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Negotiation Towards Intersubjectivity and Impacts on Conceptual Outcomes

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Abstract: To achieve a collective goal, students collaborating in groups must share their interpretations of the goal to negotiate a shared understanding, or establish intersubjectivity, before making progress towards that goal. To investigate negotiation towards intersubjectivity along with students' conceptual outcomes, we studied the discourse of two groups of middle-school students who participated in a 12-week science curriculum. We also evaluated differences in scores on a physics assessment. We found differences in how groups negotiated shared understandings of tasks and concepts and how they participated in conceptual discourse. Group A required significantly more instances of negotiation to establish intersubjectivity compared to Group B, indicating that Group A struggled with establishing shared understandings. Students in Group A also demonstrated greater variance in conceptual discourse and assessment scores, whereas Group B demonstrated more aligned conceptual outcomes. These results indicate that effective negotiation for establishing intersubjectivity is not only an important first step for students' participation in conceptual discourse, but also for achieving balanced learning gains across group members.

Keywords: collaboration, intersubjectivity, conceptual discourse, learning outcomes, CSCL

Introduction

Small groups participating in coordinated activities must establish intersubjectivity, or shared understanding of the current activity; this often occurs through group discourse (Rogoff, 1990; Wertsch, 1979; Jarvela, 1995; Rowe, 2011). Upon initiating group work, each group member may have different interpretations of the shared goal and its sub-components, even when group members receive identical instructions, content, and/or materials. As a result, each group member may describe the current activity differently in terms of the goal itself, necessary tasks, relevant domain knowledge, intentions, and affective responses (Rummel, Dieglmayr, Spada, Kahrimanis, & Avouris, 2011; Jarvela, 1995). For example, students collecting physics data with a rollercoaster simulation may have different understandings of physics concepts; different ways to use classroom tools to collect, record, and organize task-related information; and different connections between collected data, initial hypotheses, and final conclusions. In this example, we can see multiple opportunities for different interpretations – and thus a need to negotiate shared understandings. Different interpretations of the goal and its components necessitate dedicated discourse for establishing intersubjectivity, particularly during collaborative decision-making (Barron, 2003). Students must reveal their reasoning through sharing, negotiating, and jointly creating understandings of the goal in order to make progress.

Group members' interpretations or understandings may be described as *situation definitions* (Wertsch, 1984). During group work, students actively create mental representations of the current situation or activity. However, different students may have different representations. Differences among representations may arise from differences in individual zones of proximal development (ZPD) within the group, especially when considering prior knowledge (Vygotsky, 1978; Wertsch, 1984). Students may define and decompose a situation (e.g., goal, task, or concepts) differently based on their actual levels of development. Additionally, situation definitions are located in time and subject to change. Students may alter and adapt their representations as they encounter others' perspectives and co-construct knowledge (Park & Moro, 2006). These evolving situation definitions may be described as *fluctuations,* which are developed as co-construction "through the process of conflict, negotiation, and renegotiation about the activity during interactions" (Park & Moro, 2006, p. 113) occurring as utterances over time (Rowe, 2011; Hall, 2011; Rommetveit, 1976). Fluctuations help the group to overcome rigid (and possibly inaccurate) representations. They also allow the group to develop a collective situation definition for the activity based on their negotiated understandings.

As group members share and iterate on their situation definitions, they also engage in negotiation of shared conceptual understanding. Collaborative learning involves mutual construction and negotiation of cognition through interactions, such as patterns in discourse (Roschelle, 1992; Rummel et al., 2011; Barron, 2003). Group members collaboratively co-construct meaning as they negotiate conceptual situation definitions. Through a progression of contributing and listening, group members build mutually shared cognition (Baker, 1994; Miyake & Kirschner, 2014; Barron, 2003; Roschelle, 1992). Beyond ensuring that students have similar conceptual understandings, mutually shared cognition is also associated with greater group effectiveness (Miyake & Kirschner, 2014).

In this study, we investigated how two small groups engaged in negotiation of situation definitions of tasks and concepts as they participated in a science curriculum. We used a comparative case-study approach to investigate two research questions: *How did negotiation of situation definitions move students towards establishing intersubjectivity, and how did negotiation towards intersubjectivity impact conceptual outcomes over time? By* investigating these questions, we aim to reveal potential relationships between collaborative group dynamics and meaning-making outcomes. We also aim to identify opportunities for interventions within group discourse that increase the likelihood of greater learning outcomes for *all* group members.

