Investigating Peer Observers' Perspectives on Middle School Engineering Designers' Communication Challenges (Work in Progress)

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Introduction

Effective communication is central to engineering design[1, 2] because engineering is a discourse intensive endeavor that requires collaborative interaction.[3, 4] However, even professional designers struggle with in-team communication, with literature reporting misunderstandings, conflict avoidance, and persuasion during design activity. [5] Middle school students are likely to have even greater difficulties navigating communication challenges when engaged in engineering design projects because of their limited experience with such collaboration. Previous research suggests that middle school designers simultaneously regulate their design task, collaborative relationships, and engineering identity while communicating with peers on an engineering design project.[6-8] Yet, there is a gap in the literature about how that communication is perceived by the students themselves. Little is known about middle school designers' perspectives on their own communication challenges or their perspectives on peers' communication challenges. Further, few studies report on interventions aimed at improving young students' ability to negotiate communication challenges during collaborative design sessions.

In previous analysis of students' self-reported data related to communication challenges during engineering design teams, we found that middle school designers grew in their metacognitive awareness of their group's communication patterns across an engineering design-reflect-design procedure, but not in their individual-level interactions.[7] Middle-school students need a great deal of scaffolding and opportunities for practice in order to develop their collaboration skills since perspective taking and understanding diversity, necessary for effective collaborative interaction, are not innate capabilities. Thus, teachers need to develop ways to support students' in learning to negotiate communication challenges associated with collaborative engineering design activity. Based on previous research, we wondered whether assigning peer-observers might be one way of providing such support.

Several lines of research have investigated peer-observer roles. Assigning audience or listener roles has been found beneficial for encouraging both speaker and listeners' cognitive engagement during science inquiry learning.[9] Studies also suggest that observing can be as beneficial as actively participating in a learning experience when the observer is cognitively active.[10] but not when an observer takes a passive role.[11] Thus, we wondered whether assigning peers to actively and purposefully observe their classmates participating in collaborative engineering design challenges might similarly benefit the observers and the designers. Therefore, we implemented a peer-observer innovation to explore the potential of assigning peer observers for providing such support, wondering whether the implementation of such a role might positively impact not only the observed design team members' learning, but also the peer-observers' learning.

The study reported here was part of a larger a design-based experiment in which we implemented an innovation aimed at improving middle school students' ability to navigate communication challenges during collaborative engineering design activities. We introduced students to four types of communication challenges and assigned them one of two roles: design team member or peer-observer. In this study, we focused only on the peer-observers, particularly on their discourse during peer-observer debriefings that occurred immediately after observing their classmates engaged in design activity. We limited our analysis to investigating what peer-observers discussed when given the opportunity to compare their observations with each other during debriefing meetings. Specifically, the following research questions guided analysis:

> Research Question 1 (RQ1): What do peer observers notice about how design teams managed the four communication challenges during the two collaborative design projects, and how do they interpret their noticings?
>
> Research Question 2 (RQ2): How do the peer observers' noticings change from Day 1 to Day 3?

Method

Context and data collection

The context of this study was four eighth-grade science classes in one Title I urban school (88% of students qualified for free or reduced lunch) in the southwestern U.S. Parent consent and student assent was obtained from 104 students. The second author was the teacher of all three classes. 14% of students in the school were classified as English Language Learners; 76.4% of students were Hispanic, 8.8% White, 8.4% African American, 3.6% Asian/Pacific Islander, and 2.5% Native American. Both authors helped facilitate all activities.

Taking a design-based approach, in this, our second iteration of the innovation, we implemented a design-reflect-design protocol over three 50-minute class periods on consecutive days. The purpose of this protocol was to provide an opportunity for designers and observers to reflect on communication patterns in design challenges. Students were assigned to one of two roles for the entire process: (a) design-team member in three-to-four member groups, or (b) design-team peer-observer. Peer-observers were assigned to only five groups in each period. Neither roles nor team-members changed across days except when necessary because of absences. On Day 1 and Day 3, the designers collaborated to create similar marshmallow tower challenges following two different sets of constraints each day, while a peer-observer assigned to their group took notes about their communication. In between the two design challenges (Day 2) the peer-observers gave their classmates feedback and made suggestions for more effective communication. Analyses in the current study is limited to data from Day 1 and Day 3.

