

**Discourse in Science Classrooms: The Relationship between Teacher Perceptions
and their Practice**

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Introduction

The use of language in science is a distinguishing feature of the domain that serves to allow its members to theorize about the world through generalizations, abstractions and metaphors (Halliday, 1998/2006). The ability to participate in this form of discourse is a requirement for those who wish to understand science and therefore can be an aspect of the discipline that renders science exclusive to select individuals. Like any language, however, to make meaning of science, students must be given the opportunities to talk about scientific concepts in active ways that resemble the forms that characterize the community (Lemke, 1990).

Learning to effectively communicate in science is a difficult task for many students (Driver, Newton, & Osborne, 2000; Sadler, 2004). Acquiring the necessary skills to participate fully in science requires guidance (Scott, Mortimer, & Aguiar, 2006). Understanding the role of the teacher in supporting student skills in this area, above and beyond the attainment of factual information, is therefore imperative if we hope to prepare students who can contribute to the scientific progress of our nation. Research suggests however that the focus of dialogue in science classrooms revolves around the retention of facts with limited attention given to the development of the students' abilities to engage in meaningful scientific discourse (Crawford, 2005; Jiménez-Aleixandre, Rodríguez, & Duschl, 2000; Lemke, 1990). Although the urgency for students to participate in authentic forms of discourse have been outlined by current science standards movements (American

Association for the Advancement of Science [AAAS], 2008; National Research Council [NRC], 1996), teacher beliefs greatly influence the practices they choose to use during instruction (Jones & Carter, 2007). In order for a shift in dialogue to occur from simply authoritative discourse to one that is more dialogic not only do teachers need participate in professional development exploring alternative forms of discourse, but their beliefs associated with the teaching of science must also shift (Bartholomew, Osborne, & Ratcliffe, 2004). Although research has focused on teachers' beliefs about inquiry (Brown & Melear, 2006; Wallace & Kang, 2004), little research has focused specifically on teachers' beliefs about discourse in science classrooms. Therefore, this study sets out to understand the relationship between teacher beliefs about discourse and the science talk that occurs in their classroom by investigating two questions: How do teachers describe the science talk that occurs during whole-class discussions and how do they perceive their role within this talk? What is the relationship between teacher beliefs about science talk in their classroom and their actions during science instruction?

Theoretical Background

Dialogue in Science Classrooms

Science talk can be conceptualized as occurring in two dimensions during science lessons: organizational and thematic (Lemke, 1990). The organizational pattern focuses on the manner in which individuals in the classroom are interacting (e.g., who is asking the questions, when do students speak, etc.). In whole class discussions, this pattern is most often characterized by some variation of the triadic dialogue: teacher initiates (usually with a question), the student responds (with an answer), and the teacher evaluates or gives feedback. More commonly referred to as the initiate-response-evaluate (IRE) pattern

(Mehan, 1979), this structure for dialogue serves to maintain the authority of the teacher and establishes an efficient means by which the content of the lesson can be related to students (Lemke, 1990). The ubiquitous nature of this pattern (Cazden, 1988) would suggest that it may act as a cultural tool for learning science, but the limitations it imposes on student responses requires that other tools be used in order to encourage more skillful practice of science talk by students (Polman & Pea, 2000).

The meaning of the lesson or content is built within the thematic pattern and it is the active construction of meaning by combining and structuring words in scientific ways that constitutes science talk (Lemke, 1990). In this case, the focus is not only on what words are being said, but how they are being joined to make meanings in a way that is consistent with the scientific domain. Learning to talk science therefore requires that students are taught “how to put together workable science sentences and paragraphs, how to combine terms and meanings, how to speak, argue, analyze or write science” (p. 22). Because the thematic pattern occurs within the organizational pattern, both must be considered during the analyses of science dialogue.

The patterns that emerge in any science lesson are the result of a complex interplay among several factors. The purpose and content of the lesson will play a key role in what type of communicative approach is chosen by the teacher during instruction and therefore influence the organizational patterns and teacher contributions to the dialogue (Scott et al., 2006). Considering the analytical framework set forth by Mortimer and Scott (2003), the focus of the lesson, which includes both the purpose and content, will determine what types of interactions and viewpoints are allowed during the science talk. Identified as the communicative approach of the lesson, this approach consists of two dimensions. If the

teacher allows for only the scientific explanations to be discussed, this is considered an authoritative approach. If however, more than one viewpoint is allowed into the discussion, it is considered to be dialogic. In a similar way, the teacher can decide that the dialogue for a lesson will be either interactive or non-interactive. The extent to which students are allowed to participate verbally in the discussion determines this dimension. It is also directly related to the manner in which the teacher chooses to intervene during the talk (Mortimer & Scott, 2003). Lessons that are meant to explore student conceptions about a topic can be approached in an interactive-dialogic way, however there are instances when a non-interactive-authoritative approach is more conducive to the purpose of the lesson (Scott et al., 2006).

