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### Learning from the Periphery in a Collaborative Robotics Workshop for Girls

Abstract: This study investigates how students who are peripherally positioned in collaborative group work meaningfully engage with the activity in order to learn. Our research took place in the context of a one-day, all-girl robotics workshop. A total of 17 girls participated in the workshop. Here we focus on two students from different groups who were positioned peripherally. We analyze discourse patterns to characterize the engagement of these two students. One of the focal students exhibited meaningful engagement, while the other exhibited marginal engagement. This contrast allows us to begin to build a picture of the factors that support learning from the periphery. Preliminary results indicate that agency exhibited in group discussions is a key aspect of meaningful engagement.

#### Purpose

Here we report on research of students' collaborative learning during an all-girls, day-long robotics workshop. The question guiding this research is: How do students who are peripherally positioned in group work meaningfully engage with the activity in order to learn? This work builds on our previous research about group role negotiations and students opportunities to learn in a robotics environment (Author, 2015). In that work, we found that students developed creative ways to actively negotiate who would control the

robotics materials. We postulated that, in a robotics context, learning is mediated most directly by interaction with the materials, hence the students ongoing negotiations over them. An observation from the previous study was that one individual persistently occupied a peripheral position in the group's work. This student was a girl who strongly identified with feminine roles (e.g., Mother). We argued that the inherent gender inequality of society, and the identification of technology as a "male" activity (American Association of University Women, 2010; Margolis, 2008; Nosek, et al., 2009) were social factors that served to peripherally position this feminine student. Indeed, canonical research on the role of gender status in collaborative group learning supports this interpretation (Cohen, 1994).

In this study, we sought to create a seemingly more equitable learning environment by eliminating gender as a variable. However, in the all-girls robotics environment, we observed the same phenomenon of peripheral and central participation as marked by control of the robotics materials. And we observed group negotiations over who would control materials at any given time. Moreover, in our initial investigation into the formation of these roles, we have observed that some students appear to be able to assert an agentic identity from the periphery, while other students struggle to participate. In this study, we explore participation from the periphery of small group work in a robotics environment. The goal of this research is to develop greater understanding of how students learn from the periphery in order to guide instruction and curriculum development in technology rich environments, such as robotics.

## Perspective

### *Sociocultural Perspective on Engagement*

At a macro level, engagement has been defined as when something catches the attention of a learner (Dewey, 1913; Hidi & Baird, 1986). Through the sociocultural lens, a more micro level definition focuses on the social interactions that occur as a marker of engagement. Vygotsky (1978) situates learning as a social process where the genesis of higher order thinking occurs through social interaction and, especially, language. An individual's learning evolves through the social negotiation of roles and the sharing of individual and collective knowledge that mediate the activity (Wertsch, 1993). In this way, in a collaborative learning situation all of the participants are, theoretically, afforded an opportunity to contribute to the building of knowledge.

Engagement has also been characterized as meaningful changes in participation. Ryu and Lombardi (2014) posit that in a science learning environment, engaging in discourse is fundamental to a process of change in *epistemic identity* (how students find a place of belonging in the environment) and *epistemic agency* (the practices associated with knowledge construction). Moreover, changes in discourse, such as discussion and argumentation, are indicative of changes in engagement (Herrenkohl & Guerra, 1998). From a sociocultural lens, then, discourse patterns in the learning environment are indicative of collective and individual engagement and learning. Our research proceeds from the sociocultural position – we focus on participants' discourse patterns in examining if and how they are meaningfully engaged in the activity.

## Methods

### *Research Design and Participants*

The participants in this study included 17 girls, ages 8-13 ( $M = 11.725$ ) who attended 5 different schools in New England. Purposeful sampling was used to select

students from various backgrounds and geographic areas from the pool of students who volunteered for the event. Four of the five schools were not meeting state standards for performance. One of the schools had a student population that was identified as 93.2% Hispanic. All of the participants were working with robotics for the first time.

The students were divided into six teams (five teams of 3 and one team of 2), girls from the same schools were on the same team. Chaperones/teachers accompanied each of the groups and were present for the entire day. We focus on two participants from two different groups, each of whom was positioned on the periphery of the activity. In order to identify students who were positioned on the periphery, we viewed the videotapes and reviewed the transcripts. Our criteria for peripherality was twofold: first, if a student was neither the main programmer nor the main builder, she was positioned outside; second, if this outside person's ideas were not taken up by the group, she was peripherally positioned. We selected two cases where both of these conditions were met (Kelly and Katrina). Moreover, we selected one case that indicated meaningful engagement from the periphery and one case that indicated marginal engagement. This contrast allows us to begin to build a picture of the factors that support learning from the periphery. Pseudonyms are used throughout.

