DOCUMENT RESUME

ED 434 031	SE 062 873
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TITLE	Steering the Course of Dialogue in Inquiry-based Science Classrooms.
PUB DATE	1999-04-00
NOTE	20p.; Paper presented at the Annual Meeting of the American Educational Research Association (Montreal, Quebec, Canada, April 19-23, 1999).
PUB TYPE	Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Classrooms; Discussion (Teaching Technique); Elementary Secondary Education; *Inquiry; Questioning Techniques; *Science Activities; *Science Instruction; Science Process Skills; *Scientific Concepts; Students; *Teaching Methods

ABSTRACT

Mastering science involves not only developing the skills of doing science, but also developing the skill of taking science. This paper describes how a teacher tried to help her students develop appropriate scientific ways of presenting explanations. The teacher employed a number of strategies as she and her students jointly constructed progressively more scientific explanations in class discussions. She also took the approach of gradual maturation in establishing a set of norms for the presentation of scientific explanations. The teacher first presented norms that appealed to lay notions, then reformulated these norms in subsequent activities to include elements specific to science. A sample case is presented illustrating how this teacher jointly constructed a scientific explanation with her students at the conclusion of an investigation project. A set of instructional strategies was identified by the teacher and used in driving the dialogue toward more scientific constructions. Finally, the way in which the teacher employed gradual maturation to establish norms for presenting scientific explanations is demonstrated. (Author/CCM)

Steering the Course of Dialogue in Inquiry-based Science Classrooms†

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ABSTRACT: Mastering science involves not only developing the skills of doing science, but also developing the skills of talking science. This paper describes how a teacher tried to help her students appropriate scientific ways of presenting explanations. The teacher employed a number of strategies as she and her students jointly constructed progressively more scientific explanations in class discussions. She also took an approach of gradual maturation in establishing a set of norms for the presentation of scientific explanations. The teacher first presented norms that appealed to lay notions, and reformulated these norms in subsequent activities to include elements specific to science. In this paper we present an example case illustrating how this teacher jointly constructed a scientific explanation with her students at the conclusion of an investigation project. We identify a set of instructional strategies the teacher used in driving the dialogue toward more scientific constructions. Finally, we demonstrate how the teacher employed gradual maturation to establish norms for presenting scientific explanations.

1. Introduction

Scientific literacy consists of understanding scientific content, understanding the scientific enterprise, and having the ability to apply the methods of science to construct or evaluate explanations of natural phenomena (NRC, 1996). Implicit in this definition is the idea that the mastery of science includes the development of specialized ways of using language (Lemke, 1990). Scientific disciplines, like all disciplines, have a set of terms that are unique to a discipline, or that carry a meaning that is distinct from lay and other-discipline uses of these terms. Further, there are a set of norms that determine what type of knowledge is valuable to communicate, and what form this communication should take. Science favors explanations that describe a detailed chain of cause and effect relationships that are supported by empirical observations. Gaining the ability to talk science involves building a vocabulary of scientific terms, understanding the subtleties of their meaning, and using them to describe natural phenomena in causal terms.

We can help students gain this proficiency by crafting activities where the doing and talking of science coalesce and prevail, where students engage in scientific discourse as they raise questions, devise research plans, analyze information, and construct explanations (Linn, diSessa, Pea, & Songer, 1994; Pea, 1991). Students do not spontaneously engage in "science talk," we need to help students bridge between lay and scientific ways of talking (Lemke, 1990). This scaffolded transition from everyday to scientific communication

† Paper presented at the 1999 Annual Meeting of the American Educational Research Association, April 1999, Montreal, Canada.

emerges through the interactions of teachers, students and materials (Ball & Cohen, 1996; Roth, 1995). Teachers can model and reinforce "privileged" (Wertsch, 1991) ways of speaking and doing, helping students learn how to think and act according to the system of values in a domain (Lemke, 1990; Wertsch, 1991). Materials can facilitate these interactions by providing opportunities for students to engage in desired practices.

In earlier work we described how a computer-based investigation environment provided a venue where students could plan and execute an investigation, uncovering the factors involved in the decimation and survival of a population of finches on a Galapagos island. We examined how teachers' instructional strategies augmented domain-specific supports embedded in the software and helped students develop some of the skills involved in doing science, such as evaluating and synthesizing evidence (Tabak, Sandoval, Smith, Steinmuller, & Reiser, 1998). In this paper, we describe how these investigative experiences provide a backdrop for students to engage in scientific discourse. We identify and present a set of strategies that a teacher used to help mediate students' everyday and science talk. We demonstrate how she orchestrated, shaped and sustained student explanations, and how she established norms or guidelines for the presentation of scientific explanations.

2. Background

This study takes place in the context of the Biology Guided Inquiry Learning Environments (BGuILE) project, which focuses on supporting science learning through student-directed inquiry. In this project we studied learning and teaching in a five week unit on evolution which we designed. The unit included three extended investigations (two are computer-based), as well as analysis and simulation activities. The first author observed the classroom everyday throughout the unit. Video and audio recordings of the class were also employed. This paper focuses on analyses of two whole class discussions that culminated the first two investigation activities, The Iguana Scenario, and the Galapagos Finches.