The role of the teacher in fostering various forms of discussion is therefore an essential component of science talk. Research suggests that teachers may not recognize the difference between the authoritative, interactive IRE pattern which only considers the scientifically “correct” answer and a dialogic lesson which considers many student points of view supported by reasoning (Scott et al., 2006). Furthermore, the teachers may lack the skills needed to transition from the traditional IRE discourse in the classroom to one which is more dialogic, even when such an approach is called for by the curriculum for a lesson or activity (Driver et al., 2000). Teachers who shifted their discussions to include more open questions and non-triadic dialogue patterns increased the quality of student talk in their classes (Alpert, 1987; Martin & Hand, 2007; McNeill & Pimentel, 2010). Open questions, which ask students to infer, justify or judge (Blosser, 1973), invite students to explain their ideas and reasoning, thereby giving insight into student understandings of the concept under discussion. The use of open questions by a teacher assumes an interest in the

meaning that students are making of the science. The closed questions, which focus on factual recall or involve the use of specific data (Blosser, 1973), place the teacher in an authoritative, evaluative role due to the small number of responses that are deemed acceptable. The approach that the teacher takes toward the purpose of discussion therefore dictates the extent to which students will be able to participate in science talk. Because teacher beliefs influence the instructional practices they choose to employ (Jones & Carter, 2007), a better understanding of teacher perceptions about the discussions that occur in their science classes is key to changing the firmly entrenched tendency of most lessons to follow an authoritative, triadic pattern.

Teacher Beliefs

Increasing student participation in class discussions requires a shift in teacher instructional practices (Martin & Hand, 2007), but teacher beliefs influence the practices they choose to exercise (Jones & Carter, 2007). Beliefs are not a construct that can be easily quantified. Due to the many broad categories for which it is used in research, the operationalization of the term, beliefs, in studies must be well-defined (Pajares, 1992). The conceptualization of beliefs to suit only one category like student learning or teacher efficacy fails to capture its interconnectedness with other elements which as a system guides the final actions of teachers.

In the sociocultural model of embedded belief systems (Jones & Carter, 2007), the many elements that construct a belief system interact synergistically and not in a linear fashion. Therefore, to understand the underlying system by which teachers operate when having class discussions, several key aspects of the model will be considered in the analysis: teacher beliefs about efficacy, environmental constraints, science learning, science

teaching and attitudes towards instruction. In doing so, it is hoped that a more comprehensive conceptualization of beliefs can be utilized to obtain insight into the relationship between what teachers say and what teachers do with regards to science talk.

Research conducted with mathematics teachers would suggest that teacher beliefs greatly influence the pedagogical choices that are made during instruction (Cross, 2009). Although research would suggest that teacher beliefs in science correspond with the strategies they choose to employ in the classroom, many studies have relied on teacher self-reports about instruction instead of observations, therefore limiting the extent to which this assertion can be taken at face value (Savasci-Acikalın, 2009). Teacher beliefs about science instruction must be considered and challenged in order to achieve change in the instructional strategies (Johnson, 2009). For these reasons, it is important to investigate the possible relationship between beliefs and practice with the use of multiple observations.

Design

Context of Investigation

This study occurred during the piloting year of a high school standards-based urban ecology curriculum that was intended to actively engage underrepresented students in the study of science by having them focus on relevant ecological issues and reflect on their role in improving ecological sustainability. Unlike typical ecological curricula, this one was developed to include a strong urban element throughout every topic (e.g., land use, climate change, biodiversity) such that students would be studying these aspects of their own community by way of field studies, narratives, and specially designed activities. For the purpose of investigating teacher discourse, two distinct activities were selected for

analysis: (1) developing researchable questions and (2) arguing about global climate change. Both of these activities were meant to be interactive thereby creating a lesson in which the teacher would solicit student ideas.

Developing Researchable Questions Lesson. The purpose of this lesson was to have students learn about the characteristics of a researchable question in order to be able to create them for future field studies throughout the year. A key aspect of this lesson was for students to discuss and share their ideas with the teacher and the class. Subsequently, the lesson then suggested that the students develop their own research questions that would be presented to the class. Prior to this lesson, no professional development focusing on teaching strategies that might improve student participation in discussion had been offered. The lesson was enacted in mid September – early October for all teachers.