On Day 1, the first author (a researcher at a local university) oriented observers to an observation tool designed and field-tested by the authors, while the second author (the students' teacher) oriented design-team members to a simple design challenge. Orienting to the observation tool, she instructed peer-observers to focus on how the team communicated about designing the tower, rather than on the structure itself. Peer-observers were asked to record notes on their observations of two social challenges associated with the design tasks: *negotiating roles and responsibilities* (Who's doing what?) and *evaluating progress* (How are we doing?); and two task challenges: *understanding the task* (Are we doing this right?) and *generating design ideas* (How can we solve this problem?).[12-16] Each of these categories was defined and exemplified in the training. Definitions and examples were also provided on the observation instrument. Peer-observers were not only asked to record observations about communication, but also to note the temporality of the communications. The observation instrument was divided temporally in order to encourage segmented observations according to beginning, middle, or end of the design session. Finally, observers were asked to record direct observations only, avoiding evaluations, assessments, or inferences.

Following the 18-minute design challenge activity, the peer-observers met in a separate room to compare their observations (i.e., peer-observer debriefing) while design-team members completed individual written reflections. The peer-observer debriefing meetings were audio-recorded. These debriefings were the object of interest in the current study. The researcher facilitated the debriefings, communicating the process and purpose of the activity. For example, the researcher/facilitator gave these instructions at the beginning of the peer-observer debriefing on Day 1, Class Period 2:

> ...think about what you just observed and think about what we might tell your classmates that you noticed about each of the categories… So, let's just go around and say what you noticed… What did you notice about how people were negotiating roles and responsibilities, who was going to do what?

Day 3 followed a protocol similar to Day 1. However, there were two important changes. First, contrary to Day 1, the researcher intentionally refrained from participating at the beginning of the debriefing, withdrawing after giving initial instructions and only entering the discussion at the end of the debriefing to initiate further discussion. Second, after reflecting on the processes across the first two days, on Day 3 we implemented a written reflection tool to help structure the peer-observers' communication during the debriefing.

Data sources and analysis

In this exploratory study, we limited analysis to the conversation the peer-observers had with each other and more specifically, the noticings and attributions they made during the two peer-observer debriefings in each period. Thus, data sources included transcripts of audio recorded peer-observer debriefings, field notes related to debriefing, and written artifacts associated with peer observation. Analysis began with the authors meeting to establish a coding scheme and develop initial insights and tentative themes and wonderings. We first selected one transcript to code together, working to identify all comments related to each of the four communication challenges (See also, Authors, 2015). We also tried to stay open to other issues and patterns that were potentially relevant for the research questions. Through this discussion, we came to identified timing, affective dimensions, advice, and comparisons as important aspects of the peer-observers' discourse. Thereafter, we coded the other seven transcripts individually before meeting to negotiate consensus for each one. At the end of each researcher consensus meeting, we summarized our interpretations of the over-arching patterns borne out in the specific transcript and across the transcripts we had coded up to that point. Once all the transcripts were counted the frequency of each of our codes. Finally, we conducted holistic vertical and horizontal reading of the transcripts, reading back through each peer-observer teams' Day 1 and Day 3 transcripts, then through the entire set of Day 1 and Day 3 debriefings.

Results

Analysis is ongoing, but we report initial results related to what peer-observers discussed about how their classmates managed the four communication challenges during the two collaborative design projects, and about how they interpret their noticings (RQ 1), and how peer-observers' reported noticings changed from Day 1 to Day 3 (RQ 2). In the sections below, we discuss findings related to RQ1 and RQ2 in turn.

RQ1: Noticing and interpreting how designers negotiate communication challenges

During peer observer debriefings following each design session, the peer-observer teams discussed what they noticed about how the observed design teams negotiated each type of communication challenge. Examples can be seen in Table 1.

