UNDERSTANDING TEACHER FACILITATION OF SMALL GROUP INTERACTIONS IN DESIGN-BASED SCIENCE CLASSES

Project and design-based curriculum present students with an overarching question or problem that students solve through the design, construction, and testing of an artifact. Understanding teacher facilitation during student use of hypertext as a primary science resource is critical if students are to find success by applying appropriate scientific concepts rather than finding success simply by trail and error. In this study, the dialogic strategies of three middle school teachers are analyzed as they facilitate small group use of the CoMPASS hypertext system within a simple machines curriculum. Chronological representations of dialogic strategies are presented for each teacher during inclined plane and pulley, the first and last simple machine investigated. The representations reveal that the majority of teacher talk is procedural and logistic rather than science oriented during both investigations. A focus on copying information and task completion suggests that teacher's view the use of CoMPASS hypertext as a bounded activity within the curriculum sequence for each simple machine. Identifying and characterizing teacher dialogic strategies during small group work with CoMPASS hypertext represents the first step in a sequence of research aimed at developing teacher professional development and teacher educative curriculum materials in collaboration with classroom teachers under real-world conditions.

Katherine D. Knight, University of Wisconsin-Madison
Sadhana Puntambekar, University of Wisconsin-Madison

Introduction

Proponents of reform science place science inquiry in the context of a social constructivist framework, whereby knowledge is socially constructed, validated, and communicated during enculturation into a community of knowledge. (Driver, Asoko, Leach, Mortimer, & Scott, 1994). One such approach to science inquiry involves students designing, building, and testing artifacts in response to overarching questions or problems around which the curriculum is designed. However, research in this area has shown that without "getting to the science" (Kolodner et al., 2005, p. 508), students may solve the problem or create an artifact simply through trial and error. One promising line of research to address this tension studies the efficacy of integrating hypertext and hypermedia sources within an inquiry based science curriculum to provide information about the underlying scientific concepts to support designing and building in project-based approaches (Hoffman, Wu, Krajcik, & Soloway, 2003; Puntambekar, Stylianou, Hübscher, 2007). Because hypertext is non-linear, it supports multiple investigation paths. This strength, however, also presents a number of challenges. Students familiar with the linear presentation of information in traditional science textbooks now face navigational decisions about which science concepts to explore, how each of these concepts are related, and the need focus on those science ideas most relevant to their hands-on designs and projects. Thus, an important factor that affects the successful integration of hypertext into project based curricula is the facilitation provided by classroom teachers.

Purpose and Objective of Study

In this paper we investigate the dialogic strategies of three teachers during small group work as students use a hypertext software system called CoMPASS embedded within a design-based simple machines curriculum. The objective of this initial phase of research is the identification of teacher dialogic strategies used in order to better understand how teachers help students to make connections between the science described in text to their hands-on investigations. Previous research into the use of hypertext by either children or adults has focused on individual navigational patterns.

Our study is unique in its content and scope and represents the first step in a research agenda aimed toward reconciling teacher practice with educational theory and research on scaffolding student hypertext use through an on-going collaboration with classroom teachers.

Study Context

This study uses the CoMPASS Simple Machines curriculum consisting of a hands-on design component and a hypertext component. Each component is described below.

CoMPASS Simple Machines Curriculum Hands-on Design Component

CoMPASS simple machines curriculum is a guided-inquiry, design-based middle school curriculum composed of a series of hands-on design activities for each of six simple machines: inclined plane, wedge, screw, level, wheel and axel, and pulley. The eight week curriculum initially presents students with an overarching challenge to design, construct and test an apparatus consisting of at least three different simple machines to assist a person with an injured wrist lift a can of beans. Students investigate six different simple machines during an iterative process that includes introducing and brainstorming a mini-challenge for each machine, familiarization with lab equipment, predicting, preparing and sharing group questions related to the mini-challenge, using the CoMPASS hypertext software system to conduct research to answer the group questions, conducting the challenge, sharing group results during a whole class discussion, and finally, completing analysis questions related to the challenge. Students have an opportunity to revisit and revise their initial can-left design midway through the curriculum and again at the end before they actually construct and test their final design.

