Computer Representations in Students' Conversations: Analysis of Discourse in Small Laboratory Groups

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Abstract

Language use in student laboratory groups makes apparent students' conceptions in science, their interpretation of the activity/task, and the negotiation of the roles of the members. This paper reports on a methodological approach to systematically analyze student discourse. Four grade-12 lab groups working on microcomputer-based laboratories (MBL) are the focus of the study. The MBL experiences were used to help students link oscillatory motion to graphical representations. Study of student discourse reveals the role the computer plays in the group context and the ways that this context is shaped by the computer. Developing a better understanding of the role of the computer in student conversations suggests ways to fruitfully construct contexts for learning physics.

Keywords — microcomputer-based laboratories (MBL), physics, discourse, science education.

1. Introduction

A conceptual understanding of science is typically sought among educators. We argue that focusing on language provides us with an interpretative lens to understand both what gets accomplished in small laboratory groups as well as how it is accomplished. Learning science includes constructing understandings that are consistent with empirical evidence and the theoretical backdrop of a discipline. MBL experiments allow students the possibility of interacting with the physical world and simultaneously reacting to representations of these events. This provides a unique setting for studying students' conversations.

2. Language and science learning

Learning science requires novices to be initiated into the conceptual frameworks, epistemic dispositions, and social practices of the scientific community. The central conceptual frameworks of a discipline allow a community to identify problems to be solved, to decide on what will count as a solution, and even to experience certain events (Strike, 1982). In order to participate in the ongoing conversation of a community, students/novices need to understand how the community operates, what language is used, and how evidence is evaluated. Educational contexts must be formed so that students get an understanding of what it takes to participate within the scientific community. Central to the processes of constructing scientific knowledge are the social and discursive methods used to establish a claim (Latour & Woolgar, 1986). Both experimental and theoretical evidence need to be articulated in persuasive arguments to a relevant epistemic community before it is acknowledged as scientific knowledge. In order to understand the socially derived knowledge of a community of knowers, novices need to participate in conversations and "forms of life" of the community (Wittgenstein, 1958). The processes used by students to come to know the use of scientific concepts needs to be documented to better understand how to construct appropriate educational contexts.

2.1. Sociocultural view

Sociology of science documents the problematic nature of scientific inquiry. The social processes of constructing scientific knowledge are central to establishing a claim (Collins & Pinch, 1993; Kelly, Carlsen, & Cunningham, 1993). For example, discoveries in science are typically made retroactively by a community of scientists (Brannigan, 1981). Discoveries do not happen as a specified "event." Rather, over a long period of data collection and analysis, the facts are constructed through discursive processes (Woolgar, 1980).

The empirical evidence plays only a partial role in establishing a scientific fact. Similarly, students are not compelled solely by empirical evidence to accept scientific theories. Students' ideas are formed in a social context an example of which is science laboratory experiments. Students need to see that deliberative aspects of science are as important as collecting data. As with scientists, students' discoveries are a process; ideas are constructed, debated, and reformulated. Students need to be able to formulate conceptions, explanations, and hypotheses, submit these ideas to empirical and deliberative tests, and reformulate them as necessary. The MBL experience studied here was designed to engage the students in conversations about physical phenomenon thus giving them the chance to "talk science" (Lemke, 1990). The choice of educational setting for examining these processes becomes crucial. We sought an educational context where students could use empirical evidence and practice talking science. Microcomputer-based laboratories provided both of these qualities.

2.2. Microcomputer-based laboratories

Microcomputer-based laboratories offer students the opportunity to engage in the discursive process of creating meaning in collaborative laboratory groups. MBL protocols differ from typical laboratory experiences in that students can quickly acquire and analyze data. Cycles of data acquisition, analysis, discussion, and reframing of the research question can be created. Furthermore, data acquired in real-time can be viewed in multiple representations (events, graphs, tables, equations) and manipulated to answer student questions. The MBL setting thus is thus methodologically interesting because the computer offers representations that must be interpreted by the students (Roth, 1995). Students need to talk curves and squiggles into concepts and ideas.

2.3. Research site and educational context

The study was conducted in a rural high school in California undergoing the process of systematic school reform. The students enrolled in grade-12 Advanced Placement physics course are the subjects of this study. During the episodes studied, the students worked in collaborative laboratory groups of 3 or 4. The students were guided through a lab protocol to study oscillatory motion. The technology was configured as shown below in Figure 1.

