What Are They Talking About? Findings from an Analysis ofthe Discourse in Peer-Led Team Learning In General Chemistry

Patrick Brown, Keith R. Sawyer, Regina Frey, Sarah Luesse, Daniel Gealy, Washington University in St. Louis,
Campus Box 1022, One Brookings Drive, Eads Hall Rm. 105
Email: Pbrown23@wustl.edu, ksawyer@wustl.edu, gfrey@wuchem.wustl.edu

Abstract: Peer-Led Team Learning (PLTL) is a structured method for helping students engage actively in collaborative conversations. The method originated in undergraduate chemistry courses, but is now used in math and in other science classes as well. Previous studies have shown that PLTL results in improved student learning in undergraduate chemistry. However, researchers have not studied the group mechanisms and the discourse processes that lead to this improved outcome. This study is one of three inter-related studies that are the first to explore those mechanisms and processes. In this study, we observed videotapes of PLTL sessions and analyzed the discourse of peer leaders and of students. We found that the structure and nature of the problems influences student discourse.

Introduction

There is now a consensus in science education research that the most effective learning environments are those in which students engage in productive, collaborative discourse to build knowledge (e.g., American Association for the Advancement of Science [AAAS], 1989; National Research Council [NRC], 1996). Knowledge building occurs when students engage in collaborative conversations intended to advance both individual understanding and the collective knowledge of the group in pursuit of a common goal (Bereiter, 2002; Engle & Conant, 2002; Rogoff, Matusov, & White, 1996). In response to this research, numerous institutions of higher education have introduced a form of collaborative learning into lower level science courses that is called peer-led team learning (PLTL) (Gafney & Varma-Nelson, 2008; Gosser et al., 2001; Gosser & Roth, 1998; Hockings, DeAngelis, & Frey, 2008; Sarquis et al., 2001). Although there are still large lectures each week, PLTL supplements the lecture with formalized study groups that are facilitated by a peer leader and provide opportunities for active and collaborative learning. A PLTL study group contains 6-8 students facilitated by a peer leader, a student who has previously received a high grade in the class, and who works under the close supervision of the instructor of the class. In each PLTL session, students work together to solve problems designed by the instructor of the class. Neither the peer leader nor the students are given the solutions to the problems, because the goal of the session is not to get the correct answer; instead, it is to provide opportunities for engaging in problem solving while discussing the concepts in the problem. The goals of PLTL are to: (i) teach undergraduates how to effectively study in a group; (ii) improve students' problem-solving skills; (iii) provide facilitated help for students; and (iv) provide an active- learning environment for students to engage in scientific discourse.

Although previous studies have shown that PLTL results in improved learning in undergraduate chemistry (Gafney & Varma-Nelson, 2008; Hockings, DeAngelis, & Frey, 2008; Tien, Roth, & Kampmeier, 2002), few researchers have studied the group mechanisms and discourse processes that lead to this improved outcome. In two inter-related studies, we found that peer leaders used two distinct interactional styles, which we call *instructional* and *facilitative*, that influence students' dialogue, participation, and knowledge building. In the first study, we found that peer leaders who use a high percentage of facilitative discourse was related to increased chains of student-to-student interactions and more equal student participation (Brown, Sawyer, & Frey, 2009b). Conversely, peer leaders who used equal amounts of facilitative and instructional discourse had shorter chains of interactions and unequal participation. In the second study, we observed that when a peer leader used primarily facilitative discourse and provided abundant managerial support, students displayed extended discussions that went beyond applying equations in a rote manner and began to develop an understanding of the concepts (Brown, Sawyer, & Frey, 2009a). This study is the third in a series of studies that examines the discourse practices used in PLTL. After observing the transcripts of the first two studies, we believed that the specific nature and framing of the problem presented to the students had an impact on their discourse, and we wanted to better understand the specific links between the posed problem and the resulting discourse. Thus, the research question we posed for this study is: How does the nature and structure of the problem influence how students talk about the underlying concepts?

Research Design

Participants

In fall 2006, during the 14-week semester, three PLTL sessions (# 4, #7, and #9) of each of 15 returning peer leaders were videotaped. For the project, all verbal interactions in 6 PLTL groups for two parts of session 7 were analyzed from these recordings. We used a purposeful sampling approach to identify cases and parts of problems that were "information-rich" (Beals & Tabors, 1995; Patton, 2002). The 6 groups were chosen based on observation of all the video data. Based on our experiences working with peer leaders, we purposefully selected: (1) 6 PLTL groups that represented a range of peer leader styles (instructional or facilitative) (see Brown, Sawyer, & Frey, 2009b); and (2) questions that represented typical PLTL activities (reviewing content, problem solving, and concept discussion).