Methods

To study negotiation of situation definitions and students' conceptual understandings, we examined the discourse of two small groups over a 12-week science curriculum. The groups participated in the CoMPASS project (Puntambekar, Stylianou, & Goldstein, 2007), which investigated how students developed science literacy as they interacted with digital textbooks and other distributed scaffolds. CoMPASS was designed as a 12-week design-based physics curriculum that applied physics concepts such as forces, work, energy, and motion to roller coaster design. Students collaborated in small groups and used a computer simulation, a digital textbook (CoMPASS), and scientist's journals throughout the unit. The experiments involved students' manipulation of variables within the simulation to discover relationships between concepts. In this study, we examine how students negotiated shared understandings of goals, activities, and concepts during four of the experiment sessions using a combination of cognitive ethnography and comparative case studies (Puntambekar, 2013; Barron, 2003).

Participants

For our two cases, we selected two groups of four sixth-grade students ($N = 8$) from the larger study sample. These groups were selected because they were from the same classroom, instructed by the same teacher, and attended the same CoMPASS sessions. Participants also had similar prior knowledge based on pre-test scores (see Data Sources). Their class consisted of 22 students divided into six groups. Group A's students included Simon, Ben, Ali, and Mallory. Group B's students included Zach, Lucas, Morgan, and Ana. They attended a large suburban public middle school in the U.S. Midwest.

Data sources

We collected video and audio data of the groups' experiment sessions over a 12-week curriculum (14 sessions total). We selected four sessions to analyze discourse over time: two sessions (1 & 3) from the beginning of the unit, and two (13 & 14) from the end of the unit. All group members were present for each session.

We also used a test designed by the project that assessed understanding of physics concepts. This test was administered prior to and after the 12-week implementation. The test consisted of 29 items related to relationships between forces, work, energy, friction, and Newton's Laws. Correct answers received one point while incorrect answers received zero points; the maximum score was 29 points. The groups' pre-test scores were not significantly different, indicating that students in both groups had similar prior knowledge.

Analysis

Qualitative analysis

Overall, students in both groups contributed 1579 total turns of talk over the four sessions. After reviewing several sessions, we designed a grounded coding scheme that focused on conceptual and procedural and negotiation in small-group discourse. This two-dimensional coding scheme (see Table A1 in Appendix) focused on how students established common ground through negotiation in discourse. Each turn of talk was coded for content (Purpose Code) and progression towards shared understanding, or intersubjectivity (Negotiation Code). Turns that did not fit these categories were coded as Off-Task (19.7% of turns) or N/A (7.0% of turns). Multiple codes were permitted for turns of talk. For inter-rater reliability, we achieved a Cohen's kappa value of 0.904 with an external coder for a subset of the data. Differences were resolved through further discussion.

Quantitative analysis

We used quantitative analyses to compare differences between and within groups, using turns of talk as our unit of analysis. We calculated frequencies and proportions of coded turns of talk for groups and individual students.

To compare Groups A and B, we performed two-tailed tests of homogeneity for proportions of coded turns (critical z-score = +/-1.96, $\alpha = 0.05$). To study differences over time, we used nonparametric chi-square tests to compare Purpose (2 x 4) and Negotiation (3 x 4) coded contributions over the four sessions for each group. To assess conceptual outcomes, we compared proportions of individual students' contributions to conceptual talk over the four sessions. We also calculated learning gains on the physics conceptual assessment (as differences in pre-post scores), along with the mean, standard deviation, and range of learning gains for each group to understand how groups' conceptual understandings developed over time.

Findings

Group differences in talk and changes over time

To see how the two groups negotiated situation definitions, we compared both groups' coded contributions to talk over four sessions. Table 1 shows that Group A contributed significantly more suggestions (0.124 vs. 0.094, z = 2.607, p = 0.009), agreements (0.043 vs. 0.025, z = 2.778, p = 0.005), and disagreements (0.046 vs. 0.029, z = 2.485, p = 0.013) than Group B over the unit. Group A engaged in cycles of suggesting and disagreeing with ideas significantly more often than Group B. In contrast, Group B engaged in more off-task talk (0.136 vs. 0.075, z = -5.366, p < 0.001) than Group A over the unit. Considering that both groups had the same amount of time for experiment sessions, Group A may have struggled to establish shared understandings, while Group B readily established shared understandings and thus had time available to engage in unrelated talk. Overall, Group A engaged in negotiation of situation descriptions significantly more often than Group B.