Arguing about Climate Change Lesson. The purpose of this lesson was to have students discuss their views about global climate change. It was suggested that two video clips depicting different perspectives on this issue be shown and then students be given time to write an argument about whether they believed climate change was occurring or not using evidence from the video or from previous knowledge. Students would then share their thoughts in a class discussion and critically analyze the videos. Prior to this lesson, teachers did participate in professional development centered around specific strategies that could be used to enhance student classroom discussions. This lesson was enacted in mid November – early December for all teachers.

Participants

All the teachers involved in the piloting of this curriculum were volunteers who responded to a solicitation for their participation. All teachers in the program participated

in a summer workshop and several professional development days throughout the school year. Due to limited resources, the videotaping of the enactment of one selected lesson from each module was conducted for only six teachers out of fifteen in the New England area to serve as a source of data for this study. Of the six teachers who were videotaped, only five were included in the final analysis because video for one of the teacher's lessons lacked audio and therefore could not be used.

All teachers participating in this study reported that they had received bachelor of science degrees in a scientific discipline. All but Mr. Rubenstein, also had received a Master degree in education. Some additional school and class characteristics relative to each teacher are represented in Table 1.

Table 1. School and class characteristics

Teacher	School Location	Teaching Experience	Student Grade	Class Size	School Size
Mr. Harris	Urban	2 years	11 th , 12 th	24	1174
Ms. Moran	Sub-urban	10 years	11 th , 12 th	21	1039
Mr. Rubenstein	Urban	6 years	12 th	28	319
Ms. Smith	Urban	9 years	10 th , 11 th , 12 th	22	323
Ms. Wilkerson	Urban	13 years	11 th , 12 th	21	355

Four teachers in the study taught in distinct high schools from the same urban district in New England while the fifth teacher, Mrs. Moran, taught in a suburban high school in a different district. The overall school demographics associated with each teacher is depicted in Figure 1. The four schools in the same district had similar demographics in that over 70% of the students in those schools identified themselves as either African-American or Hispanic. Mrs. Moran's school was distinctly different with 93% of its students identifying themselves as White.

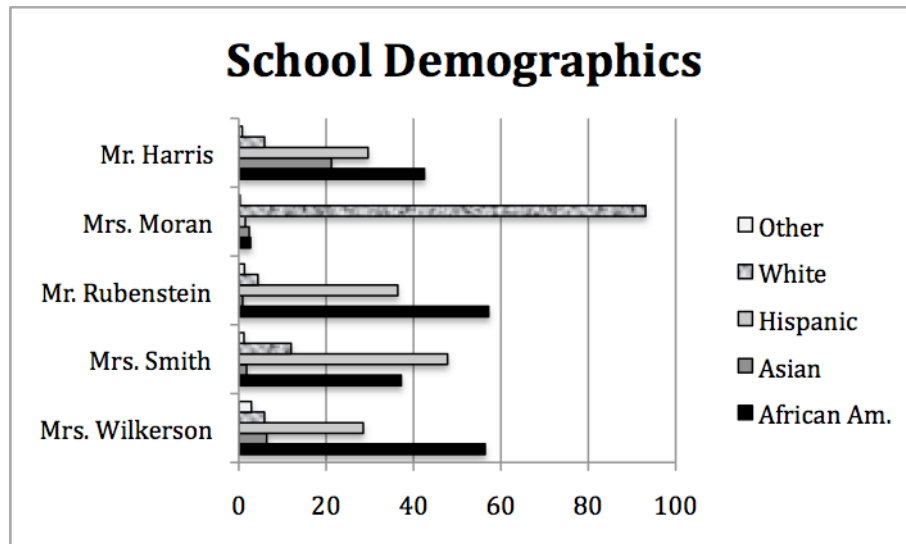


Figure 1. School Demographics associated with each teacher in the study.

Data Sources

Lesson Observations/Video Recordings. During the piloting of the curriculum, one lesson was video recorded in each module. For the purpose of investigating science talk patterns, two distinct activities associated with the curriculum were selected for analyses: (1) developing researchable questions and (2) arguing about global climate change. Both of these activities were presented by the curriculum as being conducive for dialogic and interactive dialogue within a whole-class discussion context. Lesson 1 was recorded in late September (early in the school year) and lesson 2 was recorded in mid-November (approximately one quarter into the school year). Professional development focusing on strategies to encourage science talk in the classroom took place before lesson 2. All video recordings were transcribed for analyses.

Interview. A semi-structured interview protocol was used approximately three months after the enactment of the second lesson which focused on the teachers' beliefs about science talk in their classrooms. In addition, two short vignettes depicting science

talk about developing researchable questions (lesson 1) were read by the teachers and then questions about their perceptions of that talk were asked. Vignette A depicted no direct dialogue between students and an authoritative role of the teacher, while vignette B depicted a more interactive student dialogue and less authoritative role of the teacher. The interview was recorded and then transcribed.

