SUPPORTING PEER CONFERENCES IN INTRODUCTORY CALCULUS

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This paper focuses on the nature of student talk during peer conferences about calculus problems. Conversations were studied in the context of Peer-Assisted Reflection (PAR), an activity structure that supports communication and conceptual understanding through peer assessment. Despite a wealth of research on peer assessment, relatively little has been published on the specifics of students' conversations as they discuss each other's work. This paper introduces a coding scheme for analyzing such conversations, and applies it to illustrate the impact of a systematic training procedure on improving student conversations.

Keywords: Classroom Discourse, Design Experiments, Metacognition, Post-Secondary Education

Calculus is an area of persistent challenge for students pursuing STEM careers (Bressoud, Carlson, Mesa, & Rasmussen, 2013). This paper focuses on student conferences in Peer-Assisted Reflection (PAR), a promising activity for improving student outcomes; PAR increased pass rates (completing the course with a C or higher) by 13% and 23% during two phases of study (Reinholz, in press-a, in press-b). PAR is built around peer assessment, a core part of formative assessment (Black & Wiliam, 2009). Broadly, formative assessment is focused on eliciting information about student thinking and using it to modify learning activities, which improves student outcomes (e.g., Black, Harrison, & Lee, 2003). In peer assessment, students collaborate and explain their reasoning to each other, developing self-assessment skills as otherwise invisible assessment processes become more explicit and transparent (Reinholz, in press-b).

Despite considerable work on peer assessment (e.g., Falchikov & Goldfinch, 2000), little is published on student talk during peer conferences. As a result, it is difficult to design to improve such discussions, because they are not well understood. This paper focuses on student talk during two phases of a design experiment (Cobb, Confrey, Disessa, Lehrer, & Schauble, 2003), exploring the impact of systematic training included in Phase II. It addresses two questions:

1. What was the focus of student conferences on calculus problems?
2. What was the impact of systematic training on student conferences?

Method

Design

Each week, students completed a challenging PAR problem as a part of their homework (14 problems total). After completing an initial solution, students came to class and exchanged their work with a peer. Students read each other's work silently for five minutes before discussing it together for five more minutes. After conferencing, students revised their work and turned in a final solution. This cycle of activities was implemented during both Phase I and Phase II.

During Phase II, a systematic training procedure was added. Each week, the instructor led a whole-class discussion in which students analyzed three sample solutions to a part of the PAR problem and discussed how to improve them; these discussions focused on how the solutions explained and communicated the mathematical concepts of the PAR problem.

This paper focuses on conferences from three PAR tasks: PAR06, PAR10, and PAR14. These tasks were chosen to span the duration of the semester. These tasks had: a low floor and high ceiling, multiple solution paths, and required explanation (cf. Schoenfeld, 1991); PAR6 explored the difference between radians and degrees with sine and cosine functions, PAR10 focused on the approximation of complex areas using simple shapes (as a precursor to Riemann sums), and PAR14 involved creating a bead as a solid of revolution (the napkin ring problem).

Participants and Data Collection

Students in a semester-long introductory calculus course at a research university attended four 50-minute class periods each week. Phase I (409 students) took place in the fall, while Phase II (336 students) took place in the subsequent spring semester. There were a total of ten parallel sections each semester (taught by 8-9 different instructors) with a common curriculum. PAR was implemented in a single experimental section each semester; this paper focuses on only these two sections (not the comparison sections). Student PAR assignments were collected and scanned, and 4-7 student dyads were randomly chosen each week to be audio recorded during their peer conferences. A total of 155 conferences were recorded (66 during Phase I, 89 during Phase II).

Analysis

A total of 44 conferences were transcribed and de-identified. The transcripts were coded randomly to avoid systematic bias across tasks or phases of study. Each conversation was coded by assigning each sentence of talk to one of seven dimensions. Using a single sentence as a unit of analysis, it was possible to assign each sentence uniquely to a single category.