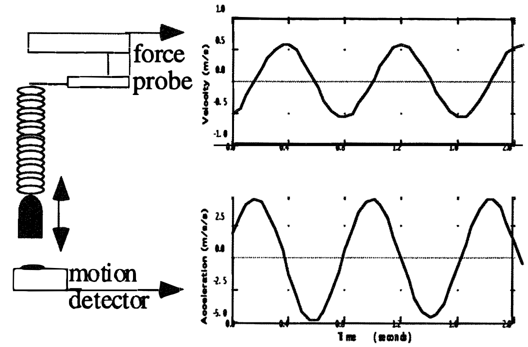

Figure 1. Experimental configuration. Pictured is the mass on a spring, a force probe, and a motion detector. The force probe and motion detector both send electronic signals to an interface box and the computer generates graphical representations as shown on the right. Representative graphs generated by MBL acquisition software (Vernier Software MacMotion Version 4.03).

3. Methodology

Students' words and actions while working in the laboratory groups were captured on videotape. Each of the four 45 minute group sessions was analyzed on multiple levels building on the methodology of classroom discourse (Green & Wallat, 1981; Bloome & Egan-Robertson, 1993). First, we broke down the episodes in detail in order to understand how the conversation was being created by the actors (students, teacher, researcher, and computer). Second, we identified the ways these smallest building blocks were put together by the actors to form larger structures. We then used these larger units to identify patterns of interaction.

3.1. Student discourse

We analyzed the episodes at multiple levels. First, we identified *message units*. Messages units are defined boundaries of utterances or social action. Message units are the smallest unit of linguistic meaning and must be identified post hoc by cues to contextualization (Gumperz, 1992). This was done both from the audio dub but also directly from the videotape as the non-verbal cues are important in identifying the message units. Figure 2 is a representative portion of a transcript. This group is comprised of three human members and the computer. The transcript starts with L saying, "that is really neat." This is a complete message unit. Nancy then gives direction to Laura, "do big circles." Nancy's first message unit is separated by only a very short pause before her next message unit, "jump up and down" is given. On the transcript, each message unit is on a separate line.

Second, we identified the actors' *action units* which are comprised of one or more message units. Action units often show a semantic relationship among messages and represent an intended act by a group member. These are likewise identified *post hoc*. Action units make visible the thinking students choose to display publicly. This level of analysis provided us with the opportunity to see how the computer representations entered the students' conversations. For example, N's two message units, "do big circles," "jump up and down," are tied as one action unit. She is giving a directive to Laura. The action completes her task of telling Laura how to move so that another experimental run can be completed. The third and fourth levels are not relevant to the interpretations described below.

transcript		codes
L:	that is really neat	responding
N:	do big circles	
	jump up and down	
C:	*produces representation*	responding
N:	so why does it go lower?	clarification
	distance versus time	demonstrating
	so when you get closer	claiming
	it goes	"
	further this way?	"
	=no that's time=	demonstrating
S:	=no that's probably	claiming
	just how far	
L:	that's time	
S:	how far	
	it is away	
N:	time is that	claiming
	and	
	and	
	distance is	
	this	
	when you're that close	
	you go crazy	
	go crazy far away	

Figure 2. Representative transcript of students' conversation in MBL context (L, N, S are students, C is the computer).

3.2. Patterns of interaction

The research methodology of following closely the students' conversation in the laboratory setting makes visible patterns of interaction. In this paper we report on just one of these: the use of computer representations in student conversations. Throughout our analysis of student discourse we were able to recognize the multiple uses of the computer by the student group members. After analyzing the student discourse at the level of action units, we reviewed again the videotape and noted each instance that a computer representation was produced or that a student specifically employed a computer representation in the conversation. Each of these instances was coded based on how the reference fit into the larger conversation. Figure 2 shows how the analysis of student discourse allows for the identification of interactional patterns on a representative piece of transcript. In each case the computer representation enters the conversation in one of the two ways described below.

There are two pathways in which the computer representations enter into the group conversations. In the first case (Pathway 1), the computer creates a representation of acquired data (see Figure 3). This representation must be interpreted by student(s) to become a message in the conversation. Typically, these messages provide information regarding a physical event.

Reciprocally, these messages can be become interpreted representations that enter the conversation through pathway 2. In this case (pathway 2), a student employs an interpreted representation (the computer message) for support in her argument or explanation. The new message is used now by the student for the purpose of supporting her own conceptions. Our claim is not that the two pathways represent mutually exclusive entrees into the conversation. Rather, the difference is one of perspective. We can choose to see the computer operating as a member, or alternatively, as being employed by other members in the conversation. Thus, for each way the computer acts as a member, there corresponds instances of students employing the computer representation. The computer must be recognized in order to participate.