The Galapagos Finches (Tabak & Reiser, 1997) and the Iguana Scenario (Tabak & Steinmuller, 1997) present students with a novel problem to investigate. Students determine what data to collect, what procedures to follow, and construct their own explanations. In the Iguana Scenario students are asked to explain why some members of a population of iguanas forage in one location, while the remaining iguanas forage in another location. This is a paper-based activity. Students receive packets of data. They can examine data about quantitative measurements of environmental factors (e.g., water temperature), and of various structural characteristics of the iguanas (e.g., weight, claw length). Students can also examine field notes collected about the animals' behavior, plant life, and other environmental factors. The Galapagos Finches is a similar, computer-based activity. Students are asked to explain why so many finches in a population of finches on a Galapagos island are dying, and more importantly, what enables the surviving finches to survive. Students can make the same types of observations as in the Iguana Scenario, although they have available a richer, more complex data set, as well as a number of data management tools. This activity is described in more detail elsewhere (Tabak & Reiser, 1997; Tabak, et al., 1998).

The teacher of focus, Ms. Patrick[1], had been teaching for three years at the time of this study. Before entering the teaching profession, she worked as a medical technician for several years. She was very interested in having students work autonomously on complex problems. She had worked on a pilot version of our curriculum with her class in the previous year, and collaborated with our project on some of the curriculum design. Ms. Patrick teaches at City High School, a Chicago public high school. The school has a diverse student population (e.g., 30% white, 27% black and 23% Hispanic, 20% other). In 1997 (the year this study took place), 68% of the students scored at or above the national norms for math, and 52.8% scored at or above the national norms for reading (based on the Tests of Achievement and Proficiency, TAP).

The class that participated in our study was a regular level introductory biology class. Introductory biology is a requirement for all freshmen (9th grade). During the unit students were fairly engaged in classroom activities. Although students were fairly active during in-class activities, they often did not complete homework assignments. When working in class, students continually shifted their attention between the task at hand and social, "off task" discussions. Students readily participated in class discussions, but the majority of participation came from a minority of the students in the class.

Ms. Patrick enacted the Iguana Scenario and the Galapagos Finches using a similar structure. She introduced the activity by presenting the driving question and having students brainstorm about sub-questions and data they would need to collect. Students worked on their investigations in groups of three to four students. Ms. Patrick circulated among the groups as they worked on their investigations, asking about their progress, providing feedback and suggestions, and challenging some of their claims. Midway though the investigation she conducted a whole class discussion asking students to report on their findings to date, and on the process they went through in uncovering these results. As a culminating activity, Ms. Patrick convened the whole class and asked the groups to share their explanations of the problem phenomenon. Each investigation activity spanned about seven 45 minute class periods.

In the next section we present an example of one group's presentation during the Galapagos Finches culminating discussion. This presentation illustrates the set of strategies that Ms. Patrick used to help her students present scientific explanations.

3. Mediating everyday and scientific explanations

Working on the Iguana Scenario and the Galapagos Finches activities, Ms. Patrick's students spent several class periods making observations of the animals' environment, physical characteristics, and behavior. Most groups made between 30 and 60 observations, as they pieced together an understanding of the factors that influenced these animals' foraging behavior and survival. Ms. Patrick invited the different groups to share their explanations with the class – "what are some of the stories you came up with, briefly, what did you guys figure out." Initially, students would simply declare a finding that they thought was central to the explanation, e.g., "no mating in the dry season," or "some of the beaks weren't strong." Ms. Patrick engaged students in a process of joint construction (Lemke, 1990), asking for elaboration, repeating their statements in the form of a question, and pulling together and rephrasing earlier statements. Through this process, a causal explanation for the problem phenomenon unfolded.

These dialogues revealed the rich picture and causal understanding of the situation that the students had actually acquired, as they were able to participate in this exchange, responding to questions and providing details, examples and justifications. Students who were versed in the short response format typical to school discourse had the opportunity to practice the telling of a chain of causally related factors and events that explain an episode in nature. Further, they were presented with some rationale for the need to tell their stories in this way.

We present one groups' explanation for the Galapagos Finches problem, which is typical of the type of exchanges that Ms. Patrick had with her students in both discussions. Through this example, we illustrate the specific strategies that Ms. Patrick employed in the process of jointly constructing scientific explanations with her students.

3.1. An explanation unfolds through joint construction

The excerpt below, lines 1 - 91, presents one group's presentation of their explanation, and their exchange over this explanation with Ms. Patrick. The group is particularly large, because it consists of two groups that were joined together due to some students' absence during some of the investigation sessions.