Data Analyses

Lesson Observations/Video Recordings. Using both the written transcripts as well as the video recordings, data analyses of the science talk in each lesson was performed at three levels: students, teacher, and overall organizational patterns.

Initial coding schemes, following an iterative analysis of the transcripts, were developed (Miles & Huberman, 1994) using student responses as the unit of analyses. Each student contribution to class discussion was coded into one of four categories depending on the level of depth associated with the response: Level 3 – Thought and Reasoning which included some extension which explained the thinking behind the statement, Level 2 – Complete Thought which included at least a noun and a verb but lacked an explanation of his or her thinking, Level 1 – Word or phrase response and Level 0 – No student response (Table 2). The intention was to distinguish those aspects of the student science talk that elucidated the students' reasoning or meaning making from those that showed a less elaborate joining of words to formulate scientific ideas. Inaudible responses were not coded. The two independent raters were trained by coding one lesson for Mrs. Smith. Having obtained an inter-rater reliability of 95%, the two authors proceeded by coding all subsequent transcripts separately and all disagreements were resolved through discussion. The coding scheme focused on student contributions to the class discussions.

Table 2. Coding Scheme for student contributions to the discussion.

Code	Category Name	Description	Example
3	Thought and Reasoning	The student's contribution includes a complete thought which resembles a sentence and includes an explanation his/her thinking.	Doesn't that school like the wetlands because they're a science school so they study more of the outside?
2	Complete Thought	The student's contribution includes a complete thought which resembles a sentence but no explanation is included.	Birds aren't around in the winter.
1	Word/Phrase	The student's contribution consists of a word or phrase only.	Yeah The ecosystem
0	No Response	There is no significant contribution to the discussion.	I don't know

Further analyses of the transcripts were conducted with Mortimer and Scott's analytical framework as a reference (2003). The focus of the lessons were similar for each teacher and defined by the curricular lesson plans that were being piloted. The teachers approaches, each lesson's patterns of discourse and the teacher interventions associated with each lesson were categorized.

Communicative approaches taken by teachers in each lesson were categorized as interactive or non-interactive and authoritative or dialogic as defined by Mortimer and Scott (2003). Interaction patterns were first categorized by noting the teacher-student exchanges that took place. Particular attention was given to teacher moves that seemed to drive the organizational and thematic patterns of the discussion. Using Chin's questions framework (2007) and Mortimer and Scott's teaching interventions framework (2003) as a starting point, four adapted categories of teacher moves were used to code the discourse:

Teacher Elaboration, Cutoff, Probing, Toss Back (Table 3). The presence of these teacher interventions that seemed to foster elaboration by students as well as those which appeared to discourage student talk were identified.

Table 3: Coding Scheme for Teacher Interventions

Code	Category Name	Description	Example
L	Elaboration	Occurs after a student response in which the teacher gives a specific, extended meaning or application to a student's brief response	Student - "Specific" Teacher - "It's very specific. I can give you a thermometer and point to some trees and you can go through the city and measure this. You could find out the answer if you sit there long enough"
C	Cut Off	Teacher interrupts a student before they can finish their response	Student - "Yeah it's like" Teacher - "okay you could also take some dirt and some worms inside"
P	Probe	Teacher asks student to expand on their response either asking for further explanation or a clarification of student response.	Teacher - "What do you mean by, it doesn't make sense?" Teacher - "Why"
B	Toss Back	In place of an evaluation, teacher asks for students to comment on a student's response.	Teacher - "What does someone else think" Teacher - "A question has to have more than one answer?"

Excerpts of the transcript that exemplified patterns were selected to illustrate the manifestation of the patterns within the actual dialogue. Initial analyses of the organizational pattern considered the traditional I-R-E approach, but in describing the overall pattern of the dialogue, teacher moves or interventions that were driving the discussion, including IRE patterns, were of most interest.

Interview. Teacher responses were analyzed using the sociocultural model of

embedded beliefs systems framework as a guide (Jones & Carter, 2007). Any phrases that were perceived to connect with any of the elements within the framework were highlighted and used to describe teacher beliefs. Key elements of particular interest were responses that spoke to the purpose of science talk, factors influencing science talk, the role of the teacher in science talk and the beliefs about students engaged in science talk.

Results

The following section summarizes the patterns which were determined to most inform the research questions: How do teachers describe science talk in their classrooms and how do they perceive their role within this talk? And what is the relationship between teacher beliefs about science talk in their classroom and their actions during science instruction?

The purpose of this study was to investigate how teachers support scientific talk in their classrooms during those lessons that call for this type of dialogue. We were specifically interested in identifying which strategies supported student contributions that exposed the thinking behind their responses. The teachers approaches to each lesson were consistent in many ways with slight variations in the ordering of activities overall, except for Mr. Rubenstein's lesson on researchable questions for which there was only field site data and Mrs. Wilkerson's climate change lesson which included a teacher-led Power Point presentation (Table 4).

