Interplay of Group Dynamics and Science Talk in a Design Based Classroom

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Abstract: This exploratory study investigated the interplay between science discourse and group dynamics of two groups of 6th graders over time as they learned in a technology-rich, inquiry-based science environment. Analysis showed that the group with problematic dynamics engaged in less science talk and failed to improve over time. Despite dynamics and dialogue differences between groups, both groups primarily focused on procedural aspects instead of science. Future studies of group collaboration over time are discussed.

Small group collaboration is now an integral part of inquiry-based science learning, with an emphasis on "learning to talk science" (Lemke, 1990, p.1). While peer interactions comprising explanations, arguments, and examples can enhance learning (O'Donnell, 1999), studies reveal that students often focus on task outcomes instead of the science (Coleman, 1998), and share factual information instead of deeper explanations (Arvaja, Häkkinen, Rasku-Puttonen, & Eteläpelto, 2002). Although researchers have attempted to support collaboration with scripts and prompts (Coleman, 1998; O'Donnell, 1999), these have mainly focused on the content of collaboration. Group processes such as dominance, competitive interactions, and lack of mutual engagement (Arvaja *et al.,* 2002; Barron, 2003) also pose challenges to collaboration. Barron has emphasized attending to the dual nature of collaborative learning –the content related dimension and the social dimension to understand factors affecting collaborative learning.

In this paper, we report an exploratory study that investigated the interplay between the level of science discourse and group dynamics, as students learned in a technology-rich, inquiry-based science environment. We analyzed face-to-face (FTF) interactions as students collaborated in small groups around a single shared computer. Such FTF collaboration represents an emerging area of research in CSCL as students have to simultaneously manage their task and interactions (van Diggelen & Overdijk, 2007). In our study we examined the patterns of group dialogue and dynamics over time to understand the variability in group interactions. We investigated the following research question: *How do group dynamics change with increasing familiarity with group members and task content, and affect the quality of science talk over time?*

Method

This study was conducted in a sixth-grade science classroom in a Midwestern school. Students used CoMPASS (Puntambekar, Stylianou, & Goldstein, 2007), a design-based science curriculum with a hypertext system and design challenges, to learn about Simple Machines. While using the CoMPASS hypertext system, students collaborated in small groups in a face-to-face medium, and interacted around a single shared computer. To complete the design challenges, they brainstormed predictions and questions, used the CoMPASS hypertext system to conduct research for their designs, and completed their designs. Students worked on five mini design challenges, for each of the simple machines. Of the five, we used data from the Inclined Plane (IP) and Pulley units- the first and the final units- to study the two groups over time. The IP challenge involved designing the best ramp to lift a mini pool table, while the Pulley challenge, with more complex science, involved designing the best pulley set-up to lift a bottle of water.

Participants, Data sources, and Analysis

Based on the idea that contrasting cases can reveal differences in processes and outcomes between more and less effective groups (Rummel & Hmelo-Silver, 2008), we chose two groups, out of six, with contrasting learning gains on the post-test. Students took content-based pre-post tests of for IP and Pulley units. The IP test had nine multiple choice and one open-ended question(s). The Pulley test had 11 multiple choice and two open-ended questions. Students could score a maximum of 14 points on the IP test and 17 on the Pulley test.

We transcribed audiotapes of the two groups' collaborative interactions. The data consisted of 222 minutes of audio and 57 pages of transcripts. The rubric was generated inductively by two researchers, and consisted of seven broad themes denoting science talk and group dynamics. These were: (i) *deep science talk* (DT)- connections between science concepts and to concrete features, discussing formulae, misconceptions, science questions, explanations, and examples; (ii) *connection to the goal* (CG)- connections and predictions between text and the design challenge; (iii) *distracting arguments* (AG), (iv) *missed opportunities* (MO)- ignoring science question, explanation, or misconception that emerged, (v) *off-task talk* (OT) (vi) *teacher facilitation of group discourse* (TG)-

teacher intervention during group discourse; and (vii) *procedural talk* (PT)- navigating, reading aloud, paraphrasing, taking notes, specific answers and definitions, exchanging factual questions and clarifications. All of the 57 pages were coded by the first author after two researchers independently coded a sub-set of 10% percent of the transcripts and achieved an inter-rater reliability of 86.11%. Each conversational turn was the unit of analysis.

Results

We selected two contrasting cases based on high and low post-test scores and percent learning gains, calculated as difference in scores between pre- and post-tests. Group A had the highest mean post-test scores with 11.3 for IP unit and 10.66 for Pulley unit, while Group B had the lowest with 8.25 for IP unit and 8.33 for Pulley unit. Group A had 100% learning gain in IP and 60% in Pulley, while Group B had 73.68% in IP unit and 25% in Pulley unit.

We examined how group dialogue and dynamics changed when students used CoMPASS during the IP and Pulley units. This section reports the differences between and within the two groups in the IP and Pulley units based on the seven broad themes identified earlier. In general, comparison of the *deep science talk* of the two groups revealed a low proportion of science dialogue during both units (see Figures 1 and 2). Group A had 24.55% science
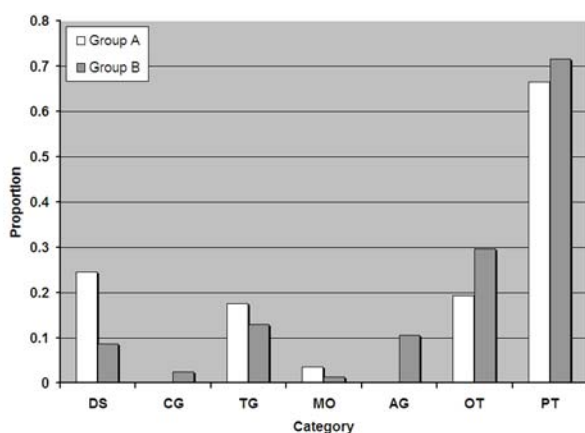

