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An Examination of Children's Scientific Argumentation

Danielle B. Harlow and Valerie K. Otero
University of Colorado, Boulder, CO 80309-0249, Danielle.Harlow@colorado.edu

Abstract This paper describes preliminary results of the analysis of a subset of data in which third grade children argue about how current travels through a simple circuit in a whole-class discussion. A model of four distinct patterns of argumentation among these eight-year-old children is proposed and described in this discussion.

Introduction

Scientific argumentation is defined here as the examination of different viewpoints in order to reach a shared understanding of observed phenomena. This process is vital to the development of scientific knowledge. Scientific argumentation in the classroom aids students in their acquisition of science knowledge. In addition, participation in scientific discourse increases students' understanding of the social nature of scientific knowledge [1]. Findings from educational research show that elementary students have a predominately factual view of science, but that they are capable of a much more sophisticated understanding of the nature of science [2]. The study reported here suggests that young children can participate in sophisticated argumentation about physics phenomena.

This paper describes preliminary results from the analysis of a subset of data on elementary school children. These data suggest a four-stage model of increasing sophistication of argumentation which we call the *Sophistication Stages Model*. The four stages are summarized in Table 1. The remainder of this paper discusses the development of the model and describes each of the four stages in greater detail.

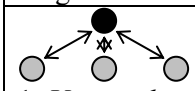
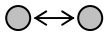
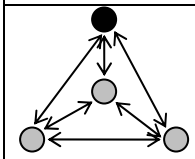
Stage	participants	Statements
 1. *Univocal – Descriptive*	Teacher – Students	*Elicitation* (teacher) *I saw* (students)
 2. *Univocal - Model Identification*	Teacher – one student	*I think* (students) *You think – probing* (teacher)
 3. *Dialogic - Model Establishment*	Student – Student	*I think* (students)
 4. *Dialogic - Model Discussion*	Teacher – student and Student – student	*You think probing, You think clarifying, Evaluation, I think*

Table 1: Patterns of discourse Black circles represent adults and grey circles represent students.

Methods and Coding

The students in this study participated in an after-school program targeted toward underrepresented populations in science. Ninety percent of the students were English language learners. For some children, this was their first year in an all-English environment in their bilingual elementary school. They met for one hour each week for twenty weeks.

The structure of each class was designed with the idea that children should talk about their ideas and use evidence (rather than the teacher or a textbook) as authority. The

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students spent the majority of their time in small groups of four students, observing and making sense of observed phenomena. The children were expected to display their ideas as a group on presentation boards and to share their group's ideas verbally with the entire class. At the conclusion of each topic, the teacher led the students in a consensus discussion to construct shared explanations for their observations. Five adults were present in the classroom: two teachers who implemented the lessons and three researchers who worked with the teachers to develop the lessons and observed and video taped each class meeting. We collected forty hours of video tape of student conversation. This video is currently being transcribed and analyzed using a constant comparative method [3].

In the segment discussed here, third grade (eight-years-old) children discuss what they believe is happening inside of a completed simple circuit. The conversation began as a whole-class discussion about electricity and progressed to a debate between two students, David and Ricardo, about how electricity travels through the circuit. David argued that electricity must travel in a circle in only one direction and Ricardo argued that electricity exits each end of the battery and meets at the bulb. Additional students then entered the discussion about the path of the electricity in the circuit, supporting and challenging the ideas proposed by David and Ricardo.

Results and Analysis

The codes which emerged from the data are described in table 2. A seventh code which was not actually found in the data is *Authority Seeking*, statements which look toward the teacher other expert (another adult or a textbook) for an accepted viewpoint. Although this code is not found in this sampling of data, it is included because the lack of *Authority Seeking* statements is significant.

From the coded transcript, four patterns of increasingly sophisticated discourse emerged, suggesting the possibility of stages. These patterns are characterized by the arrangement of the codes within the verbal exchange. We have identified these patterns first as *univocal* or *dialogic* to distinguish between discourse used to convey meaning and to generate meaning respectively [4][5]. Univocal discourse is often characterized by the teacher asking a question to the class, a student responding, and the teacher asking another question. Students rarely talk to one another in univocal classroom conversations. In contrast, dialogic conversation is often characterized by discourse *between* students.

Code	Description
I saw	Descriptions of observations
I think	Statements of opinions, theories or analogies
You think – clarifying	Statements and questions to better understand another person's idea
You think – probing	Statements and questions asking another student to think more about a model
Evaluation	Statements of why one does or does not agree with an opposing viewpoint.
Elicitation	Questions to elicit information.

Table 2: Description of Codes

After identifying the pattern as either univocal or dialogic, we further identified the function of the discourse (e.g. model establishment). We then named each stage. Each stage is identified as univocal or dialogic and given an additional descriptor related to the function of the discourse. This remainder of this section describes the four stages of argumentation we have identified.