The categories were: (1) communication (focused on how mathematical ideas were expressed), (2) comparison (of different solutions or multiple parts of the same solution), (3) concepts (the underlying mathematics of the problem), (4) procedures (computational fluency), (5) task (clarifying the parameters of the task), (6) other (mathematical talk in none of the above categories), and (7) unrelated (talk not related to the problem). These categories were drawn from the framing of PAR (asking students to talk about communication and correctness), the nature of the tasks (focused on multiple solutions, allowing for comparison), and an iterative process of working with transcripts to develop a minimal set of codes. Because students often introduced themselves to start a conversation and said "thank you" to end the conversation, "unrelated" talk from the beginning and end of conversations was not analyzed. This also meant that off-topic talk that took place after students finished their discussion was not analyzed.

Results

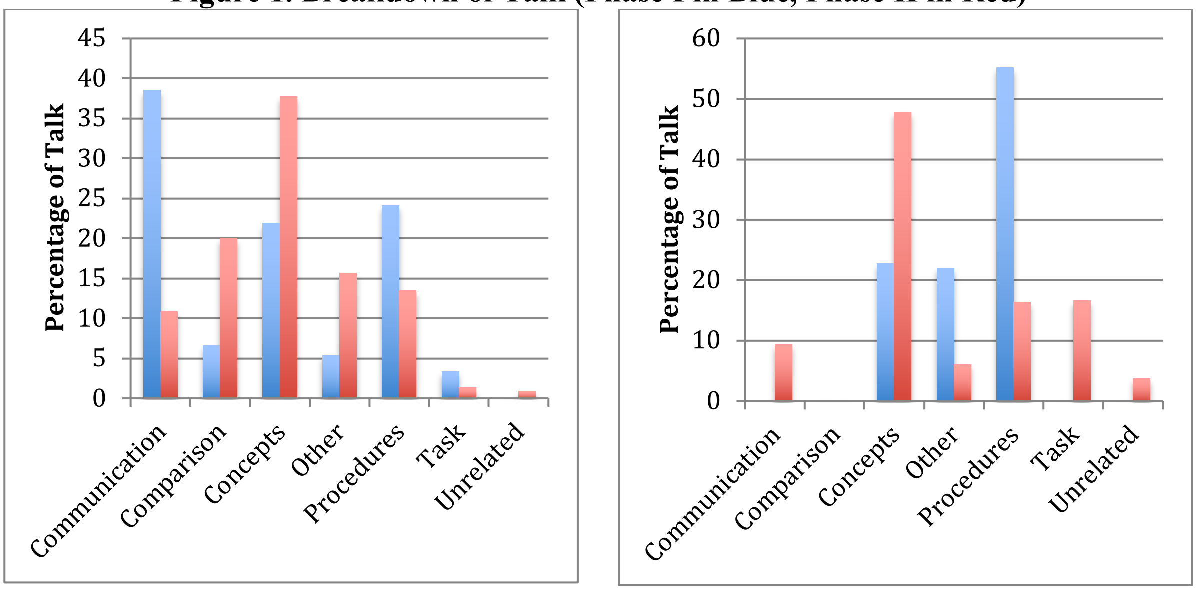
Student conferences during Phase II were more than twice as long as those during Phase I (see Table 1). Conversations were also analyzed for percentage of on-topic talk (categories 1-6); overall, 98% of talk during Phase I and 97.8% of talk during Phase II was categorized as on-topic. This indicates that students during Phase II spent more than twice as much time as the Phase I students discussing the mathematics of the PAR problems.

Table 1. Length of Conversations (Number of Sentences)

	Phase I	**Phase II**
PAR06	18.8	31.9
PAR10	12.8	43.7
PAR14	17.0	44.8

Figure 1 gives the breakdown of talk for PAR06 and PAR14, averaged over all student conversations (PAR10 omitted due to space). During Phase II, students focused more on concepts, while Phase I students focused more on procedural computations. Nevertheless, students during both phases used peer conferences to deepen their understanding in a variety of productive ways, connecting their solutions, improving their explanations, and discussing mathematical procedures and concepts.