Table 4: Teacher Approaches to Each Lesson

Teacher	Researchable Questions	Climate Change
Mr. Harris	<ul style="list-style-type: none"> -Students answered Do Now question: What are the characteristics of a good research question? -Class discussion of characteristics -Students visited field site developing researchable questions in groups given a specific topic -Students presented their questions to the class for critique (mostly by the teacher) 	<ul style="list-style-type: none"> -Students answered Do Now question Is global climate change happening? - Teacher discussed term “global climate change” --Students watched climate change videos taking notes about the evidence for or against climate change. - Students wrote an argument for or against climate change. -Students discussed their arguments in pairs and then shared with the class.
Mrs. Moran	<ul style="list-style-type: none"> -Students answered Do Now question: What are the characteristics of a good research question? -Class discussion of characteristics -Students visited field site developing researchable questions in groups given a specific topic -Students presented their questions to the class for critique (mostly by the teacher) -Class discussion of scientific process. 	<ul style="list-style-type: none"> -Students watched climate change videos taking notes for or against climate change. -Students wrote down an argument for or against climate change. -Class discussion about whether or not climate change was occurring.
Mrs. Smith	<ul style="list-style-type: none"> -Students answered Do Now question: What are the characteristics of a good research question? -Class discussion of characteristics -Student developed researchable questions in groups about their field site given specific topics but did not visit the site. -Students presented their 	<ul style="list-style-type: none"> -Students answered Do Now question Is global climate change happening? -Students discussed their views about climate change. -Students watched climate change videos taking notes for or against climate change. - Students wrote an argument for or against climate change.

	<p>questions to the class for critique (mostly by the teacher)</p> <p>-Class discussion of scientific process.</p>	
Mr. Rubenstein	<p><u>-Students were at their field study site and were asked to develop 3 researchable questions about the site.</u></p> <p><u>-Teacher circulated amongst the students giving feedback.</u></p>	<p>- Students answered Do Now question asking them to Brainstorm terms they associated with global warming.</p> <p>- Students shared the terms with the class.</p> <p>-Students watched climate change videos taking notes about the evidence for or against climate change.</p> <p>-Students critiqued the credibility of the videos.</p>
Mrs. Wilkerson	<p>-Students each wrote one characteristic of a good research question on the board.</p> <p>-Teacher commented on student initial responses.</p> <p><u>-Teacher-led Power Point presentation about the characteristics of a good research question including a student critique of presented questions.</u></p>	<p>-Students watched climate change videos taking notes about the evidence for or against climate change.</p> <p>-Students discussed what each video was claiming about climate change.</p>

An analysis of the talk that occurred in the teachers' science lessons suggests that the predominant contributions that students offer in the classroom are phrases (code 1) or statements that do not include reasoning (code 2) unless solicited further by the teacher. For example, in the climate change lesson (Figure 2), the student responses which included reasoning as a component of their statements (code 3) were observed least frequently for all teachers, noting that in Mr. Harris' classroom, no such type of student response was apparent. We found a similar trend in the researchable questions lesson in which less than 5% of the responses included reasoning.