Kellie: we found that [inaudible]
Ms. Patrick: what, I'm having trouble hearing you, what about the season?
Kellie: no mating in the dry season
Ms. Patrick: no mating in the dry season, well that, ok, but tell me a little bit more, you just gave me a statement, and that doesn't [statement not finished]. Assume that I don't know anything, all right you're talking about the finches, you noticed that there's no mating in the dry season.
Gwen: the shorter the beak length the faster they died, and the females had shorter beak lengths
Ms. Patrick: all right, that's another statement. Ladies [admonishing other students]
Ben: but that's why there was no mating
Ms. Patrick: sh, I don't know why, but I'm having a really hard time hearing today, either there's lots of underground noise or the humidity is plugging up my ears, but you need to be quiet. you need to listen because your turn is coming, so she said so far, these two groups, that there is no mating during dry season of when?
Kellie: 73
Ms. Patrick: 73, and the shorter the beak length the higher the death rate. OK. So tell me a little bit, those to me seem a little bit like unconnected facts.
Gwen: ok, because the females had shorter beak lengths than the males
Ms. Patrick: oh, ok, now think about the question which was why were the finches dying and more importantly why were the finches that were surviving why were they surviving, and tell me the story again in that context, all right why were the finches dying?
Gwen: because they had shorter beaks
Ms. Patrick: because their beak lengths were short, and then now, do you want to connect that to gender?
DG: what did they eat?
Gwen: the males had longer
Ms. Patrick: the males were longer, all right, now what, all right, do you think directly if someone asked you that question and you had done all this research and you said that they were dying because, that the finches were dying because they had short beaks
Sam: you can't prove that
Gwen: we can
Ms. Patrick: ok, sh, maybe she can, think about it Hanna for a second, and Kellie you said this was you're story too, so think about it for a second, if I asked you this question again and you came back from your research project and you told me that these finches were dying because they had short beak lengths, think about it for a minute, I'd think you were nuts, what does that have to do with anything?
Hanna: because they couldn't get food
Ms. Patrick: all right, now why were, hang on a second, let me ask you this question, let me ask the question again [a number of students start talking, can't really discern statements] shh, all right how they ate and foraging behavior all depended on?
Hanna: on the beak
Ms. Patrick: on the beak, what about the beak

Hanna: ok, they squeezed the food
Ms. Patrick: all right
Sam: see we tried to find the length of the plants, to see if maybe the shorter beaks could not get the plant, but we couldn't find that information
Ms. Patrick: ok
Sam: that showed the length of the seed
Ms. Patrick: oh, ok.
Hanna: see it put the food in it's beak squeezed them and swallowed them, and another one was it put the seed on the ground and then pushed it in its beak, and then shoved it aside and couldn't eat it
Ms. Patrick: ok, all right, so now I'm starting to understand, you're telling me that beak length had a lot to do with their eating habits, and so why were the finches dying?
Gwen: food
Ms. Patrick: what about food?
Ben: shortage
Ms. Patrick: shortage? is that what you said?
Ben: yeah
Ms. Patrick: all right, I didn't say that you said it right? ok. So they were dying of starvation basically, now start your story again, because
Gwen: dry season of 77
Ms. Patrick: because of no, how would you explain
Gwen: no rain
Ms. Patrick: no rainfall, and then the next, you're telling a story here that's all connected, right, so in the dry season of 77 began to starve to death because they had no food, now why
Sam: they didn't die all at once though
Ms. Patrick: they didn't die all at once,
Sam: there was few food
Ms. Patrick: there was few, there was a little food
Ben: because of the drought
Ms. Patrick: because of the drought, I got that part, um, all right go on, now bring in the physical characteristics
Sam: maybe the big beaks they had a better chance for finding the food for surviving
Ms. Patrick: finding it?
Sam: maybe the seeds that were left were high above the ground
Ms. Patrick: so they could reach their food better, making sense, and then what, anything else? Now you had another part, don't forget
Gwen: the mating
Ms. Patrick: about the mating?
Gwen: the females died and then the males were left
Ms. Patrick: the females died?
Gwen: and there was more male than females
Ms. Patrick: so they had no mate. All right. OK, now you read some real interesting facts to me off of the journal, where did that come from?
Gwen: field notes
Ms. Patrick: field notes, ok, so that's part of your evidence. Ok, I want to hear a couple more stories before we talk about it in general,

A statement is not an explanation

The students' explanation (initially presented by Kellie, one of the group members) begins with the statement that there was no mating in the dry season. Ms. Patrick qualifies Kellie's response, saying that it is a "statement."

She begins to explain why that is not sufficient for an explanation, but does not complete that line of thought. Instead, she instructs the student to tell her story assuming that Ms. Patrick "doesn't know anything." She calls on the student to continue her explanation based on these comments by repeating the students' statement, lines 1- 7 in the excerpt below.

You have a story, but I can't tell you do

A second student in the group, Gwen, responds by introducing an additional factor, beak length (lines 8 - 9). Again, Ms. Patrick qualifies that the students' response is "another statement" (line 10). In this instance, Ms. Patrick's response is a little surprising. Although Gwen's remarks do not articulate a causal explanation for the problem phenomenon, they are more elaborate and more scientific than Kellie's initial remarks. Gwen presents a causal relationship between beak length and survival – "the shorter the beak length the faster they died." She also includes information about the sub-population most likely to be afflicted, by noting that it was the female finches that had the shorter beaks. It seems that at this point Ms. Patrick was more focused on pushing the students to articulate a full explanation, than on recognizing instances of more scientific responses.