#### *Data Collection Methods*

The data were collected at a day long, all-girl introduction to robotics event called Girls Connect, which is periodically offered to girls in the Massachusetts region by the Commonwealth Alliance for Information Technology Education (CAITE). The day included solving robotics problems using the Lego® Mindstorms® EV3 systems and the FIRST® Lego® League challenge arena from 2011: Food Factor.

Each group of girls had their own worktable, EV3, and laptop computer to build and program their robot. Two challenge arenas were set up in the room so that the girls could test their solutions. A video camera mounted on a tripod was used at each group table to capture the building and programming of the robots. Two additional cameras were used, one at each of the arenas, to capture the test-runs of the robots. See figure 1 for an illustration of the room set-up. We chose to leave the cameras stationary so as to attenuate the impact of the cameras on the participants' activity.

[Figure 1 about here]

Each of the participants in the study wore a wireless microphone; two of the Girls Connect presenters also wore a microphone. From these data, we created a video and audio recording of each group's activity and discussion for the day. A professional transcriptionist transcribed all group talk.

### *Data Analysis*

In previous work, we developed a qualitative model of student activity, focused on the troubleshooting cycle in the problem-solving environment (Author, 2011). This troubleshooting cycle includes the following activity: “(1) writing and testing the program, (2) diagnosing problems with the program or structure of the device, (3) proposing and arguing for specific changes to the program/structure, (4) making changes to the program/structure, and (5) testing the device again” (p. 57). Based on our domain expertise and this troubleshooting cycle qualitative model of problem solving, we developed an analytic coding scheme (Table 1).

[Table 1 about here]

Application of our coding system was a deliberative process undertaken by the first and second authors of this paper. The process included viewing the videos and reading the utterances in context and discussing each one – in this way, we inductively coded the transcription. We then counted the instances of specific types of utterances and we qualitatively analyzed the contributions that focused on problem solving (codes 1a – 3c). Our qualitative analysis was guided by the criterion outlined in table two.

[Table two about here]

Our preliminary analysis has allowed us to begin to develop some understanding of the differences in discourse activity that may help account for Kelly’s ability to be more meaningfully engaged from the periphery than Katrina.

## Results

### *Frequency of Types of Talk*

Tables three and four present the respective problem solving discourse profiles of Kelly and Katrina over a four-hour period. As can be seen, Kelly offers more comments focused on diagnosis and on building content and concepts than Katrina. Moreover, Katrina spends more time discussing the organization of tasks and roles than does Kelly, and she spends more time engaged in off task talk.

[Tables three and four about here]

### *Quality of Comments*

We found differences in the focal participants' discourse patterns over a range of discourse types. However, due to space restrictions we provide results on just two of the discourse types: diagnostic observation and argumentation, content and concepts, building elements.

*Diagnostic Observation.* Table five presents a comparative analysis of representative comments uttered by each girl over three hours in the afternoon, when the main problem-solving activity was taking place.

[Table five about here]

Kelly's skills as an observer are apparent in these utterances. She is present for almost every test run of the robot at the arena and is obviously paying attention to what is going on. The robot moves fairly quickly and a lot happens in the 5 to 10 seconds that the robot is running its program. Kelly often initiates an explanation about what transpired on the course. As the day progresses, these explanations are often initiated as a direct request from her teammates. She often not only explains what happened, but offers additional data on how the program can be improved during her commentary. While Katrina also participates in observing the test runs at the arena, her utterances regarding observations

are never specific and don't offer much in the discourse regarding the successful completion of the challenge.

*Argumentation: Content and Concepts: Building Elements: Explanation.* The physical environment of the group table allowed all of the student's access to the building elements. However, in both cases, because they were on the periphery of this activity they did not initially have access to the object that was being built to help solve the challenge. Additional building elements, often a plough or a claw, were necessary to augment the robot's ability to complete the challenge. Kelly is often actively observing the building of these parts as is evidenced by her discourse. She offers help and suggestions both at the group table as well as the arena. Near the end of the day she attempts to make a move toward improving the plough because she sees an issue with the design of the plough. Although Katrina has similar access to the materials and the building process as Kelly, her utterances show that she has taken a much different role for this process. In hour 4, she talks about adding an accessory to the robot that does not move the group forward toward solving the challenge. In hour 5 we found no evidence that she offered any help toward the building elements. In hour 6, she does offer some assistance, but because her experience with the pieces has been so minimal she doesn't know the names of the pieces nor the implement that they have built. Table six presents a comparative analysis of representative comments uttered by each girl over three hours in the afternoon.

[Table Six about here]

In this proposal we have presented a small portion of our preliminary analysis of our data set. Our initial impressions of Kelly's ability to stay meaningfully engaged revolve around her personal agency in the environment. We will explore these topics further in the full paper.

