to share his idea about which fractions work in the task.	---	---
Green	Andre and Naomi reinforced each other in dialogue be agreeing with each other and supporting each other's ideas. (Briana was absent during moments of uncertainty in this group.)	---	---	---
Yellow	Students in this group exchanged thoughts and ideas on how to solve problems yet Tiana and Connor rarely interacted with each other.	---	Lyla scaffolded Tiana's thinking by pausing the group's conversation and asking Tiana to explain her work.	---
Orange	Makayla and Keri often exchanged thoughts and ideas on how to solve problems but also made their dialogue exclusive and did not actively involve Tyrone or Darnell.	---	---	---
Red	---	Wendy distances Mary twice, first by shutting down Mary's explanation and second by rebuffing Mary's attempt to share her ideas on how to represent a number line.	---	Mary explained her thinking to Wendy, but Mary was not being heard; Wendy provided Mary with answer options to choose from, suggesting that group members should not discuss ideas beyond the answers known to the group.

B.3 STUDENT INFORMATION BY GROUP

Group	Students	Gender	Prior Achievement	Special Ed
Purple	Brad	Male	n/a	
	Leona	Female	High	
	Terrell	Male	Low	
	Aliyah	Female	High	
Blue	Max	Male	n/a	
	Steve	Male	Low	Y
	Nya	Female	Mid	Y
	Audrey	Female	Mid	
Green	Naomi	Female	High	
	Andre	Male	Mid	
	Briana	Female	High	
Yellow	Lyla	Female	High	
	Tiana	Female	Mid	Y
	Molly	Female	High	
	Connor	Male	High	
Orange	Makayla	Female	High	
	Tyrone	Male	High	
	Keri	Female	High	
	Darnell	Male	Mid	
Red	Mary	Female	High	
	Wendy	Female	High	
	Jamal	Male	Mid	Y
	Kate	Female	High	

B.4 ANNOTATED INTERACTIONAL PATTERNS



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