Table 1. Group comparison z-scores for proportions of talk. Positive values indicate greater contributions from Group A, while negative values indicate greater contributions from Group B. *Significant result at $p < 0.05$.

	Purpose Code		*Negotiation Code*			
Session	**Task**	**Learning**	**Suggesting**	**Agreeing**	**Disagreeing**	**Off-Task**
1	0.138	2.434*	-0.814	3.430*	-2.022*	-2.764*
3	-0.616	-0.223	-0.290	0.084	2.306*	2.223*
13	2.111*	0.548	3.526*	1.586	2.497*	-6.138*
14	-0.373	1.170	2.018*	0.497	2.436*	-2.059*
Overall	0.671	1.427	2.607*	2.778*	2.485*	-5.366*

We also evaluated contributions of talk over time. We used chi-square tests to detect session-based differences in groups' turns of talk related to Purpose (2 x 4 test) and Negotiation (3 x 4 test). Both groups contributed significantly more task-based and learning talk between sessions over time (Group A: $\chi^2 = 9.919$, p = 0.0193; Group B: $\chi^2 = 14.166$, p = 0.0027), indicating that both groups engaged in more turns of talk more over time. Also, both groups demonstrated significant differences in the frequency of suggestions, agreements, and disagreements over time (Group A: $\chi^2 = 16.718$, p = 0.0104; Group B: $\chi^2 = 16.928$, p = 0.0096), indicating that the types of their contributions varied significantly over time.

Conceptual understanding over time

This unit was designed to facilitate learning of concepts through collaboration and interaction with distributed scaffolds. We would ideally see improved conceptual outcomes for all group members (i.e., all students benefited from the unit). To assess conceptual outcomes, we studied group members' contributions to conceptual discourse over four experiment sessions (as seen in Table A2) along with performance on the conceptual assessment. We calculated pre-post differences for each student, or learning gains, in assessment scores along with the mean, standard deviation, and range of learning gains for each group.

To see how groups' contributions to learning-based discourse varied over the unit, we examined differences between group members' proportions of conceptual discourse (from highest to lowest proportions). Figures 1 and 2 (below) show individual students' contributions to conceptual discourse over time. We see that Group A demonstrated greater differences between students ranging from 0.041 (Session 1) to 0.114 (Session 14; see Table A3 in Appendix for all differences). Group A's contributions to conceptual discourse were highly varied between students over time, indicating that some group members participated in conceptual discourse more often than others. In contrast, Group B demonstrated differences between students ranging from 0.000 (no difference; Session 1) to 0.054 (Session 14). This indicates that students in Group B contributed relatively similar levels of conceptual discourse over time than Group A.

Overall, students in Group B were more aligned in their individual contributions to conceptual discourse than students in Group A. This fits with both groups' learning gains on the conceptual assessment. Table 2 shows that Group A's scores showed greater variance (*SD* = 5.377, range = 13), while Group B's showed less variance (*SD* = 1.291, range = 3). Overall, students in Group A demonstrated greater variance in conceptual outcomes while Group B demonstrated relatively similar conceptual outcomes.