Data Analysis

We implemented multiple approaches to analyze the data. We identified, labeled, and time-stamped the amount of peer-leader talk, student talk, individual tasks, and off-task behaviors that occurred during the selected PLTL activities based on relevant, transcribed portions of the video data. Each transcription was divided into segments of talk, in which a segment of talk represented an individual's contribution to the discussion. An individual's talk could consist of multiple utterances depending on how many ideas were included in one segment of talk. Each utterance was assigned a code (Brown, Sawyer, & Frey, 2009b). The coding scheme involved two levels of coding: categories and codes. The categories we developed were consistent with the constant comparative method of qualitative data analysis (Glaser & Strauss, 1967). Categories are general types of speech observed and include 4 broad areas: (1) explanation, (2) content question, (3) facilitation, and (4) problem solving. Codes refer to specific types of identifiable speech within these 4 categories. For example, closed question and open question are both codes within the category "content question."

To calculate the reliability of the coding manual, two trained coders were used; one has a background in science education and qualitative research and the other was a co-instructor of the general chemistry series. The second coder was blind to the motivation and hypotheses of the study. When disagreements arose, the two coders discussed differences and either a rule for coding was decided upon or a revision was made to the coding manual. Cohen's Kappa is an inter-rater reliability measure for qualitative studies (Bakeman & Gottman, 1986; Lunn, 1998). Bakeman and Gottman (1986) characterized a Cohen's Kappa of greater than 0.75 as excellent. The Cohen's Kappa for the final stage of coding was 0.90; thus, meeting the criteria for excellent inter-rater reliability.

Results

Our data at this stage of the project is preliminary. Thus, we chose relevant portions of the data from our qualitative analysis to highlight findings from our full data set. We focus on a specific trend in our data that we observed across our 6 PLTL groups.

To study whether the nature and structure of the problem influences knowledge-building discourse we examined a portion of the seventh PLTL session. During the session, students reviewed and solved problems associated with understanding the topic "periodic trends" — characteristics of elements as one moves across a period (row) and down a group (column) of the periodic table. This analysis focuses on the Review and Problem 1 portion of the session. During the review, students discussed the content covered in lecture and recitations. During Problem 1, students arrange each set of atoms (e.g., (a) Rb, Cs, Li; (b) B, Li, F; (c) Cl, F, Br; (d) Rb, Be, K) in order of increasing atomic radius.

Review

The transcript that follows is an example of how Gillian's students began to talk about the periodic trends during the review.

[1] F1: So I have a bunch of periodic trends (inaudible). There's Z* (effective nuclear charge), one for electronegativity, and one for Atomic radius. Do you wanna draw all those?
M7: And electron affinity.
F1: Draw the, Draw the boxes [[2]*Student tells peer to draw a "box," in the shape of a rectangle, on the*
F4: *front board*]
F1: Why don't you just draw the boxes?
F4: I like the boxes. (laughs). Just write like, Z*, and then arrow, increasing (pointing). And then arrow down, decreasing (pointing). [*Student tells her peer who is at the front board to draw a box with a one-sided arrow pointing from left to right and another arrow pointing from the bottom to the top of the box*]

[1] Line number
[2] Relvant nonverbal interactions

In this excerpt, students drew a "box" to represent the periodic table and used arrows to indicate whether atoms increase or decrease across a period (row) and down a group (column) according to the different diagrams for the period trends that they covered in lecture (e.g., electronegativity, atomic radius, electron affinity, and Z*) (LN: 1-6). For example, students began talking about the periodic trends by focusing on the procedures for describing how Z* increases and decrease across and down the periodic table (LN: 7). When identifying important content to review from the lectures and recitations, and without prompting from the peer leaders, students used the diagrams they had learned in class as an algorithm (a set of finite rules) for solving problems (LN: 7). Without the peer leaders guidance, we found that students used the diagrams they had learned in class almost exclusively when reviewing the periodic trends.

Problem 1

In problem 1, students arranged atoms in order of increasing atomic radius. The problem-solving discourse was characterized by students using the diagrams they discussed during the review to solve atomic radius problems. The transcript that follows illustrates how Rachael's students focused on applying the diagram that was discussed during the review to arrange the atoms B, Li, and F in order of increasing atomic radius. Rachael's students' discourse was typical of how students talked about the atomic radius problem (Problem 1).

254 M1: Umm, Bi, Li, and F (reading the problem). So we're going left to right, and the diagram says is
255 decreases (referring to the diagram on the board developed during the review), so, if I want it
256 from increasing, it's Li, B, F. [*Student looks at the diagram on the board showing a one-sided*
257 *arrow pointing from right to left to answer the question*]
258 F3: No
259 M2: No, it goes the other way (inaudible).
260 PL: Increasing should start with the smallest, and then…
261 M1 Oh. So, F, B, Li.
262 PL: Don't let it trip you up. Does everyone agree?
263 F3: Yeah.

In the excerpt above, M1 used the diagram on the board that they discussed during the review to solve the problem (LN: 254). In this example, M1 accidentally listed the elements from largest to smallest atomic radii (the directions in the problem asked students to list the elements from smallest to largest atomic radii). In line 259, the peer leader calls to attention that M1 has placed the elements in the reverse order. In line 260, M1 reacts by listing the elements in the correct order. In this excerpt, students discourse was entirely focused on the diagram discussed during the review and they did not discuss the underlying concepts associated with the trend.

Gillian's students' discourse was also focused on applying the diagram they had discussed during the review on problem 1. However, Gillian engaged students in the concepts by using probing questions (LN: 337).