### Significance

Our research contributes to the literature on collaborative learning in a unique way. Rather than focus on the characteristics of well or ill-functioning groups (Barron, 2000; 2003), the role of friendship (Anderson, et al., 2009; Strough, Berg, & Meegan, 2001), the role of status (Cohen, 1994; Esmonde, 2009) or the quality of overall discourse (Mercer, 1996), we focus on the participation of the learner who is positioned on the periphery of the group. Our preliminary analysis suggests that both well and ill functioning groups may include a member who is positioned peripherally. In focusing on how students on the periphery find ways to become and stay meaningfully engaged in the activity, we aim to develop pedagogical ideas for how to scaffold the transformation of marginal participation into meaningful participation for these students.

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Figure 1 – Research Video Camera Set-up

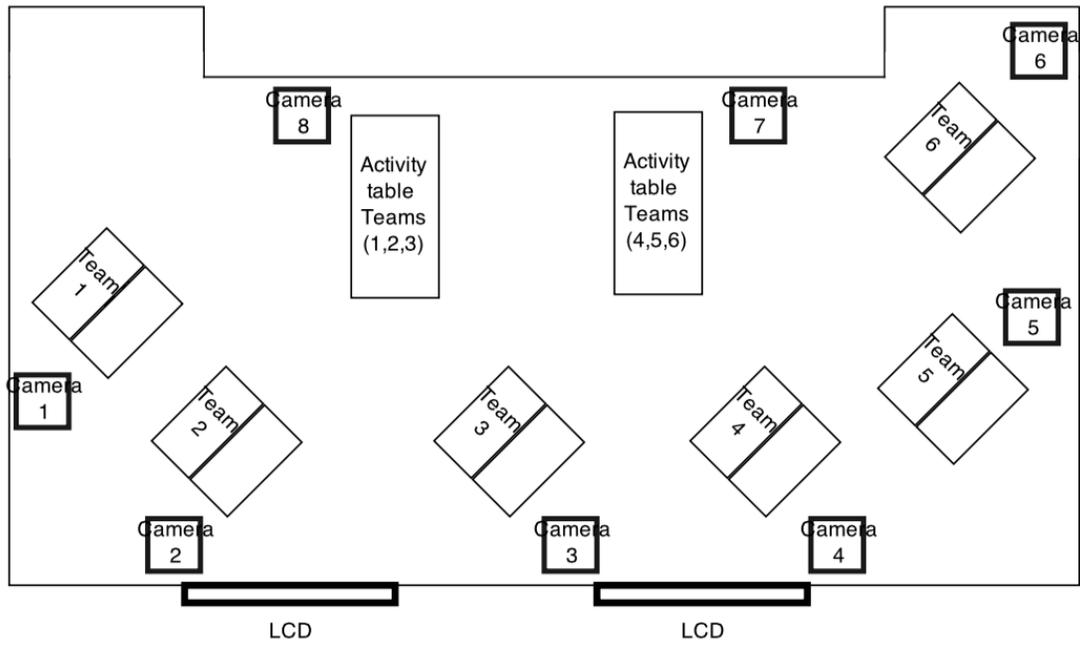


Table 1 – Problem Solving Speech Codes

Main Category	Sub-category	Sub-sub-category	Sub-sub-sub - category
1. Diagnosis	a. Evaluation		
	b. Confirmation		
	c. Puzzlement		
	d. Observation		
2. Query	a. Clarification		
3. Argumentation	a. Group Regulation	1. Organization of Tasks/Roles	
		2. Modal	
		3. Activity Negotiation	
	b. Content and Concepts	1. Programming Elements	
			c. Comparative
		e. Explanatory	

		2. Building Elements	
			c. Comparative
			e. Explanatory
	c. Problem Definition		
		1. Familiarization	
4. Off Task			
5. Affirmations			

Table 2 – Discourse Quality Categorization

Quality	Code	Definition
Low	Comment	A general comment
	Guess	An unsupported choice
Mid	Analysis	Offering and understanding of the issue
	Generalization	Restating previously stated ideas
High	Articulation	Explaining difficult concepts (goes beyond simple understanding)
	Alternative	Offering a substantively different idea
	Brainstorm	Introducing new ideas