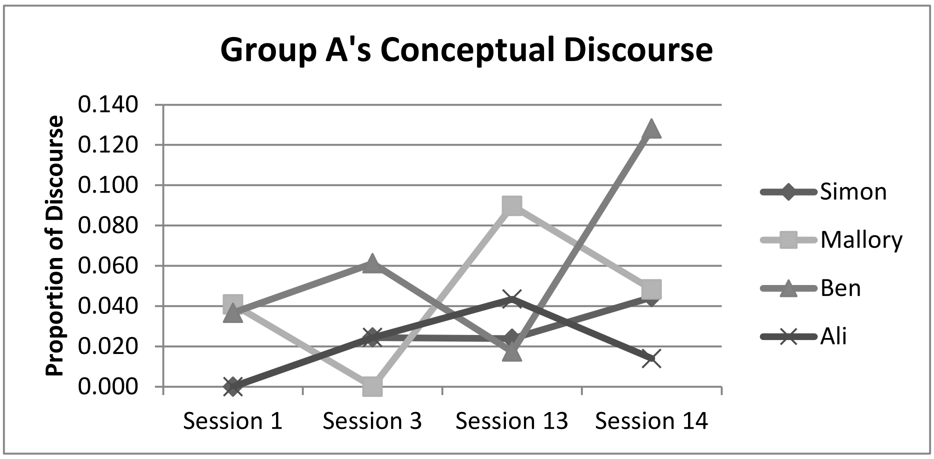

Figure 1. Conceptual discourse contributions (as proportions of talk) by students in Group A.

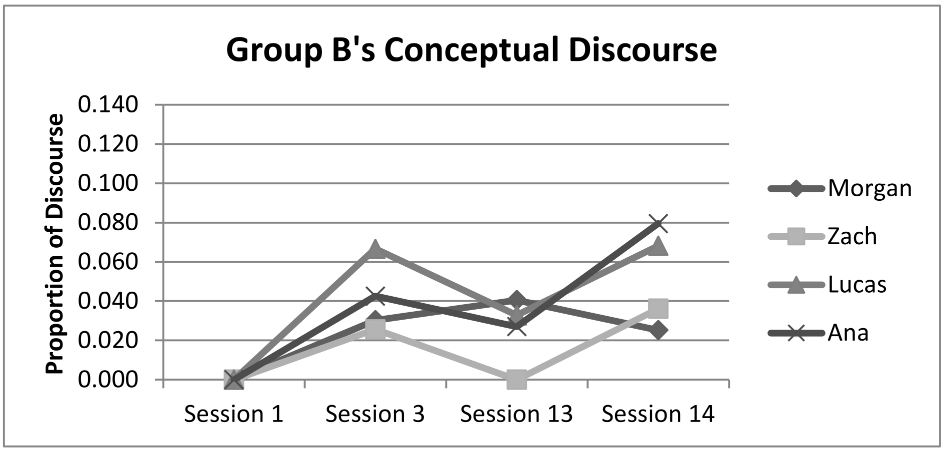

Figure 2. Conceptual discourse contributions (as proportions of talk) by students in Group B.

Table 2. Student learning gains and descriptive statistics for the physics conceptual assessment (max. score = 29 points).

Group	Student	Pre-test Score	Post-test Score	Learning Gains	Range	Mean Gain	Standard Deviation
A	Simon	17	10	2	13	2.75	5.377
	Mallory	18	20	2			
	Ben	13	23	10			
	Ali	18	15	-3			
B	Morgan	15	21	6	3	5.50	1.291
	Zach	14	21	7			
	Lucas	12	17	5			
	Ana	16	20	4			

Here we present excerpts of conceptual discourse as qualitative evidence of group differences. Group A's discourse frequently involved negotiation as initial suggestions followed by disagreements and/or several alternative suggestions. In this excerpt, Group A reached a standstill in their decision for a rollercoaster simulation variable. The goal for this activity was to stop a rollercoaster car in a way that was quick and efficient but did not put excessive force on the riders. Mallory and Ben had different interpretations of the lesson goal; Mallory prioritized shorter stopping distance, while Ben prioritized rider safety. They attempted to explain their reasoning to each other, but their conversations were cut short by Ali and Simon, who prioritized completing the task over reasoning through debate (turns 5 and 10).

Ali:	I think we should do 3 anyway.
Ben:	I think we should do 2.5. That works.
Mallory:	It's not going to help if we take a vote. It's going to be two-on-two.
Ben:	'Cause 3 just stopped it too fast. No, no. It's not fair. It's not scientific-y.
Ali:	Let's just do it.
Ben:	No, it's not fair. Why do you guys think it's 3?
Ali:	Because, um, it takes, um, less [inaudible] and less track to stop it, and it's still safe and efficient.
Ben:	2.5 was more efficient. Uh, 2.5 is more safe. And it still doesn't take that much track.
Ali:	It took --
Simon:	Let's just do this right now and worry about that when we're at the simulation.