It is obvious to the students' how their different statements connect to form a causal story of the finches' demise. Ben calls out (in frustration almost) – "but that's why there was no mating" (line 11). With this statement he is demonstrating that in the students' view Gwen's statement, which seems like an additional, unrelated statement to the teacher, is an appropriate response to the teachers' request for more information. It reveals the cause behind their first statement of "no mating in the dry season." The students do not realize that they need to explicitly state the connection between their first and second statements. While they have successfully engaged in scientific practices by analyzing and synthesizing primary data into a causal explanation, they are not yet versed in the appropriate ways of communicating these findings. They have some initial mastery of "doing" science, but need to acquire the skills of "talking" science. Ms. Patrick tries to help the students recognize the need to explicitly state the causal relations between findings. She repeats their statements, invites them to tell her more, and explains that to her these statements seem a bit like unconnected facts (lines 12 - 18).

Imagine a naive audience's response

After encouraging the group to explicitly state the causal relationship between their two statements, Gwen responds by restating that the female finches had shorter beaks than the males (line 19). Ms. Patrick invites the students to retell their entire story. This time she tries to encourage causal elaborations by reminding them of the problem's driving question – "why were the finches dying and more importantly why were the finches that were surviving why were they surviving," and asking them to tell their story in the context of this question (lines 20 - 23). Gwen again responds that it was "because they had shorter beaks" (line 24). Ms. Patrick repeats Gwen's statement, adding the beginning of a causal continuation "and then," and prompting Gwen to relate her statement to gender (lines 25 - 26). Gwen responds with another declarative statement – "the males had longer" (line 28). Ms. Patrick initially attempts to extend Gwen's statements into a causal story by prompting her for the subsequent causal relation, but abandons this strategy mid sentence, and instead asks Gwen to consider how a naive audience would respond to their statements. Ms. Patrick presents this question as a rhetorical question, which she emphatically answers herself – "....[if] you told me that these finches were dying because they had short beak lengths, think about it for a minute, I'd think you were nuts, what does that have to do with anything?" (lines 29 - 38). As the discussion progresses, the teacher tries to not only prompt the students to tell their story in a particular way, but to also provide them with the rationale for this particular way of communicating.

Lets just put more of your findings on the table

A fourth student, Hanna, joins the discussion. She responds to the teacher's query of what beak length "has to do with anything," by stating that it prevented the finches from getting food (line 39). Ms. Patrick seems to start to prompt Hanna for further explanations, but instead summarizes earlier statements in the form of an incomplete statement, prompting Hanna to complete the statement – "how they ate and foraging behavior all depended on?" (lines 40 - 43). In the next few turns, lines 40 - 61, Ms. Patrick does not instruct students to articulate causal relationships, but instead either asks follow up questions that could yield the subsequent relation (e.g., "what about the beak?" line 44), or just acknowledges the student's comment (e.g., "ok"). Through this sequence of turns a number of important findings in the students' story are revealed. The students present a number of elaborated responses. One of these, "we tried to find the length of the plants to see if maybe the shorter beaks could not get the plant..." (lines 47 - 48), demonstrates the causal reasoning they employed in their investigation. Another comment, "see it put the food in it's beak squeezed them and swallowed them, and another one was it put the seed on the ground and then pushed t in its beak, and then shoved it aside and couldn't eat it" (lines 52 - 54), illustrates some of the justifications behind some of the students' claims. In fact, if Hanna had added that it was the longer beaked males that could eat the food, and it was the shorter beaked females that could not, she would have come a long way in explicitly stating the full chain of causal relationships in their story.

So your full story is...

In the final segment of this excerpt, lines 62 - 91, after a significant portion of the details of the students' explanation had been expressed, Ms. Patrick invites the students to retell their story one final time. Ms. Patrick tried to launch students into a causal mode by prompting them to start their story with the stem "So they were dying of starvation basically, now start your story again, because" (lines 62 - 63). Gwen responds by stating the season in which the finches were under stress. Ms. Patrick is tempted to state the pressure which is the cause of the finches starvation "because of no" but cuts herself short, and instead prompts the students to provide the cause "how would you explain" (line 65). Gwen responds "no rain" (line 66). Ms. Patrick summarizes the chain of causality raised thus far, and prompts the students to continue the causal chain – "now why" (lines 67 - 69). In lines 70 - 76 the teacher and students go through a sequence of turns where the students repeat statements they had made at the beginning of this segment, and the teacher simply repeats their statements. Finally, she declares that they had covered that part of the story already, and prompts them to continue the chain of causality by directing them to the type of factor implicated in the next part of the story – "now bring in the physical characteristics" (lines 75 - 76).

Sam continues the story by explaining that the bigger beaked birds had a better chance of finding food for surviving (line 77). He later also explains that the remaining seeds were high above he ground (line 79). The teacher follows with a comment making explicit the causal relationship that the bigger beak enabled them to reach the high food better (line 80). It is interesting that Sam starts his statements with conditionals – "maybe the big beaks...," "maybe the seeds that were left..." (lines 77 and 79). Sam may have appropriated, and is displaying, the scientific practice of distinguishing between conjecture and supported findings. Recall that in the previous segment Sam voiced similar statements, and described that they looked for evidence supporting these conjectures, but were not able to find such evidence.

