Examining Discourse in a High School Robotic Club

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Research has shown the importance of discourse in developing deep understandings of science concepts. Science students need to participate in science discourse in which they use social language to facilitate the cultural traditions that constitute a scientific community. When social languages are joined with activities, tools, and values of a group, they become what Gee (2001) calls Discourse (with a capital "D"). We examine high school students' participation in the cultural tradition, practices of science community, and students' Discourse enactment of Discourse in an afterschool robotics club. Using Critical Discourse Analysis (CDA), we analyzed video recordings of discourse, semi-structured interviews, and researcher field note to examine participants' use of language.

Keywords: Discourse, Cognitive apprenticeship Model, Critical Discourse Analysis

Introduction

The paper aims to contribute to the theoretical discussion of discourse as a lens by examining the use of social language by students to approximate cultural traditions resembling that of scientists. Research has shown the importance of discourse is in developing deep understandings of science concepts (Graesser, Person, & Hu, 2002; Roth & Bowen, 1995; Roth & Lawless, 2002). Halliday (1978) identified *resource* and *formation* as two semiotic functions of language. Semiotic resources involve the use of vocabulary "to communicate social and cultural ways of understanding a phenomenon" (Gomez, 2007, p. 43) whereas semiotics formation is an "institutionalized" way of talking, gesturing, or behaving (Lemke, 1990, p. 194). Other researchers have investigated how language evolves as students' views of science become more sophisticated (Kawasaki, Herrenkohl, & Yeary, 2004; van Zee, 2000) and allow students to move along a continuum of proximal to distal understanding of concepts (Gomez, 2007). Stromdahl (2003) discusses the notion of conceptual localities to describe the notion of transitioning between everyday experiences about science and canonical knowledge in science. Therefore, the use of language in facilitating the cultural traditions that constitute a scientific community becomes instrumental in transitioning students from the proximal to distal understandings as well to bridge the gap between their everyday experiences and canonical science knowledge (Gomez, 2007). Our study examined high school students' practices of cultural traditions generally associated with scientists, as they participated in an afterschool robotics club.

When social languages are joined with activities, tools, and values of a group they become what Gee (2001) calls Discourse (with a capital "D"). Gee defines Discourses as any undertaking where the meanings of words, phrases, and sentences are situated or where the use and meaning of language is "customized to our actual contexts" (p. 716). The students in the robotics club, engaged in the sorts of technical and social activities representative of communities of scientists and were very different from other out-of school inquiry activities such as science fairs (Gomez, 2007) in at least two ways; 1) the nature of situated learning of the robotics club and the culminating competition allowed students to work on-site and continue to make adjustments during the final competition with their robots; and 2) the educational scripts looked very different as the students were mentored by the professional engineers therefore the educational scripts mirrored the practices of mentors' professional lives.

Theoretical Framework

Gee (2005) views language as being sociolinguistic and contends that the process of appropriating a social language, a speech genre, is Discourse. Sociolinguists propose that language is a cultural product, and that a language has no meaning outside of the context of the community of its users. When members of a language community speak, write or use other symbol systems, they do so with certain social functions in mind. Gee refers to these functions through which we form our social realities as "Building Tasks". Gee's list of Building Tasks activities is general and associates Discourse with "ways of talking, listening, writing, reading, acting, interacting, believing, valuing and feeling (and using various objects, symbols, images, tools and technologies) in the service of enacting meaningful socially situated identities and activities" (p. 719). Gee argues that language is used to build situations using seven building tasks: 1) significance; 2) activities; 3) relationships; 4) identities; 5) politics; 6) connections; and 7) sign/systems and knowledge.

In the scientific community, as in the community of craftspeople, novices are initiated into the knowledge and culture of the community by appropriate support of more knowledgeable members of the community. When knowledge is acquired through such interactions, learning goes beyond traditional teacher-centered classroom functions to learning that is contextual, student-centered, and situated. Situated learning is described by cognition theorists as learning that is sociocultural and thus resulting in certain 'communities of practice' immersed in social interactions (Lave & Wenger, 1991). Learners are indoctrinated into communities of practice through engagement with experienced members of the community.

In science learning, this means that at some point the teacher must step out of the way to permit students to practice being scientists and use the language of science (Gallas et al., 1996; Roth, 1993; Roth & Bowen, 1995). While the teacher/mentor may always function as a facilitator/referee in the case of disputes of a social and logistical nature, to the extent that dialogic argumentation or discourse becomes an element of student collaboration, the students themselves become the arbiters of disputes that center on knowledge claims (Duschl & Osborne, 2002; Watson, Swain, & McRobbie, 2004).