CoMPASS Simple Machines Curriculum Hypertext Component

A second component of the curriculum is a hypertext software system called CoMPASS, which serves as the primary source for science information. CoMPASS (Puntambekar, et al., 2007) is a hypertext system that integrates two different representations by placing textual descriptions of science concepts alongside concept maps, thus producing a conceptual unit on each page. This dual presentation allows students to navigate either by selecting science concepts as they read from the text or by selecting concepts on the accompanying concept map. Each map is dynamically drawn from a database placing the selected concept in the center. Related concepts are also presented with the strength of relationships to the central concept indicated both by color and proximity. Concepts most closely related are shown in the first level and those less related appear in the outer level. Figure 1 illustrates the conceptual representation presented to students for work in pulley.

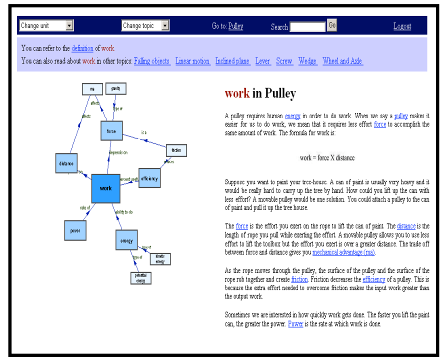

Figure 1. CoMPASS Screen Shot

Participants

Three veteran middle school teachers, each with over twenty years of classroom experience implemented the CoMPASS Simple Machines unit during the 2006-2007 school year. Joyelle and Gwen (pseudonyms) taught 6th grade at a grade 5-8 Title 1 targeted assistance middle school in a small town in northeastern Wisconsin. All sixth grade students participated in the study (N=132). Lauren (a pseudonym) taught 7th grade in a grade 6-8 middle schools in north-central Wisconsin. All seventh grade students participated in the study (N=60). Student populations at both schools were quite homogenous with 96% and 93% of students identified as Caucasian respectively.

Teachers attended a four day workshop during the summer before the implementation to participate in the hands-on activities, familiarize themselves with the CoMPASS hypertext system, and review simple machine science content. Although teachers had previous experience monitoring and assisting individual students using the Internet for activities such as web quests and scavenger hunts, none had experience facilitating group use of a hypertext system for inquiry science investigations. Students collaborated in groups of 3-4 with a single computer as they conducted research using CoMPASS.

Methods

Data Collection

For this study, we used video data from classroom implementations from a single representative class for each teacher as student groups investigated inclined plane and pulley using CoMPASS. These machines represent the first and the last opportunity for students to utilize the CoMPASS hypertext software system and were chosen to allow for the comparison of teacher dialogic strategies when students are both novice and experienced users. The video corpus of approximately 2.2 hours of video resulted in 62 pages of transcripts.

Data Analysis

Initial data analysis consisted of viewing the video corpus and identifying dialogic segments that coincided with teachers facilitating small group work during CoMPASS investigations of inclined plane and pulley. Dialogue directed toward the whole class, assistant teachers, or the researcher was eliminated. In order to keep the meaning of the teacher dialogue unit intact, the grain size for analysis was identified as a single teacher utterance. This meant that some utterances were as short as one-word acknowledgements while others where as long as two or three transcribed paragraphs, especially when teachers were providing detailed instructions and procedures. Complex utterances were assigned more than one code. Coding categories used in this study mirrored those used to analyze a previous CoMPASS implementation that considered teacher dialogue during whole class discussions (see Puntambekar, et al., 2007). Two additional codes were identified during the inductive viewing of classroom video and are included in this study. The final 14 coding categories are identified in the next section.

After one researcher completed coding, a second researcher independently coded sub-sets of approximately 10% of the transcripts, resulting in an inter-rater reliability of 91.1%.

Coding categories. Two overarching categories of codes emerged during this study, procedural and science content. The five procedural codes and nine science content codes, along with examples, are identified in Figure 2.