Ms. Patrick prompts the students to continue their story "and then what, anything else?" reminding them that they had mentioned other factors earlier "Now you had another part, don't forget" (lines 80 - 81). Ms. Patrick and Gwen go through a similar sequence of turns with Ms. Patrick mostly echoing Gwen's statements. In this sequence Gwen reintroduces the element of more females dying than males, and that no mating occurred (lines 82 - 87).

3.2. An explanation unfolds: Discussion

The case we just described illustrates how in a process of telling and retelling their story, guided by prompts, questions and critiques the students' initial statement that "there was no mating" unfolds into a more detailed story. The students eventually describe that no rain resulted in a lack of food. They identify an advantageous trait that enabled some finches to gain the scarce food. They continue to describe that this resulted in a better chance of surviving, which resulted in a disproportion between males and females in the population, which resulted in no mating. Ms. Patrick, the teacher, used a number of specific strategies (described below) in guiding students through the retelling and elaboration of their story.

Although the final rendition of the students' story is more elaborate and is presented in more causal terms than earlier renditions it still does not reflect an ideal scientific explanation. There are causal elements that were introduced throughout the discussion, that were not included in the final segment (e.g., noting that female finches tended to have smaller beaks than male finches). Causal elements are expressed in sequence, but causality is mostly suggested through proximity of expression, rather than explicitly articulated. In the few cases where causality is explicitly articulated, it is usually the teacher, not the students, that is practicing this type of speech (e.g., line 68 "so in the dry season of 77 began to starve to death because they had no food"). This highlights how foreign the language of science can be to students, especially since the case above is the students' second experience of presenting a scientific explanation at the conclusion of an investigation.

The many challenges that students face in appropriating this discursive style also forces the teacher to ignore some issues and preferentially focus on a fraction of the components that characterize scientific ways of communicating. For example, in the case above the teacher only marginally attends to the issue of supporting claims with evidence. It is not till the end of the segment that she raises the issue of evidence. Even when she does she only asks for the source of the evidence and does not discuss the content of particular evidence and its relevance and strength in supporting or refuting claims. In addition, the teacher does not question the content of the students' explanations (the extent to which they conform with the data and with normative explanations), she only focuses on encouraging students to articulate a full sequence of cause and effect relationships. Similar patterns of preferential focus were observed in physics classes where in some instances the teacher gave preference to process over content. The teacher, whose goal (at the time) was to promote the development of inquiry skills, ignored statements that were not consistent with physical laws in order to enable students to raise alternative hypotheses and construct thought experiments (Hammer, 1995).

In encouraging students to articulate a causal explanation the teacher used a number of strategies repeatedly throughout the case above. We examined each of the explanation elaboration exchanges that the teacher had with each group at the end of both investigation activities and found similar patterns of prompts and questions. We identified four distinctive strategies that appeared repeatedly across most exchanges. We present and describe these strategies in the next section.

3.3. Teacher strategies for joint construction of scientific explanations

General elaboration prompts

General elaboration prompts are prompts where the teacher asks the students to elaborate their stories, without providing specific directions about the content of these elaborations. These prompts include phrases such as "tell me more," "why," "what else."

In some cases these prompts are combined with a repetition of the students' last statement. In some cases they are combined with a rationale for the need to elaborate.

Example:

Kellie: no mating in the dry season

Ms. Patrick: no mating in the dry season, well that, ok, but tell me a little bit more, you just gave me a statement, and that doesn't [statement not finished]. Assume that I don't know anything, all right you're talking about the finches, you noticed that there's no mating in the dry season.

Gwen: the shorter the beak length the faster they died, and the females had shorter beak lengths

Specific elaboration prompts

Specific elaboration prompts not only ask students to elaborate on their original statements, but also provide some guidance concerning the desired content of these elaborations. These prompts can be an explicit directive to relate their next statement to an earlier statement. In some cases these the teacher rephrases the student's last statement in the form of a question – "tell me more about their food."

Example:

Gwen: because they had shorter beaks

Ms. Patrick: because their beak lengths were short, and then now, do you want to connect that to gender?

Restating the driving question

The teacher restates the driving question giving students the opportunity to examine whether their statements fully answer the question, and to consider what information might be missing from their explanation.

Example:

Ms. Patrick: oh, ok, now think about the question which was why were the finches dying and more importantly why were the finches that were surviving why were they surviving, and tell me the story again in that context, all right why were the finches dying?

Synthesizing and revoicing student remarks

The teacher pieces together statements that students had made and revoices (O'Connor & Michaels, 1993) them in scientific, causal terms. In this way the teacher models the preferred ways of communicating, and helps students recognize what they had generated over a number of speech turns.