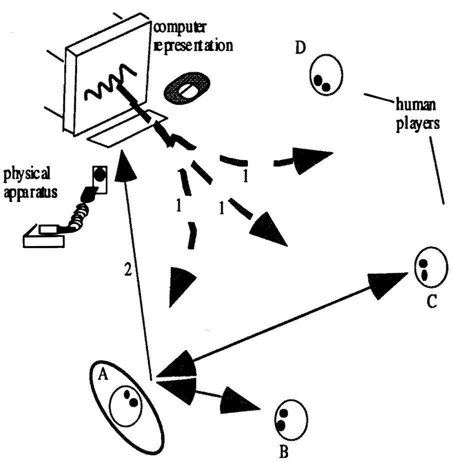

Figure 3. Pathways of computer entree into conversation. Through pathway 1 a representation is made available for the students. In Pathway 2 a student acknowledges the computer representation, in this case by making a case to other students by employing the representation.

Computer representations enter through pathway 1 in multiple ways. A means-end domain analysis (Spradley, 1980) of the entrance of these representations into the conversations shows five distinct avenues of entree. (a) The computer *enters as an ally* for one or more students in their effort to make a case. One way the computer acts as an ally is by providing the possibility of a successful prediction. (b) The computer acts to *help construct meaning* in the group; there is an explicit appeal to the computer. Students demonstrate an event or events to others by drawing attention to a specific piece of data. (c) The computer *exhibits* vital information. Data crucial to the point being made in the conversation is exhibited on the computer screen. (d) The computer *elicits* students responses. These responses can be exclamatory ("cool," "neat," or "what?"). (e) The computer presents students with *anomalies* to the students' expectations or conceptual frameworks.

Similarly, students used the interpreted computer representation entering through Pathway 2 in seven ways. We used means-end domain analysis to categorize the seven ways these representations were employed in the student conversation (see Figure 3). For each of these student uses of the computer representation, there is a reciprocal relationship with the computer acting as a member. The seven uses of the representations by students are: (a) The computer representation is used by students to make a *claim*. The representation thus becomes a piece of evidence supporting a larger student argument. In order to be a claim, we required that the student action linked a real event to a representation. See Figure 2. (b) The computer is employed by students as they make *predictions*. They suggest that the computer will give a particular result given certain circumstances. (c) Students bring in the computer by *demonstrating* a particular feature of a representation. Typically, students seek to demonstrate the location of a specific aspect of the representation on the screen. A typical example would be "distance versus time" (See Figure 2). In this case N points to the axes by moving the mouse (and arrow on the screen) to bring the attention of the other group members to this portion of the representation. (d) Students look for the computer to make sense of physical phenomenon, coded as *looking for clarification*. Physics concepts may be initially inaccessible to the students. An example is provided on Figure 2 where N asks, "so why does it lower?" (e) Students find information on the computer screen, coded as *reading*. Students may be reading numbers or information from the computer screen. (f) The students also *respond* to the computer as a member in the group. When the computer gives a representation it's treated by students as a utterance in need of response. L responds to the computer "that is really neat" in Figure 2. (g) Students *recognize anomalies* to either their own initial conceptions or to the expected result of an experiment based on the standard physics account.

4. Conclusion

The results of this project reveal both how the computer enters into students' conversations about physics and the importance of focusing on student discourse in the computer learning setting. Above we've described two pathways for computer entree into a conversation. Throughout these episodes of computer/student talk there exists an interchange as students seek support from the computer and the computer offers support to the students. The detailed analysis of looking closely at student discourse demonstrates the role a computer can have in the social and conceptual interactions of collaborative lab groups. The computer is thus best interpreted as a member in the group and conversation. Nevertheless, the computer has a special dual status in the group. The computer representations are meaningless without student mediation. Computer representations must be brought into the conversation through the interpretative lens of a student. In this way the computer has a lower status as a partner. However, the computer has access to the empirical data the students are seeking to understand. This elevates the computer to "judge of appeals," and a privileged status. The appeals to the computer can be variously interpreted and aren't decisive. Resolution lies entirely within the lab group interactions.

The analysis we presented above provides a way of seeing what gets accomplished through language in small laboratory groups. We provided evidence of how the four groups employed the computer and made the computer a member of the group. This analysis can now be extended to compare across groups and across time within a group. Such comparisons would help us further understand student actions and how these may be related to our goals of conceptual understanding in science education. The processes engaged in by students to play the language games of science can be revealed through this analytical procedure.

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