	Coding category	**Example from transcript**
Procedural Codes	Instructions and procedures	Page nine is going to be the page where you're gonna record anything important, or anything that you find today on compass. Alright? Anything that's gonna help you for tomorrow. Any kind of notes, I don't care how you do it, if you draw it, you write it. However you want to, put it on there.
	CoMPASS assistance	T: Mmmm. You can always go back, up here (name) and select simple machines and that'll take you back and then you have to pick the right simple machine. So, if you're really lost you can do that.
	Task completion focus	T: How many answers have you found? S: One T: So how many more do you have to find? S: Nine
	Provide encouragement	T: There ya go! You're right, trust your teammates, you guys.
	Progress check	T: How ya doing what question are you on?
Science Content Codes	Encourage to reflect	T: I wonder how friction works in a pulley?
	Deep science question	T: Ok. / So how did you increase mechanical advantage?
	Address misconceptions	T: Ok, do you have why? Ok, because, the most pulleys you have, the more, mechanical advantage. Is that what it said on the website? The more pulleys you have?
	Relate science concepts	T: O-, ok, I, I guess I, I understand where you're going. So the longer the board, the less force, which also means less...
	Focus on challenge goal	T: If you think it's gonna help with your challenge. If there's something you don't know, and you learned about, you think it might help you with your decisions tomorrow, I would definitely write that down.
	Everyday examples	T: Think of a machinery, or think of a tool, do you want it to have a lot of power?
	Concrete to abstract reasoning	T: Like your materials and the board. You're not gonna just find tinfoil, you're gonna find the connection between tinfoil and a board.
	Reiterate big ideas	T: Different simple machine, right? But work is still defined the exact same way, and this trade-off is still the distance that you had to pull the string, right? (Example from a whole class discussion)
	Science telling	T: Mmm hmm. Ok, and, here's a combination of a fixed, and a moveable, pulley. Changes direction, and produces a gain in force, at the same time. The tradeoff is, that the end of the rope, must move a greater distance, than the load, ok?

Figure 2. Coding categories and examples from transcripts

Results and Discussion

To better understand teacher dialogic strategies used during CoMPASS small group work, we present the data in the form of representations produced using the methodologies of CORDFU (Luckin, 2003) and CORDTRA (Hmelo-Silver, 2003) which allow a chronological depiction of how the dialogue progressed in the classroom. To illustrate the differences between the two coding categories, we have identified the procedural category codes as triangles at the top of each representation and science content category codes as circles on the bottom. Figures 3-5 present a chronological representation of each teacher's strategies during both inclined plane and pulley.