337 PL: …So what's the, what's the idea with radius? What are you doing, to kind of put those(referring to
338 atoms) in order?
339 F1: We just compared it to the, the, drawing up there (referring to the front board), the table.
340 F5: The number of, like, protons, um, of each element and then the number of, I don't know, I guess
341 electrons?...
342 F1: Well, one, we didn't have any ions, so that wasn't really important (laughs).
343 F5: Right. So if there was like, more protons, like, going down the periodic table, like down a column,
344 or whatever, um, they (referring to atomic radii) would be increasing because they would just be a
345 bigger
346 F1: Well, there's more elect...(referring to electrons)
347 F5: It would be more electrons...If we're going down, it's, it would be more electrons.
…[3] … …
420 PL: So you guys down there, what's the, what's kinda like the trend?
421 M7: Whichever one has the lower number of protons has a tighter pull on the electrons, so the radius
will be smaller (across a group)
… … …
425 PL: … (Does everyone) agree with that?
426 F1: And as you're adding elect..., it's like the same if you're adding electrons (down a period), then an
427 increased radius.

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[3] Transcripts were omitted because student talk was off task.

Gillian's students' responses indicate that they focused on applying the diagram they had discussed for atomic radius during the review to the problem (see line 339). However, Gillian used probing questions to promote discussions, student interactions, and scientific explanations of the content (LN: 337 and 420). Students acknowledged, built upon, and elaborated on each other's ideas. Additionally, Gillian's students' explanations went beyond using the diagrams they learned in class to solve the problems and they began to address some of the underlying concepts (LN: 340-346, 421, and 426).

In summary, both the nature and structure of the problem influenced student discourse. We found that during the review students focused on describing the periodic trends according to diagrams that they learned about in class. Without prompting from the peer leader, students almost exclusively talked about the periodic trends according to a finite set of rules that they learned about in class. Students' discussion during the review had an influence on how they talked about the periodic trends problems. Students used the diagrams that they discussed during the review to solve the periodic trends problems. Thus, the nature and the structure of the PLTL problems influenced students discourse.

Conclusion

There is a great deal of research evidence that students who participate in PLTL perform better than students who learn individually and alone. Our work begins to examine exactly how the discourse in PLTL groups contributes to improved chemistry understanding. From our analysis, it appears that not all peer-group experiences are equivalent in promoting chemistry understanding.

Based on previous research we found that peer leaders who used equal amounts of facilitative and instructional discourse had shorter chains of interactions and unequal participation. Conversely, the use of a high percentage of facilitative discourse was related to increased chains of student-to-student interactions and more equal student participation (Brown, Sawyer, & Frey, 2009b). Second, we observed that when a peer leader used primarily facilitative discourse and provided abundant managerial support, students displayed extended discussions that went beyond applying equations in a rote manner and began to develop an understanding of the concepts. Conversely, when a peer leader used more equal combinations of discourse coded as instructive and facilitative, students spent considerable time working individually and their discourse focused on the algebraic steps necessary to solve the problem (Brown, Sawyer, & Frey, 2009a). In this study, we observed that students' discourse was related to the nature and structure of the problem. Students mostly talked about the periodic trends using the diagrams they learned about in class. The discussions that occurred during the review influenced how the students solved periodic trends problems. Students focused on using the diagrams they discussed during the review to solve problems and rarely engaged with the underlying concepts associated with understanding the periodic trends. Thus, for some problems, students would benefit from explicit conceptual questions in order to engage in discussions of the underlying concepts.

The goal of PLTL is to engage students in building chemistry knowledge through a more open forum of collaborative discourse with greater student involvement. To provide quality PLTL sessions, Chemistry instructors must understand the discourse practices of peer leaders and students. Many education researchers have stressed that an effective student culture of collaboration requires close attention and scaffolding, and once a collaborative group culture has emerged, classroom conversations can lead to significant individual cognitive advancement and the development of deep conceptual understanding (Greeno, 2006; Sawyer, 2006; Scardamalia & Bereiter, 2006). This preliminary study suggests that the nature and structure of the problem influence student discourse. If problems include explicit conceptual questions then collaborative group cultures could emerge that encourages students to engage in deep knowledge building.

Implications for Future Research

Examining student discourse during a content review and problem solving activity has implications for the redesign of PLTL problems and future research. We believed that students would discuss the underlying concepts associated with the review and the problem based on their experiences in lecture and recitation sessions. Based on the early stages of our third study, implications arise for the redesign of PLTL problem sets. Based on the findings of the third study we are redesigning PLTL problem-sets to begin with guiding questions that encourage students to discuss key concepts and experiments in addition to equations and variables. Altering existing problem sets to provide explicit questions that have students discuss phenomena before problem solving may engage students in higher-order thinking and alter students' interactions with each other and the peer leader. Future research is needed that investigates whether revising the way PLTL problems are written better fosters the type of conversations that lead to deep conceptual understanding. Restructuring the problems could favorably affect student's chemistry understanding, critical thinking, and knowledge building from collaborative discourse.

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