Methodology

In this study, we used Critical Discourse Analysis (CDA), a particular way of looking at Discourse within the larger discourse analysis paradigm, as a lens to look into students' and mentors' use of language within the context of an afterschool robotics club activity. Using CDA the focus is on 1) analyzing discourse in terms of the text produced by the participant which can include both written and spoken forms; 2) analyzing the process or history of the text production, which can include looking into how the text was produced, distributed, and consumed; and 3) analyzing the sociocultural practices involved in the discourse event (Faircloug, 2001).

Context and participants of the study

This study focused on a group of high school students and their engineering mentor who were involved in an afterschool robotics club activity that culminated in their participation in a regional robotics competition. The students in the club placed themselves in one of four units within the robotics team, with each unit being responsible for specific tasks. During the building phase, students with necessary help from their mentors worked on building their robot. Students' roles included being a robot driver, coach (co-driver), safety captain, pit crewmember, and scout. Participants for the study were comprised of 6 female students, 9 male students and their mentors including one professional engineer.

Data collection and analysis

Study participants' discourse-related data was collected during the three-day period of the robotics competition, and interview data was collected in the eight-week period after the competition. Data were collected in the form of audio/video recordings of participants' language use during the robotics competition, participants' created artifacts as part of their robotics activity, researcher field notes documenting participant interactions, and post-activity interviews with a selected number of participant. We used CDA to analyze linguistic data by using Gee's (2005) Discourse to view the reflexive role played by learning context and language. In beginning our analysis, the paragraphs of the transcripts from the robotics completion were reduced to sentences, and these were broken into clauses that dealt with unitary topic or perspective, and marked for tone units and pause. These were then analyzed for the significance of stress. Both these transcripts were subjected to form-function and language-context analysis to identify the discursive resources (Gee, 2005). The transcripts from the competition and interviews were coded for themes that emerged within and among the texts. The codes changed as the study progressed, but in the end the codes that were employed were based on Gee's building tasks (Gee, 2005). The building tasks are Gee's version of the ways that language is used to construct human reality. The building tasks that were most evident in the study data were *activities*, *identities*, *relationships*, *politics* (in the sense of distribution of social goods), *sign systems and knowledge*.

Results

We begin this section with a transcript of a conversation that occurred in the pit area of the competition as robotics team strategized about the problem of having too little traction for the robot to maneuver to share students' use of language in validating knowledge and showing solidarity (see Table 1).

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Validating knowledge in communities of practice and showing solidarity

At the beginning of the transcript, SB, the engineering mentor, focuses the group's attention on the robot's traction problem and hence PL's and PP's language focuses on this issue. In fact, much of PL's first utterance (2a-2b), *"Yep, that's a problem because I'm not getting much of anything."* was, in essence, an endorsement of SB's bid (1) to make traction the topic of the discussion. PL finishes this utterance by posing the essential question, *"How can we get more traction out of this thing?"* PP offers an answer to this question (3) by posing an argument that we will call argument I. In argument I, PP makes the claim that the traction could be addressed by repositioning the batteries closer to the rear wheels. PL rebuts PP's argument by claiming that he doesn't think PP's solution will help much (4a) and offers a backing reason (4b) for his judgment. PP's and PL's pattern of an argument is based on observation followed by a rebuttal, or an agreement that is empirically testable.

Speaker	Utterance	Line	
SB	1	1	All right let's, let's talk about ***traction***
PL		2a	Yep, that's a problem
	2	2b	because I'm not getting much of anything
		2c	So, how can we get ***more traction*** out of this thing?
PP	3	3	We can ***concentrate the mass*** of the ***batteries over the wheels*** [Argument I]
PL	4	4a	Don't think that'll ***change*** much
PL		4b	The change in ***lever arm is too small***
SB		5a	Let's swap these
	5	5b	like we did in the field test
		5c	That may be the ticket.
PP		6a	If we take off the ***universals*** [Argument II]
		6b	and put on the ***gummies***
		6c	that will ***help traction***
	6	6d	because we'll go from ***passive front*** to a ***four-wheel drive***
		6e	but it will ***change the handling*** [Argument III]
		6f	and make us even ***lighter in the front.***
		6g	We're screwed for ***center of mass.***
PL		7a	Yeah, that won't help the ***hurdling*** or ***placing***
		7b	The ***field-of-play*** is more ***like the floors at school***
		7c	than I thought
	7	7d	they'd be
		7e	Yeah, maybe those ***tires are better***
		7f	***No problem*** with the handling
		7g	I've had time with ***that set-up***
PP	8	8a	All right, but why did it ***fishtail***?
		8b	Are the wheels getting the ***same torque***
PL		9a	Yeah. Well?
	9	9b	When we drove it like that in the other tests
		9c	it didn't fishtail
		9d	I think the new ***tires'll fix it.***
SB		10a	Uh, Guys, the ***way it is geared***
	10	10b	I can't see how
		10c	the wheels could get ***different torques.***
PL		11a	Well, uhm, without the ***counterweight***, I think the rear gets out
		11b	of line
	11	11c	but I can get rid of the fishtailing by ***accelerating less***
		11d	when I have to steer around a jam
		11e	The ***four-wheel drive'll*** help, too
			The front won't be ***passive***
PP	12	12a	Uh the, those wheels are bigger
		12b	so we'll have to ***reposition these wires***.
SB		13a	Any other ideas?
	13	13b	[pause] OK, let's ***reroute*** the wiring
		13c	and swap the tires.