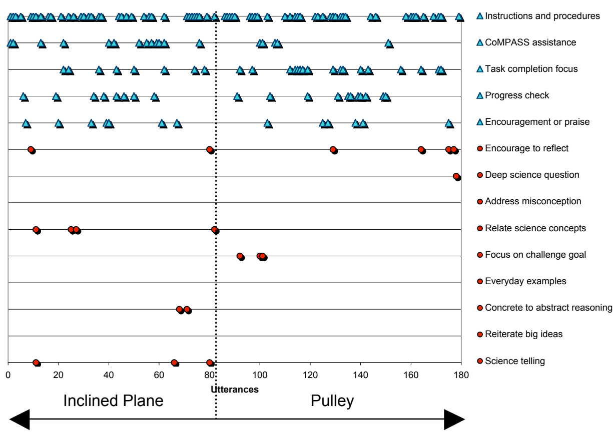

Figure 3. CoMPASS Facilitation Strategies: Joyelle

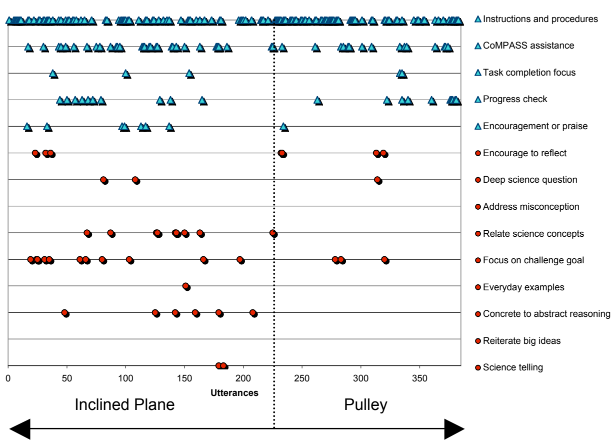

Figure 4. CoMPASS Facilitation Strategies: Gwen

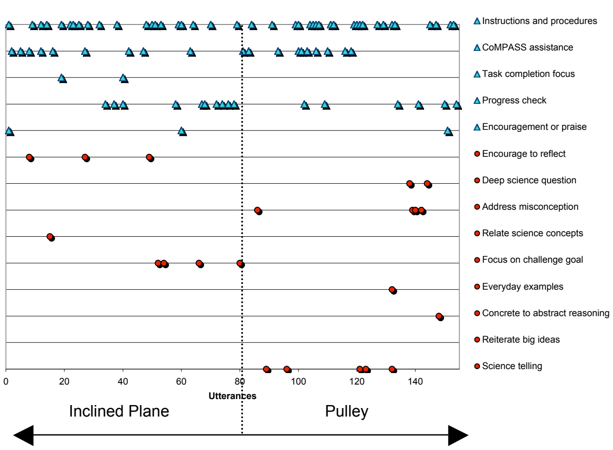

Figure 5. CoMPASS Facilitation Strategies: Lauren

As a whole, the three representations clearly indicate a predominance of dialogic strategies within the procedural category. The majority of the instruction and procedural utterances are logistic in nature, including directions for situating students and equipment, commands to record information and include justifications for answers, and instructions for logging on and off the CoMPASS web site. CoMPASS assistance codes include utterances where teachers help students navigate within the hypertext, describe how to use concept maps to consider connections between concepts, and topic research suggestions. Questions or statements inquiring about the progress of a group as a form of initiating dialogue during a visit was common for all teachers and all three included encouragement and praise in varying degrees during their visits. The most pronounced difference between teachers in the procedural category is the frequency with which Joyelle's utterances indicated a focus on task completion. Joyelle commonly made statements such as, "how many facts do you have from the CoMPASS site" or "get those answered" and, "No, let's stick to the questions we talked about in class."

Dialogic strategies within science content vary only slightly by teacher and within topics, however, it is interesting that instances of teacher telling science occur while students have the information available on CoMPASS, just as it is interesting that reiterate big ideas, an important aspect of teacher facilitation, wasn't used by any teacher. One notable exception to the paucity of science content codes is Gwen's facilitation during inclined plane (Figure 4), which clearly indicates she attended to focusing students on the goal of the challenge, relating science concepts, and comparing materials to be used in the challenge with the abstract science concepts found on CoMPASS. For example, by suggesting that CoMPASS does not provide information about newspaper or tinfoil surfaces, Gwen asked students to think about the interaction between the surfaces. As a result, students quickly identified friction as the concept they needed to investigate. However, Gwen's facilitation of science content during pulley research on CoMPASS is far less robust and similar to those of Lauren and Joyelle.

One possible reason for the disparity between the number of procedural codes and the number of science content codes, especially during the pulley, was that teachers wanted students to find out for themselves how to build a compound pulley system. Feigning ignorance, reflecting questions, and comments such as, "I don't want to just tell you how to do it I want you to be able to figure it out" suggests that perhaps teachers felt the need to step back and allow students to *discover* the science necessary for their designs on their own, suggesting a naïve understanding of inquiry and social constructivism (Prawat, 1992).

Conclusion and Implications

In summary, the representations clearly establish that the majority of talk between teachers and students is procedural rather than science oriented. The heavy focus on having students 'write down' information from CoMPASS suggests that teachers view CoMPASS as a separate or bounded activity within the sequence of each mini-challenge. Although there are instances of assisting students as they use CoMPASS, there were still occasions where teachers told students the science information that they could have found themselves. These findings indicate that the teachers possess a less than complete conception of science inquiry and social constructivism.

The CoMPASS simple machines curriculum was developed and is continuously being revised and refined through the collaboration of a diverse research team and classroom teachers under real world conditions. This study represents our first step in a sequence of research aimed at collaboratively developing educative teacher curriculum materials (Davis & Kracjik, 2005; Keys & Bryan, 2001). Our desire is to complement and integrate the pragmatic and action oriented pedagogical problem solving of classroom teachers with formal learning theories and educational research that informs teacher practice to improve student outcomes.

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