Example:

Ms. Patrick: what about food?
Ben: shortage
Ms. Patrick: shortage? is that what you said?
Ben: yeah
Ms. Patrick: all right, I didn't say that you said it right? ok. So they were dying of starvation basically, now start your story again, because
Gwen: dry season of 77
Ms. Patrick: because of no, how would you explain
Gwen: no rain
Ms. Patrick: no rainfall, and then the next, you're telling a story here that's all connected, right, so in the dry season of 77 began to starve to death because they had no food, now why

3.4 The role of materials in supporting scientific discourse

The example case we presented demonstrates that students can engage in scientific discourse if they are provided with opportunities and guidance. However, creating a classroom context where students can "talk science" requires more than just providing students with the opportunity to present, explain and debate scientific issues. Students may need experiences that provide a goal for discussion, and help them acquire a body of knowledge that will enable them to navigate the discussion. In the example case above, it is important to consider the context in which the discussion took place, the experiences that led to the discussion, and the affordances of the learning materials for this discussion. We posit that the investigation that the students engaged in prior to this discussion enabled them to respond to the teacher's prompts, and successfully participate in the process of joint construction of scientific explanations. The materials may have also influenced the teacher's goals and expectations, and consequently shaped the strategies she employed.

In order to examine the affordances of the investigation task for sustaining the culminating discussions, we compared the culminating discussion of the investigation activities with a culminating discussion of a more traditional activity. In this activity students simulated the process of natural selection by laying a variety of colored paper dots on a patterned cloth, and played the role of a predator, "hunting" the first discernible dots. The culminating discussion for this activity was structured around a set of analysis questions that appeared at the end of the activity handout. The teacher posed each question to the whole class, and solicited responses from volunteers. The most striking difference between the discussion following this activity and the discussions following the investigation activities is the difference in speech turns. In the investigation activities there were a number of repeated speech turns between the teacher and a particular student, however in the "dots" activity, there was usually a different student at every speech turn. As a result, in the "dots" discussion, we do not see a progression from a simple response to an elaborated scientific explanation, as we do in the investigation discussions.

Interestingly, in segments of the "dots" discussion where the topic is more familiar to students, such as explaining camouflage, students provide more elaborated, causal statements, and there is a higher degree of repeated speech turns:

[The students are responding to the question: if the predator in the simulation were color blind, would one organism–dot–have an advantage over the other?]

Clarise: No it wouldn't have an affect because the animal would know what tree it is and it would know what animal it is, and it doesn't matter if you're color blind or not, but then again it could if it looks a part of the tree.
Jona [cuts off Clarise]: The thing is, if you look at black and white on TV, you can still see the difference between the darker ones, the darker colors aren't like the light, they stand out more .
Ms. Patrick: From the white?
Jona: Yeah, from the white, but the thing is it would be more attracted to the black.
Ms. Patrick: But what if your background is black and white and your animals are black and white?
Clarise: If it looks like part of the tree you might think it's part of the tree and they might have a better advantage.

However, when students are confronted with an unfamiliar and confusing topic their remarks are sparse:

[Students are responding to the question: what is natural selection]

Ms. Patrick: Well you know what the problem is here, what is natural selection? Clarise.
Clarise: Selection can be naturally selected.
Ms. Patrick: What is natural selection?
Jona: Nature selects.
Clarise: It's a [inaudible]
Ms. Patrick: All right Jona, that sounds almost good, but, selection by nature, how does nature know, how does nature do the selecting?
Clarise: Oo, I know I got it, because it selects what animals live or not.
Ms. Patrick: How, how?
Clarise: Because the animals aren't adapted.

The differences between the familiar and unfamiliar segments of the "dots" discussion suggest that there is a correlation between the desired characteristics of student talk, such as elaborated, causal responses and the extent of students' knowledge about the topic. When we consider this point in relation to the differences between the "dots" discussion and the investigation discussions it seems that the students' experiences of a close examination of a copious set of primary data over an extended period of time equipped them with the knowledge they needed to effectively respond to the teachers' prompts. This explains the differences in the richness of the dialogue between the discussion following the investigation activities and the one following the "dots" activity.

Students' knowledge may not be the only factor that explains the differences between the "dots" discussion and the investigation discussions. In the "dots" discussion the teacher does not pursue extended dialogue with a single student, and does not seem to employ the strategies for joint construction identified above (at least not to the same extent). It is not clear whether the teacher's reluctance to pursue an extended exchange with a single student in the "dots" discussion prevented them from jointly constructing more scientific explanations. The differences in the structure of these two activity types, the "dots" activity and the investigation activity, may account for these differences in teacher practices. The investigation task is defined and presented as having an explanation as its final product. As a result, the teacher's expectation for the discussion may be to articulate a set of explanations. Thus, when students do not articulate a causal explanation, she responds with a set of prompts to help them reach this goal. However, the "dots" discussion which was structured around a set of analysis questions may not have established the same type of explanation orientation.

In summary, instructional materials can invite students and teachers to engage in scientific discourse. Experience analyzing and synthesizing primary data can provide students with a refined understanding of a natural phenomenon. This can enable them to respond to teacher's prompts for elaborations. In addition, investigation activities which present explanation construction as a goal can help to establish an explanation orientation for the discussion. This orientation can encourage teachers to focus on explanation construction when they are orchestrating a class discussion. Thus, teachers are more likely to prompt students for the elaborations that result in more scientific constructions.

Our analysis to this point has focused on the strategies and factors involved in articulating particular explanations. However, teachers provide additional supports for science talk in their classrooms. They establish a set of guidelines or norms for the presentation of scientific explanations. In the next section we describe how Ms. Patrick tried to help her students understand the demands of scientific explanations by gradually bridging between day to day norms and scientific norms.