The first stage in the *Sophistication Stages* model is *Univocal-Descriptive.* This stage is characterized by the teacher eliciting knowledge from the students. This *descriptive* dialog alternated between the teacher and students in the following pattern:

Teacher: *Elicitation Question*
Student A: *I saw* statement
Teacher: *Elicitation Question*
Student B: *I saw* statement

In this stage, the teacher did not probe for further explanation from the students and students did not converse with each other. All conversation either came from or was directed toward the teacher. This initial stage of the conversation began when the teacher asked an open ended question, attempting to elicit knowledge gained about electricity.

Ms. Diller: Who can raise your hand and tell me something you learned about electricity?

Ricardo: it travels through a wire but um, it travels through any, um most stuff that's made out of metal like wires.

David: The battery's right here and then there's a wire and then more wires and that makes a circle.

In the dialog above, the teacher asked only a single question to elicit knowledge and both students state only direct observations.

The second stage, *Univocal – Model Identification,* consists of statements of belief or theory (*I think* statements) and clarification statements. An example of this pattern is:

Student A: *I think* statement

Teacher: *You think - probing*

Student A: *I think* statement

Teacher: *you think – probing*

The dialog represented above involved only the teacher and Ricardo. While eliciting knowledge in the *univocal descriptive* stage, the teacher encountered an unexpected answer when Ricardo challenged David's statement:

Ricardo: I don't really think it goes in a circle.

Ms. Diller: You don't?

Ricardo: I mean I think it's supposed to go in a circle but like I don't think it travels like only one way.

In the above dialog, the teacher focused on Ricardo and questioned his statement with *you think – probing* questions. In this stage of the conversation, Ricardo stated a theory about something happening inside the wires which he could neither prove nor disprove with the evidence available. He was talking about his *ideas*. Although the conversation switched from focusing on evidence to focusing on ideas, so far only Ricardo's ideas have been discussed. The conversation moved from the teacher directing a conversation with the entire class to Ms. Diller directing her questions only to Ricardo who is describing his model.

The third stage of our model is *Dialogic - Model Establishment.* This stage involved a repeated exchange between two students making *I think* statements and establishing their models.

This stage began when David stated that Ricardo's model is "still a circle." In response, Ricardo turned away from the teacher and toward David to explain to David how his model was different. Not only did the children physically turn away from the teacher but the teacher dropped out of the conversation. Twice she attempted to enter the conversation with the comments, "So it might be going" and "So you think it goes like this." Both times she was interrupted by Ricardo stating his ideas. Ricardo and David appeared unconcerned about what the teacher thought.

Dialogic – Model Discussion is the forth and final stage of the *Sophistication Stages* model. In this stage, other children entered the conversation and the children further articulated and supported their viewpoints.

Stage four in our model began when the researcher stepped in to explain that two models of current flow had been proposed by the students. She asked for evidence that would support either model. The children did not actually provide evidence. Instead, they expanded their explanations and attempted to support their own models and refute the models of others. This is illustrated in the following excerpts.

Ricardo: But like so if you only use one side and don't connect the other side um, it will only give power from one side and it won't have enough power, so you need to connect the other side so it'll make double the power and then the light bulb can get enough energy to light, to light up.

Jasmine: Um, there's only one way um that the, the atoms from inside could go around and not two sides. Because, because they,

when they touch together they can't keep going so they have to go only one side and keep going.

David: If it goes through two ways then it will just get stuck right there and then it will just go and then it will just go, it would just go off. But if you do it one way it would just keep going in a circle but if you go two ways it would just get, they'd crash into each other.

In this stage, the children also began to challenge the other models. For example, after Ricardo explained that the powers combine, David asked, "But how could it do that cause, it, if it doesn't- then how could the powers combine?"

The interchange in this stage of the conversation is characterized by a greater number of *You think – probing, You think – clarifying, Evaluation statements*, and more elaborate *I think* statements. The children at this point responded to one another's models and challenged each other. Students who were not previously participating in the dialog asked for clarification from David and Ricardo. Jasmine also began to fully participate in the argument. Although these students physically faced the researcher during the final stage of the conversation, not once did they look to the researcher or the teacher for the "right answer." There is not a single instance of an *Authority Seeking* question.

Discussion

The data suggest that young children create models for physics phenomena even when not specifically asked to and that students as young as eight-years-old can and will use their ideas to construct reasonable arguments. The children discussed in this study argued with each other about their beliefs and theories. They physically turned toward each other and away from the teacher. Other researchers have found that given a science curriculum specifically intended to develop thinking, young students make large steps toward a more sophisticated view of science [2]. Ricardo, David and Jasmine were not taught argumentation skills. However, they participated in a curriculum which built in norms of talking about ideas and using evidence as authority. Our data suggest that focusing on students' thinking and talking about ideas and using evidence as authority in scientific discovery help children to develop skills in scientific argumentation. This, in turn, may lead to more sophisticated understandings of the role of ideas and the social nature of science knowledge production.

We do not argue that all dialog progresses through all four stages. Rather, we argue that the increasing sophistication of each discourse pattern suggests that these may be stages in argumentation and that this model may be useful for identifying stages of sophistication in children's discourse. Analyzing children's dialog in terms of our *Sophistication Stages Model* may lead to a better understanding of the nature of scientific argumentation among children as well as a better understanding of the potential for using scientific argumentation in the classroom.

References

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