Table 1

Examples of peer-observers discussing negotiation of communication challenges

Negotiating Roles & Responsibilities	Evaluating Progress	Understanding the Task	Generating Design Ideas
They were like, they were negotiating who has the straws and who has the scissors and stuff like that. (Day 1, P4)	I think also what encouraged them was looking at other people's things and they were like, they were like, "Ha ha, they messed up. Let's try again; let's do it better." (Day 1, P6)	The whole time they were just referring to the instructions laid out in front of them… and they always helped each other just by always looking at the instructions… they just kept talking to each other, how they were supposed to do things. (Day 1, P2)	When they first laid the materials out they just had ideas popping out, and started sharing, and then decided on one. (DAY 1, P2)

Although in future analysis we plan to further examine each set of talk turns in order to identify prevalent themes for each type of communication challenge, here we limit ourselves to discussing frequency of each code.

Table 2 shows the number of codes given for each communication challenge. Looking across all periods and both days, there was a significant difference in the number of times the peer-observers discussed each of the four types of communication challenges: X^2 (3, N = 210) = 23.52, $p < 0.001$. However, that significance disappears when looking just at the three most discussed types, X^2 (2, N = 210) = 2.10, $p = 0.35$. Also, no significant difference was found after clustering the four types into two overarching categories, social versus task communication challenges, X^2 (1, N = 210) = 2.35, $p = .13$. Thus, on the whole, it seems that task and social communication challenges were equally salient to the peer observers.

Table 2
Frequency of codes for peer-observers' comments pertaining to four types of communication challenges during debriefing meetings

	Negotiating Roles and Responsibilities	Evaluating Progress	Understanding the Task	Generating Design Ideas	Total CC*
Period 2 Day 1	4	3	3	3	13
Period 2 Day 3	6	6	5	8	25
Period 4 Day 1	9	15	2	11	37
Period 4 Day 3	9	2	0	1	12
Period 6 Day 1	12	7	9	14	42
Period 6 Day 3	9	11	1	10	31
Period 7 Day 1	6	5	0	6	17
Period 7 Day 3	6	4	3	6	19
Total Day 1	31 (30%)	30 (29%)	9 (9%)	34 (32%)	104
Total Day 3	30 (28%)	23 (22%)	14 (13%)	35 (33%)	106
Total Across All Periods and Days	61 (29%)	53 (25%)	23 (11%)	69 (33%)	210

* Total number of observers' comments coded as pertaining to any of the four communication challenges

Looking across the entire dataset of debriefings, peer observers attended equally to social and task communication challenges. This suggests to us that middle school students are cognizant of the multiple and nuanced aspects of engineering communication. However, the peer-observers rarely reported attending to how designers negotiated their *understanding of the task*; instead, they focused more on how designers *generated ideas*. This might be explained by the straightforward nature of the design instructions, or conversely, the numerous possible solutions to the open-ended engineering design challenge.

In further analysis, we are interested in learning more about the NULL code that manifested through analysis, a code that indicated a peer-observer had noted the explicit absence of negotiation of a communication challenge in an observed design team's discourse. Our preliminary coding scheme did not anticipate the need for a null code. However, after analyzing the debriefings, we noted several instances where the peer-observers explicitly described instances where their teams did not employ one of the four given communication challenges.

Valence and Advice: How peer observers interpreted their observations

The peer-observers did not simply report their observations free of interpretation and free of valenced emotions. Instead, their reporting of their observations often conveyed a positive or negative assessment of how the collaborative designers negotiated the four communication challenges. For instance, below is an example of a negative interpretation:

> "*One thing that I didn't really like about my team was that they were being really negative to each other. Like Jimmy really wanted to help and I saw him going for it but then Breana would be like, no Jimmy, don't, you're just going to mess it up. And that really killed my mojo because I saw them having a good time. But when they started being mean to each other that just kind of... I didn't like it"* (Day 3, P4).