In contrast, Group B's discourse typically involved brief instances of negotiation in which students made decisions based on earlier experiments. In this excerpt, students in Group B considered different rollercoaster hill height values, car masses, and friction levels for a complex simulation experiment with multiple input variables. We see evidence of students actively listening to suggestions and repeating them to confirm. Students were able to finish utterances and justify ideas without interruption.

Teacher:	So if this is your hill height, you don't have a – you can still change the value. You just don't have a ton of wiggle room.
Lucas:	80, 85, and 90.
Morgan:	For this you can do 0.2, 0.4, 0.6.
Ana:	Yeah, for our car masses we're doing 0.2, 0.4, 0.6.
Lucas:	0.2 K, 0.4, 0.6 K.
Ana:	I think our friction level should be four.
Zach:	What page is that on?
Morgan:	Well, for our friction level we agreed because that was the one that was, like, the most safe.

Overall, we see that Group A's discourse included unproductive debate and frequent interruptions during explanations, which resulted in incomplete reasoning in decision-making. Group B's discourse included repetition of suggestions to indicate confirmation and productive debate involving active listening and full explanations. While both groups debated how to set up their experiments, Group B's communication and negotiation practices facilitated clarity in suggestions, explanations, and decision-making over the unit.

Discussion

In this study, we investigated how students in small groups negotiated shared understandings, or established intersubjectivity, through their discourse moves. We focused on two questions: *How did negotiation of situation definitions move students towards establishing intersubjectivity, and how did negotiation towards intersubjectivity impact conceptual outcomes over time?* We found that Group A engaged in significantly more negotiation discourse than Group B. Group A required more negotiation of tasks and relevant concepts than Group B, which may be explained by Group B's better externalization and negotiation habits, such as sharing mental models of concepts and actively listening. Also, Group B demonstrated relative ease in reaching consensus on shared situation definitions compared to Group A; thus, they did not require as much negotiation. Overall, Group B established intersubjectivity as shared situation definitions more effectively than Group A.

We evaluated group meaning-making by examining contributions to conceptual discourse. Students in Group A contributed to conceptual discourse in highly varying levels over the unit, while students in Group B contributed to discourse at similar levels over the unit. Group A's varied levels of conceptual discourse aligned with their varied learning gains; Ben gained 10 points from pre- to post-test, while Ali lost 3 from pre- to post-test. Group B's similarity in conceptual discourse contributions aligned with their similar learning gains; Ana gained 4 points while Zach gained 7 points. We believe that Group A's increased instances of negotiation may have negatively impacted their developing conceptual understandings; they never seemed to be "on the same page." In 50-minute classroom sessions, increased time spent on debating situation definitions, especially as unproductive argumentation, limited engagement in conceptual discourse and resulted in differential learning gains for group members. However, students who effectively negotiated shared understandings of the task along with relevant concepts showed similar conceptual outcomes for all group members, possibly explained as reaching mutually shared cognition.

Another lens for study could investigate social dynamics, such as control, in each group. One student maintained control of the shared computer in Group A, while the students in Group B rotated control of the computer. Control over resources can impact adoption of discrete roles, such as technology manager, and alter participation in discourse (Dornfeld & Puntambekar, 2015). This could also impact negotiation of actions and shared understandings. Following studies would involve investigation of relationships between control of shared resources and constraints on negotiation towards intersubjectivity. Students who control the computer take on a role with power and responsibilities, which may impact group dynamics and participation in discourse. Additionally, examination of specific sequences of discourse moves may provide insight into productive (or unproductive) negotiation for establishing intersubjectivity. Sequential pattern analysis of coded turns of talk may reveal ideal or problematic negotiation patterns as intervention targets. For example, if teachers observe a known problematic sequence, such as repetitive arguments, they may intervene and help students to externalize situation definitions and reach consensus. Finally, we plan to develop interventions that evenly distribute and increase learning gains for group members.

The main limitation to this study is the small sample size of students ($N = 8$) and limited diversity in the sample, which decreases generalizability to other populations. However, investigation of this small sample permitted fine-grained analysis of group discourse over the unit. Replication of this study with a larger sample could provide evidence to support our finding that effective negotiation towards intersubjectivity may help group members achieve similar conceptual gains.