Table 3 – Kelly’s Discourse Activity by Hour

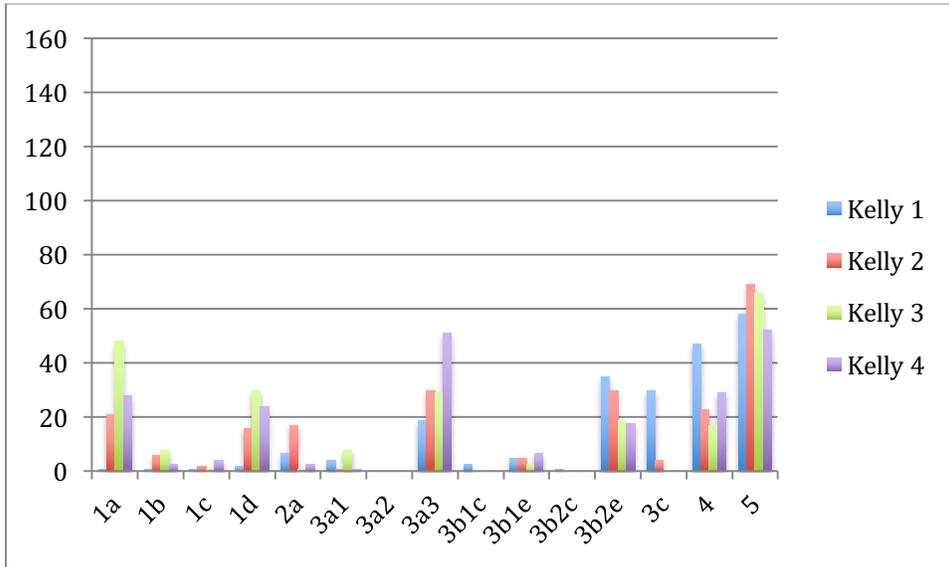


Table 4 – Katrina’s Discourse Activities by Hour

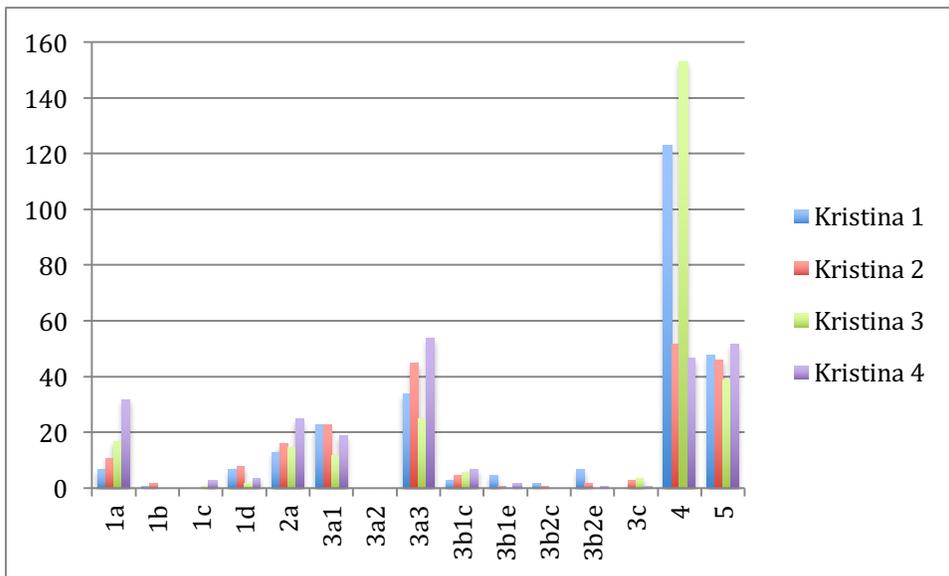


Table 5 – Diagnostic Observation Utterances

Time Period	Kelly	Quality	Katrina	Quality
Hour 4	<i>And it then it got stuck on the ball but it didn't go over the ball.</i>	Analysis	<i>Oh that's (the scrubber) thing.</i>	Comment
Hour 5	<i>It's like yeah, yeah not the balls but like the, cos they have like, I don't know if they'll like effect anything like the width of them.</i>	Brainstorm	<i>Yeah we'll probably get one (done) later.</i>	Comment
Hour 6	<i>It came over here it knocked them out and it goes right here, um it knocked the corn out and it hit the ball off, but then it backed up this way and pushed the harvester all the way over here.</i>	Articulation	<i>I didn't do anything it just randomly</i>	Comment

Table 6 – Building Elements Explanation Utterances

Time Period	Kelly	Quality	Katrina	Quality
Hour 4	<i>So I'm thinking that we should extend the plough with one of those little five notch, things, it will only, it will add on four notches, if we add on this.</i>	Articulation	<i>Genny Genny we should add this for accessory.</i>	Comment
Hour 5	<i>Okay, okay so...this part before was still getting caught on that, so I'm gonna try and perfect this by turning it to a five notch instead of seven</i>	Alternative	No comment made	None

	<i>notch.</i>			
Hour 6	<p><i>Like I made a second plough, because like I was thinking, I was kind of thinking that that one's kind of like, like it might not work.</i></p> <p><i>Because like it just doesn't seem like it's working right now, so like.</i></p>	Brainstorming	<p><i>Well right here this thing was supposed, it was out, was not there so like it would like boom boom, like boom, boom. And that might destroy the thing.</i></p>	<p>Analysis</p> <p>Guess</p>