4. Establishing norms for presenting scientific explanations

We have shown how students can be coached in the process of articulating scientific explanations. Although students were able to express a fuller argument after a series of speech turns, they strongly depended on the teacher to intervene and take part in the construction of their explanations. In addition to continual practice in articulating scientific explanations with increasing control and autonomy over the process, students need to understand the rules that govern scientific discourse in order to fully appropriate this specialized way of communicating. In the case illustration above we saw how the rationale for providing elaborated explanations was threaded throughout the different elaboration prompts that the teacher, Ms. Patrick, employed. These rationale statements can help students appreciate the norms that exist for presenting scientific explanations. In comparing the culminating discussion of the Iguana Scenario with the culminating discussion of the subsequent Galapagos Finches Scenario we found that Ms. Patrick changed the way she presented the ground rules and goals for the students presentations, progressing from lay to more scientific norms.

Teachers can employ a process where they reformulate student remarks in ways that are more consistent with the discipline of study (Lemke, 1990; O'Connor & Michaels, 1993; Roth, 1995). This process bridges between lay and specialized talk, and helps students adopt these new, specialized ways of talking. Ms. Patrick uses a similar technique to gradually introduce the norms of scientific discourse to her students. Initially, she presents norms or guidelines that are more general, and appeal to lay or every day usage. As the unit develops she presents these same norms and guidelines in ways that are more specific to the practice of science. Having first practiced these norms under the guise of day to day terms students may subsequently find it easier to adopt these norms under their scientific labels, and in some cases with their more specialized practices. However, if these norms are introduced in scientific terms from the start, students may be reluctant to engage in these practices because they might seem too novel and foreign. We present two examples demonstrating how Ms. Patrick presented norms in lay terms in the Iguana Scenario culminating discussion, and then presented these norms in scientific terms in the subsequent Galapagos Finches culminating discussion.

4.1. Progressing from general to scientific audience considerations

Ms. Patrick set the stage for students to present their explanations for the Iguana Scenario by introducing a general guideline. She told the students that when they present they need to assume that their audience is completely naive:

> Ms. Patrick: All right. Remember, kind of a hint I got one time from a speech teacher, when you're um delivering an explanation or a demonstration or whatever always assume that your audience are idiots. They know nothing about what you are talking about. Because yesterday, even though Sam's group gave a really good presentation, you made a lot of assumptions, which is ok, because we all know what you're talking about, but if

you imagine your audience as being totally ignorant, try to slow down and be specific about

Sam: I thought we were supposed to read it, not like today we're going to be talking about

Ms. Patrick: That's ok. You know, you were the first, and the first person always sets the tone, assume that your audience knows nothing, all right?

The notion of assuming that your audience knows nothing about your topic appeals to students' common sense notions, even if they do not find it easy to implement. Ms. Patrick tries to make this guideline approachable by presenting it as a tip she got from a speech teacher, rather than a tenet of scientific practice.

As students made their presentations, both in the Iguana discussion and in the Galapagos Finches discussion, Ms. Patrick continually referred back to this theme. She kept prompting her students to remember that they have to assume that she does not know anything about the problem. She tried to establish assumption of a naive audience as a norm for explanations in their class.

After groups of students made their presentations in the Galapagos Finches discussion Ms. Patrick asked students to consider what their explanations would have to include if they were presenting to a scientific audience, such as the people that gave them the grant to conduct this research. Ms. Patrick used this question to motivate a discussion about the need for evidence, and the criteria for evaluating evidence.

Ms. Patrick: All right say you were giving, say you were telling this story to an audience now, maybe the people who gave you your grant money, and you told your story, and it sounds logical, all right, and you included some of the evidence that you found, or I should ask you again, what kind of evidence would you include, even better, why is it important to have evidence as you're telling your story, why is it important to have evidence, even if you maybe didn't get it into your journal, why is it important when you write up your final report or you make your presentation that you have evidence? Why is evidence important?

Asking students to consider the role of evidence in presenting to a scientific audience served to extend the class's norms for explanations from the requirement to have a very detailed causal description to having one that is supported with evidence. This extended norm more closely fits the scientific norms for explanations.

4.2. Progressing from general narrative criteria to scientific narrative criteria

In the Iguana Scenario discussion and in the Galapagos Finches discussion Ms. Patrick continually prompted students to "connect" earlier and latter statements. She tells the students that they are telling a story and that all the pieces have to fit together.

Gwen: because they had shorter beaks
Ms. Patrick: because their beak lengths were short, and then now, do you want to connect that to gender?

Gwen: no rain
Ms. Patrick: no rainfall, and then the next, you're telling a story here that's all connected, right, so in the dry season of 77 began to starve to death because they had no food, now why

Using these terms of "connecting," "fitting together" and "story" Ms. Patrick is building on students' existing knowledge of narrative. Students are familiar with the idea that pieces of a story relate to each other. Ms. Patrick is asking them to apply this knowledge to their scientific stories. It is only after students have had an opportunity to practice applying this knowledge to their Iguana stories and to their Finch stories that Ms. Patrick starts to encourage students to consider characteristics that are special to scientific stories. She introduces the idea that the pieces of a scientific story have a particular way of connecting. They form series of causes and effects. Ms. Patrick introduces this idea by using new labels when prompting students to relate their statements. The specialized labels of "cause" and "effect" now serve as prompts for students to elaborate their explanations while jointly constructing a class, consensus explanation.