Implications and conclusion

This study indicates that establishing shared situation definitions, or intersubjectivity, is a precursor to optimal conceptual outcomes for group collaboration. Collaboration necessitates that students negotiate shared representations of their goals and relevant concepts. In this science curriculum, students needed to share interpretations of their collective goal and its sub-components to effectively make decisions, carry out experiments, and understand the conceptual relationships at work. The theoretical implication of this study involves the importance of intersubjectivity in achieving similar conceptual understanding for group members. This study reveals another piece of how collaboration processes vary between groups and impact how students' conceptual outcomes. Group negotiation of shared understandings is not always easy. For example, students with different zones of proximal development may define situations very differently and thus require additional negotiation towards shared understandings. For practical implications, this study allows identification of opportunities for instructor-based interventions involving effective negotiation of situation definitions. For example, teachers may model ideal discourse practices or class norms. Also, teachers can monitor groups for ineffective discourse patterns (such as when groups appear to be "stuck"), and then intervene with suggestions or scaffolds for building intersubjectivity and shared meaning-making.

Overall, negotiation towards intersubjectivity appears to have consequences for students' conceptual outcomes when participating in small-group work. Groups that are able to co-construct shared situation definitions may show similarities in understanding domain areas, such as physics concepts. However, groups with ineffective negotiation practices may fail to co-construct shared situation definitions and show differential learning outcomes. If we aim for balanced collaborative learning outcomes in small-group work, we must identify and encourage effective negotiation practices, such as externalization and meaning-making strategies within group discourse.

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Appendix

Table A1: Two-Dimensional Coding Scheme for Negotiation of Procedural and Conceptual Understanding

Purpose Code	Description	Example
Task-based (Procedural)	Statement or question concerned with shared task goals, task completion, or procedural decisions (i.e., completing workbook pages)	"We have to do the height."
Learning-based (Conceptual)	Statement or question concerned with shared understanding of concepts or meaning, science content, or conceptual decisions	"Do you think PE will always be the same?"
Negotiation Code	**Description**	**Example**
Questioning	Asks for others' observations, opinions, hypotheses, or other information	"What are we doing?"
Reporting	Makes a statement about observations, opinions, hypotheses, or other information	"0.49 J" "Whoa, it's bigger."
Suggesting	Gives a suggestion for the next group action or how a concept can be explained	"Let's do the height." "Okay, and then we hit play."
Agreeing	Agrees with description or interpretation of task/concept through affirmatives, repetition of descriptions, or expansion of descriptions of tasks/concepts by extending the line of thinking (i.e., finishing another's thought)	"Okay." "Good."
Disagreeing	Disagrees with description or interpretation of task/concept through short statements or with explanations of why the suggestion isn't a suitable course of action	"No, but you have to change that. Change that."
Deciding	Decides on a course of action that is carried out by the group	"Whoa whoa whoa whoa. Okay, I want to make sure. Oh wait, we need to play it again."
Off-Task	Discusses topics not related to the task or physics concepts	"I have French and gym."
N/A	Unintelligible, inaudible, random noises, or unclear meaning	"So…"

Table A2. Students' contributions to conceptual discourse over time (as proportions of overall talk).

	Group A				*Group B*			
Session	**Simon**	**Mallory**	**Ben**	**Ali**	**Morgan**	**Zach**	**Lucas**	**Ana**
1	0.000	0.041	0.037	0.000	0.000	0.000	0.000	0.000
3	0.024	0.000	0.061	0.024	0.030	0.026	0.067	0.043
13	0.024	0.090	0.017	0.043	0.041	0.000	0.033	0.027
14	0.044	0.048	0.128	0.014	0.025	0.036	0.068	0.079

Table A3. Differences between highest and lowest proportions of conceptual discourse contributed by individual students within each session.

	Group A			*Group B*		
Session	**Highest**	**Lowest**	**Difference**	**Highest**	**Lowest**	**Difference**
1	0.041	0.000	0.041	0.000	0.000	0.000
3	0.061	0.000	0.061	0.067	0.026	0.041
13	0.090	0.017	0.073	0.041	0.000	0.041
14	0.128	0.014	0.114	0.079	0.025	0.054