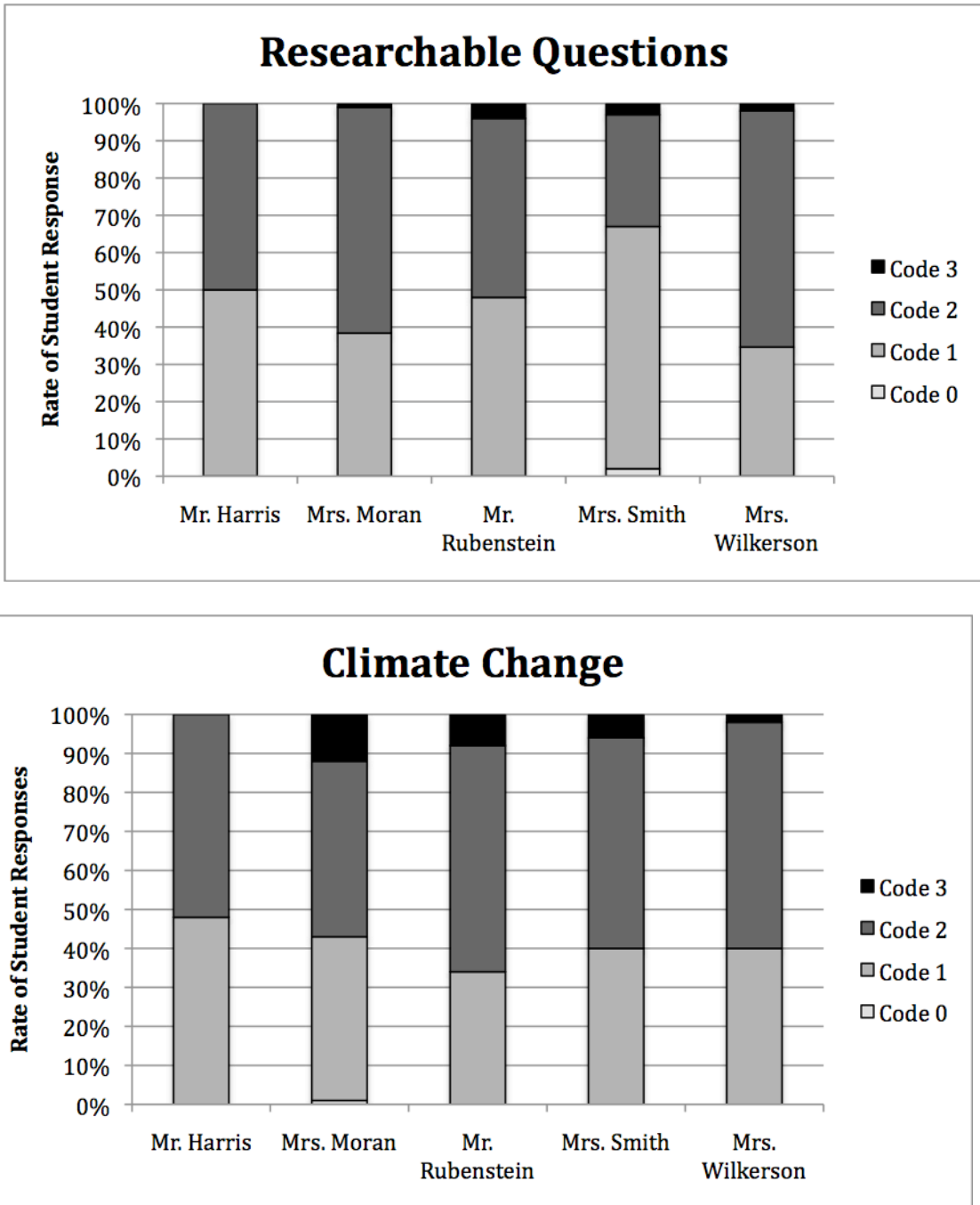


Figure 2. Percentages of Coded Student Contributions in the Researchable Questions Lesson

Further exploration of the lesson transcripts suggests that there are certain teacher moves that may serve to encourage or discourage the levels of student responses during classroom discussion. For example, Mr. Harris’ organizational pattern in both lessons was

the most faithful to the IRE pattern. After almost all student responses, Mr. Harris either evaluated or repeated the student response and then elaborated on student responses. The elaboration usually expanded on the student response to give it additional meaning that may or may not have represented the initial intention of the student. A typical interaction in the first lesson is highlighted below.

Mr. Harris: What's something else in a research question that you look for? Jake.

Jake: Making sense.

Mr. Harris: Making sense. It should be not only interesting but it should be logical.

You shouldn't ask a question that has no basis. It doesn't make sense.

That's another good reason for people not to read it. Let me ask this.

Can someone tell me why this is a good question? How does the

presence of trees affect daytime temperatures in a city? What makes

that a good question even if you're not interested in daytime

temperatures of trees? Why is that phrased in a good way? Lily?

Lily: Specific.

Mr. Harris: It's very specific. I can give you a thermometer and point to some trees

and you can go through the city and measure this. You could find out

the answer if you sit there long enough. Right? Sit there in the shade.

Sit there in the sun and just figure it out. It's doable. (Pointing to

another question) What's wrong with this question? There's actually

more than one thing wrong with this question.

In this instance Mr. Harris identifies the sample questions as being either good or bad examples for the students and then asks for students to give reasons for these

of cutoffs in the researchable questions lesson, may be a reason for the lower frequency of Level 3 responses by the students in that case.

The use of cutoffs by Ms. Wilkerson was not consistent in both lessons however. Although she did not use this move in the researchable question lesson, she did cutoff students several times during the climate change lesson. In this case, it appeared that Ms. Wilkerson was using this move as a way of controlling the discussion that was occurring in the class. She was adamant that students take time to write their arguments before beginning discussions, therefore when students would try to engage in discussion, she would interfere with their statement and encourage them to write it down. It was also used to maintain order to ensure that students were taking turns contributing to the science talk and not speaking simultaneously.

One move that differentiated the other teachers' lessons from that of Mr. Harris was the more extensive use of probing questions. The following excerpt shows how the use of a probing question used in a response to a student's answer fostered a code 3 response.