Ms. Patrick: ok, so let me tell you what I get from your story back at you and see if I get it. So, you're telling me, most of you, that the finches died, whether you called it selective pressure or environmental catastrophe, they started to die because of a drought, shortage of rainfall -- yes? And that caused, the next part, think cause and effect, the cause was lack of rain, the effect was what?

Ms. Patrick: what? no food or a shortage of food? Ok, I got that. That was the effect. Now the shortage of food caused what? If you think about this telling your story as cause and effect, the shortage of food caused and you told me what? pressure, those of you that chose selective pressure, and even those that didn't I think told me that was what you knew, it caused a selective pressure, and that pressure selected what? This is where I'm not sure I understand.

Ms. Patrick's approach to establishing norms for presenting scientific explanations is one of gradual maturation. She tries to build on students' everyday knowledge and expectations, and reformulate, or extend these ideas to include practices that are unique to science.

5. Conclusion

Mastering science is a formidable task that entails the development of many different skills. Appropriating the language of science can be particularly difficult. In designing interventions to foster scientific literacy we need to consider supports for the talking as well as the doing of science. We suggest that extended student-directed investigation activities, where students grapple with scientific questions, marshal primary data and construct explanations, can act as a catalyst and provide important fodder for students' science talk. However, our analyses and the illustrative case presented in this paper show that even if students have a fairly well formed understanding of a phenomenon, and can draw on first hand experiential knowledge of this phenomenon, they still may not be able to communicate their understanding in scientific ways.

The teacher we studied in this paper used two concurrent methods for helping students acquire more scientific ways of communicating. She engaged them in a process of joint construction, progressing from an initial lay explanation to a more scientific explanation, by providing general and specific prompts, reminding students' of the driving question, and synthesizing and revoicing student remarks. In addition, she provided students with a set of guidelines for presenting their explanations. Initially, these guidelines were consistent with intuitive notions of narrative and speech, such as cohesion, and subsequently were reformulated to include more science specific elements, such as cause and effect relationships. The set of strategies this teacher used can serve as a first step toward articulating instructional principles for helping students "talk science."

6. Acknowledgments

This research was funded in part by a Spencer Dissertation Year Fellowship. The BGuILE project is supported by a grant from the James S. McDonnell Foundation. Any opinions, findings, or conclusions expressed here belong to the authors and do not necessarily reflect the views of the Spencer Foundation or of the James S. McDonnell Foundation. We thank the principal authors of the papers in this session for their comments on earlier versions of this paper: Eric Baumgartner, Ben Loh and William Sandoval. We especially thank our collaborating teacher for inviting us into her classroom, and her students for their interest and cooperation.

7. References

Ball, D., & Cohen, D. K. (1996). Reform by the book: What is — or might be — the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher, 25*(9), 6-8.

Hammer, D. (1995). Student Inquiry in a Physics Class Discussion. *Cognition and Instruction, 13*(3), 401-430.

Lemke, J. L. (1990). *Talking science: language, learning, and values.* Norwood, N.J.: Ablex.

Linn, M. C., diSessa, A., Pea, R. D., & Songer, N. B. (1994). Can research on science learning and instruction inform standards for science education? *Journal of Science Education and Technology, 3,* 7-15.

NRC (1996). *National science education standards.* Washington, DC: National Research Council.

O'Connor, M. C., & Michaels, S. (1993). Aligning Academic Task and Participation Status through Revoicing: Analysis of a Classroom Discourse Strategy. *Anthropology and Education Quarterly, 24*(4), 318-335.

Pea, R. D. (1991). Augmenting the discourse of learning with computer-based learning environments. In E. de Corte, M. Linn, & L. Verschaffel (Eds.), *Computer-based learning environments and problem-solving* (pp. 313-344). New York: Springer-Verlag.

Roth, W.-M. (1995). Affordances of computers in teacher-student interactions: The case of Interactive Physics. *Journal of Research in Science Teaching, 32,* 329-347.

Tabak, I., & Reiser, B. J. (1997). Complementary roles of software-based scaffolding and teacher-student interactions in inquiry learning. In R. Hall, N. Miyake, & N. Enyedy (Eds.), *Proceedings of Computer Support for Collaborative Learning '97,* (pp. 289-298). Toronto, Canada.:

Tabak, I., Sandoval, W. A., Smith, B. K., Steinmuller, F., & Reiser, B. J. (1998). BGuILE: Facilitating Reflection as a Vehicle Toward Local and Global Understanding. In *1998 Annual Meeting of the American Educational Research Association,* . San Diego, CA.:

Tabak, I., & Steinmuller, F. (1997). *Iguana Scenario* . Evanston, IL: Northwestern University.

Wertsch, J. V. (1991). *Voices of the mind.* Cambridge, MA: Harvard University Press.

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[1]Pseudonyms are used throughout this paper.

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