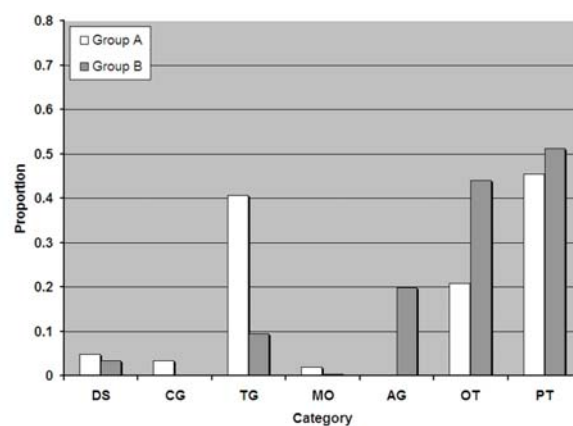*Figure 1.* Inclined Plane   *Figure 2.* Pulley

talk in IP, with members exchanging science questions, connections between concepts and discussing formulae. Group B had a smaller proportion of science talk (8.6%) consisting of science questions, explanations, and discussion about formulae. Moreover, both groups had lesser science talk in the Pulley unit, with 4.82% for Group A and 3.42% in Group B. However, a closer examination revealed some changes in the nature of science talk in Group A in the Pulley unit. Their science talk was less, although more varied in the Pulley unit. There were singular instances of deep explanation and connection between abstract science concepts and concrete features, and some student misconceptions emerged as students attempted to make sense of the science. An important change was also seen with regards to *connection to the goal*, as members made predictions and connected the text to their challenge in the Pulley unit unlike the IP unit, where no connections were made. Group B, however, showed the opposite trend. Unlike the IP unit when members connected science concepts, offered some deep questions, explanations, and talked about formulae, their talk in the Pulley unit only involved some misconceptions and examples. Although they had made predictions and connected the text to their challenge in the IP unit, there were none in the Pulley unit.

Additionally, the two groups had substantially different interpersonal dynamics. In Group A, members were fairly on task and did not have any distracting arguments in the two units. However, they had 3.5% and 1.93% of missed opportunities for collaborative engagement in IP and Pulley respectively, indicating instances of ignoring opportunities for collaboratively extending science explanations, questions, and clarifying misconceptions. An important change in their dialogue occurred when *teacher facilitation of group discourse* came into play, shifting their dialogue towards science talk in the Pulley unit, as they grappled with science concepts. The group dynamics and discourse changed with the teacher's intervention as students confronted some of their science questions and misconceptions, showing a greater engagement with each other about science concepts. On the contrary, group dynamics in Group B failed to support deeper science talk over time. Group B had substantial arguments and an off-task orientation in both units. Despite teacher facilitation to maintain an on-task focus*,* their dynamics and discourse did not shift towards discussing science. Instead, conflicts increased from 10.49% from IP to 19.78% in the Pulley unit, and off-task talk increased from 29.62% in IP to 44.06% in Pulley. Further, a comparison of the two groups revealed a greater percentage of *procedural talk*, with a focus on reading aloud, navigating, looking for answers, and

sharing factual questions and clarifications. In Group A, procedural talk accounted for 66.63% of the discourse in IP and 45.38% in Pulley. Similarly, Group B had 71.57% procedural talk in the IP unit and 51.15% in the Pulley unit.

Discussion and Conclusion

We examined the change in group dynamics and science talk in two groups in the first and final units in an inquiry based science classroom. In the higher performing Group A, the absence of arguments, less off-task talk, and shifts in discourse with teacher facilitation enabled some science talk in the Pulley unit, albeit a low proportion. However, in the lower performing Group B, members had dysfunctional dynamics. Interpersonal conflicts and off-task talk increased over time despite teacher intervention, along with a decline in the proportion and quality of their science talk. Overall, the interplay between group dynamics and science talk suggests that increasing familiarity with group members and content may not ensure more constructive interactions. Although members in Group B grew more familiar with each other and with the science in the final unit, their increased conflicts and off-task focus seemed to interfere with their engagement in a deeper science dialogue, especially in the Pulley unit. In Group A, members missed opportunities to engage in each other's ideas; instances of deep science question, explanation and misconceptions were not elaborated upon but followed by mainly procedural talk. These missed opportunities indicate inadequate co-ordination towards co-construction of knowledge (Baker & Bielaczyc, 1995). These findings confirm previous research showing uncritical dialogue (Arvaja, Häkkinen, Rasku-Puttonen, & Eteläpelto, 2002) and a task focus instead of the science (Coleman, 1998). Our findings lead us to question whether groups would improve their dynamics and have deeper science dialogue over time since challenges in co-ordination such as conflicts, missed opportunities, and off-task talk early on may distract the group's engagement in a science discourse. These results suggest that attending to the interplay between group dynamics and science discourse may facilitate a richer understanding of how group dialogue changes over time, instead of mainly focusing on examining their science talk.

Our findings indicate that groups may need support early on to promote effective collaboration pertaining to the task and social relational context (Barron, 2003). Along with teacher facilitation, groups may also need support for productive dynamics as well as generating questions, explanations, and examples, which can facilitate learning (O'Donnell, 1999). Future research will investigate support for each group specific to their needs during the early stages, and study its impact over time to understand the long-term effects of collaboration and learning.

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