Jennie: Oil companies.

Ms. Moran: Okay. Why?

Jennie: Because burning fossil fuels emits carbon dioxide.

Unlike teacher elaborations which served establish meanings for student statements that may not have been intended, the probing questions required students to link their statement to their understanding.

Toss backs were observed least in all classrooms. In the case of Ms. Wilkerson's researchable questions lesson, the toss back intervention was associated with increased

interactions among students directly. Most organizational patterns showed shifts between teacher and student with limited talk directly students (Table 5).

Figure 5: Teacher-Student Shift Defining Interactive Pattern

Researchable Questions Lesson

	Mr. Harris	Ms. Moran	Mr. Rubenstein	Ms. Smith	Ms. Wilkerson
TS	40	84	144	107	65
TSS	0	3	11	18	18
TSSS	1		3	2	4
TSSSS			1	1	1
TSSSSS					0
TSSSSSS					1
TSSSSSSS					1

*Not a class discussion.

Climate Change

	Mr. Harris	Ms. Moran	Mr. Rubenstein	Ms. Smith	Ms. Wilkerson
TS	26	99	62	41	46
TSS	2	9	9	7	4
TSSS	1	2	4	3	4
TSSSS		0	1	0	1
TSSSSS		1		3	

The following is an excerpt from Ms. Wilkerson’s class showing the interactions that occurred among her students.

John: A question has to have more than one answer.

Teacher: A question has to have more than one answer?

Lea: No. It’ll be confusing.

Mike: It’ll be a good question if it has more than one answer.

Lea: Not really. Then you’ll be confused. Then you’ll be confused.

Carlos: No. If it has more than one answer you won’t get inaudible.

Lea: If it has an experiment to go with it.

Carlos: Then you'd be confused, I said like, I said.

Teacher: If it has what? A thesis statement?

In this case, several students speak about a characteristic of a research question before Mrs. Wilkerson interjects with a statement. There are clearly two different understandings relating to student beliefs about what a good research question should consist of. These opposing views are exposed during this interaction. Through this dialogue, the teacher can address the different meanings students could have made from her presentation.

Other instances of extended dialogue among students were less extensive however. Many times, they were simply comprised of students presenting a list of answers to a question that had been posed by the teacher.

Ms. Smith: Which animals would you want to look at? (with respect to a research question)

Colby: Fish.

Jasmine: Birds.

Roy: Snakes.

Sidney: Turtles.

Unlike the previous example, this simple interaction in Mrs. Smith's class does not serve a similar function which is to understand student's thinking about a topic. In this case, however, the question which was posed was not intended to elicit such a complex response.

Teacher interventions therefore seem to play a significant role in the types of type of talk which occurs. Fewer extended responses made by the students were related to the type of approach that the teacher took towards the discussion. Questions played an important role in the types of responses which were seen. Probing question which were open to meaning making were more likely to bring about more elaborate student responses than those that were posed in a way that allowed for simple word or phrase responses. The positioning of the teacher as the authority over the discussion was also apparent given that there was some teacher feedback or evaluation after most student responses.

Teacher Awareness of the Discourse Patterns in their Classroom

Teachers conceded that the science talk in their classrooms were less ideal than they would like, with Ms. Smith being the exception. All teachers identified with their class discussions as being more like the teacher-directed vignette to some extent. In so doing, they gave reasons for why there was a disconnect between what they considered to be a more student-centered whole-class discussion and what actually occurred in the classroom. The reasons were categorized into three groups: student deficits, teacher deficits and a time deficit.

Student deficits. Teachers attributed the limited science talk that occurred in the classroom in part to deficits they perceived in their students. A lack of experience with science talk was one of the main difficulties all teachers cited with regards to the students' ability to participate in this form of learning. Mr. Harris for example said "a lot of student I teach don't have experience with this". Ms. Moran suggested however that the talk would become more ideal "as the year progresses". In Ms. Moran's case, there was a noticeable

increase in the percentage of code 3 responses that occurred in her class when the lessons were compared, thereby suggesting that her beliefs towards science talk may encourage support the gradual increase in talk as the year progresses.

Ms. Wilkerson's belief that "dialogue depends on the knowledge the student brings to the table", suggests that a lack of content knowledge on the part of the student is another factor that teachers believe limits student contributions to discussions. In both cases, these lessons were designed to explore student thinking about the topics, therefore it would appear that unlike the intended purpose that was suggested for the lessons, most teachers approached these lessons as means by which to assess student knowledge of content or "right answers" as opposed to exploring student thinking in a more general sense.