In the above comment, the peer-observer communicated a negative assessment of the interactions she observed in the design team. This negative assessment contrasts with the positive assessment in the following comment:

> "*I just think that they did much better and that they were more positive about things and that they told themselves that they were going to do better, so they did do better"* (Day 3, P2).

The frequency of comments conveying peer observers' evaluation of their design teams' communication can be seen in Table 3. Overall, across all groups and both time points, there was no significant difference between the number of positive evaluations and the number of negative evaluations made by the peer-observers, X^2 (1, N = 102) = 0.35, p = 0.55.

Table 3
Frequency of codes indicating peer-observers' evaluation of design teams' negotiation of communication challenges

	Negative Evaluation	Positive Evaluation	Advice	Comparisons of Day 3 to Day 1 Communication
Period 2 Day 1	5	3	7	
Period 2 Day 3	2	9	4	18
Period 4 Day 1	7	7	10	
Period 4 Day 3	2	5	1	5
Period 6 Day 1	21	2	1	
Period 6 Day 3	3	7	0	11
Period 7 Day 1	3	8	0	
Period 7 Day 3	11	7	7	11
Total Day 1	36	20	18	
Total Day 3	18	28	12	
Total All	54	48	30	55

As shown in Table 3, the ratio of total negative to positive assessments was 9:8, a fairly even split. These positive and negative assessments were, in turn, sometimes used to inform advice the peer-observers put forth during their debriefings. As also shown in Table 3, a total of 30 comments referencing negotiation of a communication challenge included some kind of advice from a peer-observer for collaborative design teams. This is not surprising, as part of the peer-observers' responsibility was to help their classmates improve their communication during engineering design projects. Finally, the table shows that they peer observers' frequently compared design teams' communication during Day 3 with the communication they had observed on Day 1.

Temporality of communication challenges

Because not only type, but also *timing* of actions matter in the engineering design process, the observation tool that peer observers were asked to use encouraged the observers to attend not only to what communicative actions were taken, but also to *when* those actions occurred. Thus, we were curious about whether peer observers would attend to timing and sequence of communication topics in their talk during the debriefing sessions. Examination of peer-observers' individual observation instruments shows that all peer-observers attempted to account for the timing of actions in their use of the observation tool. Analysis of debriefing transcripts suggests that they did so in their talk with each other to varying extents across time and across peer-observer team. Table 4 presents the number of comments coded as explicitly referring to temporal aspects of designers' communication. As illustrative examples of this kind of talk, one peer-observer noted, "Mine [my group] talked a little bit… and then at the end they were just like, work time" (Day 1, P6). Another peer-observer noticed, "They were giving each other roles. But then one of them would work. Two of them would work and then one of them wouldn't do anything for it, so, two of them basically came up with the design" (Day 3, P2).

Table 4
Peer-observers' noticing of temporal aspects of designers' negotiation

	Day 1	Day 3
Period 2	8	12
Period 4	7	1
Period 6	10	1
Period 7	4	8
Total	29	22

RQ2: How do the peer observers' noticings change from Day 1 to Day 3?

We saw evidence of change in the peer observers' noticings across Day 1 and Day 3. Analysis thus far indicates three themes related to the peer-observers' learning.

First, peer-observers' Day 3 observations were more specific and elaborated than their Day 1 observations. For instance, we found many talk turns in which a peer-observer discussed actions taken by individual design team members, which they almost never did on Day 1. Additionally, peer-observers used more specific language on Day 3 than on Day 1. One way they did so was to (Choi et al., 2016) give specific examples of what they observed, particularly through explication of "small stories" of design team interactions. It is our sense that small stories might indicate an elaborated interpretation of an observation, which might, in turn, indicate a more elaborated cognitive ability garnered from practice intentionally observing. Future investigation will more deeply analyze the nature, scope, and range of these small stories.

Second, peer-observers wore their observer role more confidently on Day 3 than on Day 1, taking on the identity of someone who is able to make observations. We make this assertion based on the greater sophistication in their making of attributions and multiple hypotheses, as well as their questioning of the task and the teacher. For instance, one peer-observer questioned the teacher's decision to present a design project to newly formed groups: *"I think the people should get used to each other before they actually work on the design challenges because if they don't know each other they really wouldn't work together as well"* (Day 3, P2).