Table 1: Students' arguments

Argument II is found in clauses (6a-6c), and argument III is in (6e). Argument II begins with PP's claim, "*If we take off the universals and put on the gummies that will help traction. . . "* He backs the claim in (6d) *"... because we'll go from passive front to a four-wheel drive."* There are no rebuttals to argument II. Instead, in clauses (7b-7d) PL agrees with the claim of argument II. His agreement is, *"Yeah, maybe those tires are better."* and he offers backing for his agreement, observing that, *"The field-of-play is more like the floors at school than I thought they'd be."* Here he is referring to testing the robot on a surface similar to the field-of-play, with the same wheels and drive train arrangement that have been suggested to improve the robot's performance. Argument III (6e) is, *"... it will change the handling..."* This refers to the result of changing the wheels/tires and the drive train. PL's rebuttal (7f) is, *"No problem with the handling."* This is backed by (7g), "*I've had time with this set-up."* The rebuttal refers to PL's success in driving the robot with the stickier tires and the different drive train during practice at the school.

"We're screwed for center of mass" (6g) is the last argument in utterance (6). PL's response (7a), *"Yeah, this won't help the hurdling or placing"* is in agreement with PP's claim. Both of these statements refer to the problem that the team encountered at the weigh-in. The robot was 1.7 lbs above the 120 lbs allowed by competition rules, and this weight did not include the 20 lbs of counterweight that the team hoped to use to stabilize the robot. The students understand that changing the front wheels from the heavier and more steerable universal wheels to the lighter fixed gummies will exacerbate the problems caused by the light front end. In (7a) PL is referring to *"... hurdling and placing ...,"* which are scoring maneuvers in the competition that require raising the rather heavy rack-and-arms apparatus that is located at the rear of the robot. So PL's comment is effectively that with a lighter front end, raising the robot's rack-and-arms will make the robot even more prone to tipping over than it would be with the heavier universal wheels in place.

This structure of argumentation used by PL and PP in their pit discussions and their means of validating knowledge has been described by a number of authors. Toulmin (1958) reported that, like other communities of practice, the scientific community employs mutually agreed standards of validity to its arguments. For scientists, this means, that argument must be empirically based and theory dependent. In addition to their arguments' structure, within these scientific arguments there are examples of lexicogrammatical features associated with scientific register. In the case of PP's and PL's arguments these are deverbalized nouns in the form of participles. In each case, the clauses containing the deverbalized nouns can be restated using the verbs from which the nouns are derived without changing the meaning of the clause. For example, in (11b), *"... I can get rid of the fishtailing by accelerating less..."* contains two deverbalized nouns, *fishtailing* and *accelerating*. This clause can be restated as two clauses: [It won't fishtail] [if I accelerate less]. There is no change in meaning, but this less lexically dense construction is not typical of scientific register.

PP's and PL's dialogs do not share ways to diagnose and the fix the robot's problem, but analysis of participants' language indicates their ownership of the project. They demonstrate this ownership in spite of the fact that SB essentially prescribed the pit crew's activities. Analysis of the pit crew's language (Table 1) shows that they are doing more than following SB's instructions. There are four instances, (1), (5a), (10a) and (13b), from the transcript where SB's utterances contain attempts to promote ownership. In three of these he uses "*Let's"*, the abbreviation of *"Let us."* The use of us includes everyone working in the pit with every aspect of fixing the robot.

There is another incident from the competition that illustrates the student ownership of the robotics program (see Table 2 below). The incident occurred as members of the robotics team who had volunteered to serve as scouts met after observing early practice rounds. Each scout was assigned to observe the performance of several robots. In addition, they were to visit the pit areas of the teams responsible for the robots, interview the team members and make a close-up inspection of the robots' construction to get a sense of its durability and capabilities that might not be obvious from observing them at a distance during the practice rounds. Table 5 shows the transcript of three scouts sharing their observations and opinions of competing teams and the robots, and their plans to report to their own team. As the scouts share their findings with each other, we can sense the negotiation of findings and thus group determined standards. For example NS-1 ends his utterance with *"…but like I said not so good for hurdling…"* but then HF-1 responds by saying *"Wait! Dude! I saw it on the test field and it hurdled great."* The two scouts negotiate their observations of competing teams with the help of SJ, who suggested going to the crew to talk about issue of *"hurdling"*. This conversation highlights students' ownership toward the robotic club, and their solidarity with each other for a common task.