Figure 1. Breakdown of Talk (Phase I in Blue, Phase II in Red)



PAR 06 PAR 14

Typical Phase I and Phase II discussions for PAR14 are given in Figure 2. Most of the Phase I discussions focused on computations involving solids of revolution (4 of 5 conversations):

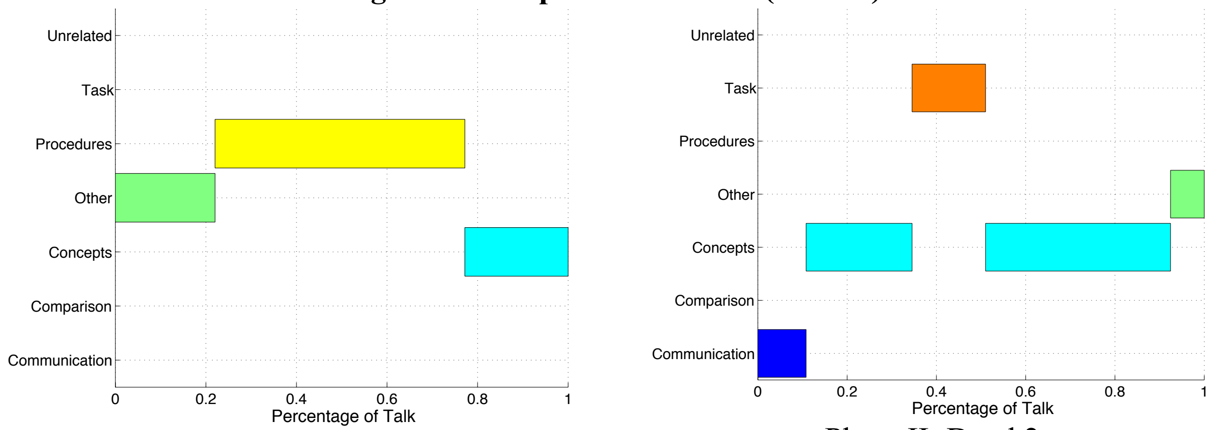
Ben: This is where I screwed up. You're going to want to substitute in 1/2 h, that quantity squared…like 1/2 h square root equals that. So when I kept subbing it kept screwing up. I kept on putting in 1/2 h to the 3/2, but it's gotta be this quantity squared in that.
Sam: Gotcha.

In contrast, Phase II students focused more on concepts. Moreover, while discussing concepts in the problem, Dyad 2 realized that they were confused and needed to clarify the nature of the task. While Tim was discussing the bounds for their integral, Bethany realized that she was not sure how to read the diagram in the problem:

Tim: So your x bounds are r and big R. Uh, integral of that and then just the 2 times pi…
Bethany: Wait, I'm confused; can I ask you about this thing? Is this saying that h is this whole thing?

The discussion continued on and the students resolved the confusion, and returned to discussing concepts. Returning to the task in this way mirrors how skilled problem solvers may return to a problem statement and reevaluate their approaches in the middle of problem solving (Schoenfeld, 1985). During Phase II, only 2 of 6 conversations were mostly procedural.

Figure 2. Comparison of Pairs (PAR14)



Phase I: Dyad 1 Phase II: Dyad 2

Discussion

This paper illustrates an approach to analyzing peer conferences and reports preliminary findings about the nature of student conversations. Students discussed a variety of aspects of the problems, such as communication, the nature of the task, procedures, and concepts. Moreover, the results suggest that the systematic training activities had a considerable impact on student discussions. Phase II students discussed more than twice as much mathematics as the Phase I students, and the nature of the conversations was qualitatively different; the students focused more on concepts than procedures. This shift is consistent with the nature of the training exercises that focused on discussing concepts. This shift may also be due in part to the deeper understanding that the Phase II students developed (Reinholz, in press-a), which allowed them to move beyond the surface aspects of the problems. Future work will focus on establishing reliability with multiple coders and analyzing all of the PAR problems in more depth.

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