Finally, there was a higher proportion of positive to negative evaluations on Day 3 (14:9) compared to Day 1 (5:9). Across the four periods, peer-observers made significantly more negative than positive evaluations on Day 1, X^2 (1, N = xx) = 4.57, p = 0.03. However, that difference flipped direction on Day 3, though not significant difference, X^2 (1, N = 102) = 2.17, p = 0.14. This could be because peer observers were comparing their observations on Day 3 with their observations on Day 1. One peer observer noted, for instance,

> "*the first day they wouldn't consider each other's ideas, and today they asked each other what they should do and they would talk about it, to help each other. And they didn't lose hope as fast as they did the first day"* (Day 3, P6).

Such comparisons were made more often than not in talk turns referencing communication challenges on Day 3 (55 compared to 46). We take it as a good sign that Day 3 observations of designers' communication compared favorably to Day 1 observations, at least in the peer observers' interpretations. Future analysis of video recorded design sessions could confirm the peer observers' collective sense that their classmates improved their ability to navigate communication challenges across the two projects.

Discussion

Although we set out to explore what peer-observers noticed about how their classmates negotiated communication challenges during collaborative design projects, our analytic processes led us to a greater appreciation that communication is a complex endeavor. Not only did the peer-observers identify peers' negotiation of communication challenges, they also interpreted their noticings, responding with positive and negative valence that informed the advice they were preparing to present to their classmates. Designing and observing are both dynamic processes emerging from dynamic interactions. Peer-observers responded to the designers' communication with curiosity, moving beyond observation to interpretation and evaluation.

It may be tempting to assume that observing is a fairly static activity, but that is not what we saw in our analysis. The communication these peer-observers were observing was dynamic – and so too was the peer-observers' own communication during their debriefing sessions. We sense that the changes in peer-observers' noticings across Day 1 and Day 3 indicate learning by the peer-observers. It seems likely that the learning indicated by analysis hinged on both observers' opportunity to intentionally and purposefully observe their classmates' design sessions and also on their opportunity to subsequently discuss those observations in peer observer debriefings. Perhaps the social responsibility to make suggestions to the designers also played a role in those changes. We contend that social interaction during peer-observer debriefings shaped the peer observers - not only their interactions with each other during debriefings, but also the social act of observing their classmates' collaborative engineering design activity in the context of being situated by their teacher as observers responsible to help those classmates improve their communication. Noticing that peer-observer teams' own communication patterns changed across the two debriefing sessions, we wonder whether peer-observers might use their own language more consciously as a result of observing and analyzing others' language with their peer-observer concomitants. Future studies should explore this question. Further research should also examine the effects of asking peer-observers to reflect on their own communication practices, and not just others' communication practices.

Understanding learners' perspectives on their own communication patterns – and the perspective of peer observers - may help educators and researchers design strategies to improve peer-to-peer communication and enhance engineering education. There are currently few guiding principles or pedagogies for training, expecting, and insisting on high quality engineering communication, despite communication being embedded in professional and educational standards. We contend that positioning middle school students as peer-observers can be a powerful opportunity to support engineering communication education. The peer-observer role gives student authority to make observations that have the potential to help their entire class improve their ability to navigate communication challenges associated with negotiating roles and responsibilities, evaluating progress, understanding the task, and generating design ideas. The peer-observers in this study took that authority and seriously. Accepting the authority to make and talk about their observations in a peer discussion forum, they took it a step further, claiming their right and responsibility to interpret patterns and evaluate communication quality, making assertions about how people should act in order to improve interpersonal communication and collectively engineered products. We suggest that peer observers are not only empowered themselves to have a voice, but that they may be changing the dynamics of the whole scene. Analysis of video recordings of designers' activity, for example, could confirm or disconfirm this sense. Through further analysis, we intend to explore how a pedagogical partnership between peer observers, design team members, and classroom instructors might positively influence all the stakeholders' practices related to engineering design/communication.

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