The students discover that while the teams were getting high points, at the same time they were also being penalized points for illegal actions (SA-1 *"…It scored points but the refs'll penalize it a lot for knocking other robots in their zone"*). The students agree that they all saw points being taken away for illegal actions. SJ thinks that this needs to be shown on their scouting reports (SJ-5 *"…We need to show that in our reports. How do we do it?"*). The students (HF, SA, PA) then negotiate possible ways to incorporating the scoring and penalizing of points in their reports. HF suggests *"We could calculate a ratio of points scored to points penalized…"* SA then suggests using net points, justifying it by saying that it's easier to determine. PA, while agreeing somewhat with SA, shares her ideas with the group on why the ratio method would be better. SJ moves along the conversation and the group and asking for vote on the ratio method. The students, realizing the need to include more information on the scouting report, decide on an appropriate method of representing that information and take ownership for collecting the necessary information. This sort of discursive act is characteristic of communities of scientists and engineers. Just as communities of scientists and engineers do, the community of scouts used their language to set standards for what will be privileged as legitimate and useful knowledge within their community.

Speaker	Utterance
NS-1	11002, the, green one, has really good way of knocking the balls off the, uh, rack [SA: the same thing it uses to pick'em up?]. Yeah but it's not so good for that. Uh, good speed too, but like I sad not so good for hurdling.
HF-1	Wait! Dude! I saw it on the test field and it hurdled great.
NS-2	It stunk in the practice round. Maybe there's, uh, like, a problem?
SJ-1	OK. After go back and talk to the crew and see if maybe they, uh, didn't try hurdling in that round or what, OK?
NS-3	Yeah, movin' on. Alright. Uh, the driver's not bad, but the 'bot was broken at the end of the round. There was a lot of bangin'. I asked about the repairs and the crew chief said it was no problem. Good herder and a definite rabbit. I'd say it's pretty strong overall.
SJ-2	Does it do hybrid?
NS-4	UH, Yeah it went flyin' down and slammed the wall. So, it got two lines but it probably didn't help the mechanics much.

Table 2: Students' utterances

Discussion

A number of features of the robotics club context fostered, through Discourse, a sense of solidarity with teammates in their efforts and ownership of the project and its products. One of these features is the way the robotics club incorporated mentors into the structure of the project. The mentor's relationship to the project was very different from a classroom teacher's relationship to a lab exercise. Unlike classroom lab exercises, the mentors are on an even footing with their student collaborators. Neither the mentors nor the student team members knew the solution to the problem that the project presents. This is one of the features that make the robotics competition a real world science/engineering experience. The mentors' relationship to the problem is a means through which students gain ownership of the problem and its solution. By this we mean that when the teacher presents a problem to which the teacher knows "*the Solution*", this is the teacher's problem, and when the teacher insists on *the Solution*, the solution is the teacher's too.

The mentor's role was essential to this process in helping students solve problems. The students were neither scientists nor engineers. The language, practices, and values of these two groups were foreign to them, and their mentor was a guide through the process of acquiring a facility in this new Discourse. Roth (1993) and Roth and Bowen (1995) propose a cognitive apprenticeship model for inquiry learning. An essential component of the cognitive apprenticeship model is the role played by a knowledgeable person who is a member of the particular community of practice into which the apprentice is to be introduced. The engineering mentor was such a person. His role is important at two levels. First, during the incident recorded in the pit, the mentor helped to focus the students' discussion of the traction problem on the problem's most likely cause and most effective repair. However, while directing the students, the mentor provided space for the students to argue and to plan driving strategies for the upcoming competition based on the changed capabilities of the robot. This is the second level at which his involvement was important. The nature of the mentor's involvement allowed the student team members to foster a sense of ownership of the project's outcome.

To someone on the outside and looking in, it might appear that robotics club was about building a robot. However, analysis of the study participants' language revealed the extent to which this language has been used to promote and portray intense personal relationships that were a part of participating in and talking robotics team activities. These relationships are the essential element of community. It is also noteworthy that the word "robot" appears infrequently in interview transcripts, and that little of the talk in interviews turn to topics directly related to the robot; the interviewees were not restrained from talking about the robot. Still, they only infrequently referred directly to the team's robot. Instead, their talk was about robotics. Here the students acted as a small community of scientists to preserve their particular view of phenomena associated with their robotics activities and to persuade others to understand and "buy-in" to their knowledge claims (Woodruff & Meyer, 1997).

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