This approach towards discussions may explain why, according to the teachers, most students are not comfortable contributing responses to whole-class discussions. Ms. Moran stated that they are afraid to be wrong "especially my very top of the class students". This belief that students were not comfortable participating in discussions because of this fear was echoed by all teachers. Ms. Wilkerson stated that "sometimes students don't feel free to share knowledge in classes and they feel like they're going to be shot down by their peers". The social aspect of talk and a tolerant classroom culture is therefore one that cannot be taken for granted by fostered by the teacher, supporting the idea that science talk might evolve as the year progresses.

The last factor that teachers believed seriously limited the science talk in class was the lack of student motivation to participate in a type of instruction that they believed required more effort. Ms. Smith for example stated that "school is more manageable for them [students] is if it's less reflective, less writing, less critical thinking and more easily

responding to questions on a page where there's a right answer and the teacher will provide the correct answer". Ms. Wilkerson echoed this idea by stating that students "depend on the teacher to lead the conversation". Ms. Moran agreed stating that she believed students "like to listen and be told" what the answers are.

These teacher perceived factors influencing science talk seem to be challenges that in some cases reinforce reliance on triadic forms of classroom discourse. Some teachers clearly chose to avoid classroom discourse at times using alternative like pair-shares or individual work because they felt that it was more manageable even though, in the case of Mr. Harris, he questioned the extent to which students in groups were actually focusing on the topic at hand. It would seem therefore that the students' willingness to actively participate in science talk initially contributes to the teachers beliefs about such a strategy is worth pursuing throughout the year.

Teacher deficits. Teachers were equally critical of themselves citing factors that they had control over. One such factor was the lack of structures in the class that would support active discussion in the class. Mr. Rubenstein stated that "maybe if there were better structures in place on how to have a discussion from the beginning of the year" the science talk in his class would more likely resemble his ideal. Mr. Harris shared this belief suggesting that if he had established stronger accountability structures in his class for the students, more active student engagement might have been expected.

Many teachers however questioned their ability to guide a more student-driven talk. Ms. Wilkerson for example believed that "facilitating discussions is an art. I mean, I just don't have it". Ms. Smith had a similar belief suggesting that it was a skill she needed to develop. So although teachers may want the talk in there classes to include more chances

for students to express their understanding of science, they may not feel prepared to support this type of active discourse in their classrooms. Ms. Moran made the point that it is the norm for teachers to do most of the talking and that “one of the ways to get kids to talk more is teachers talk less”. Mr. Harris shared this awareness stating that “it [science talk] tends to be centered around me and I’m trying to remove myself from that situation” but he’s not sure how that can happen besides moving whole-class discussions into small group work.

Perhaps the most pressing factor, however, was the lack of time that teachers perceived which established a clear tension between the extent to which talk could be focused on student meaning making vs. content coverage or assessment. Although every teacher every teacher stated that one main purpose of talk was to understand student thinking and meaning making, they more often referred to class discussions as a way to assess student content knowledge (Table 5).

Table 5: Teacher Beliefs about the Purpose of Science Talk

Teacher	Science Talk = Meaning Making	Science Talk = Content Assessment
Mr. Harris	-“though process, that’s how they develop their answers” -“looking for students to make connections.”	-“sometimes I’m looking for the correct answer”
Ms. Moran	-“to get at what kids are thinking” -“making connections to prior science learning”	-“to find out what the background knowledge is” -“other times we talk to specifically repeat and reinforce knowledge”
Mr. Rubenstein	-a space for students to “push each other for clarity”	-“guide students toward an answer or to guide something out of them that I think they have or they know”
Ms. Smith	- a way to “hash out different ideas”	-“talking is one form of assessing knowledge”
Ms. Wilkerson	-Means to “get student to think deeper to make more sense”	-“you try to think of questions to bring out the information that you want them to learn or to tell you”

Although the use of science talk as formative assessment is a valuable tool when teachers are trying to get a sense of the content knowledge that students have, these specific lessons were meant also focus on student thinking about formulating researchable questions or climate change. It would appear that teachers may have difficulties shifting to this approach of discussion. This may be due in part to their perceived lack of efficacy as mentioned previously, but it may also be the result of an engrained belief that as teachers their job is to focus on content.

In the interview, the issue of time as a constraint on the type of talk that could happen in the classroom was clear. Referring to the vignette of a lesson in which the teacher was asking many closed and guiding questions which solicited short student responses, the teachers suggested that time was probably the primary reason for this type of questioning strategy.

Ms. Wilkerson stated “She kind of gave the specificity instead of letting the kids, but that happens because she might have run out of time.” The impact of time on the discourse which takes place in the classroom was also evident in viewing Mr. Harris’ lesson on researchable questions. Although the class began with a leisurely discussion about questions, as the class period approached the end, the focus shifted to simply having students report out their question with an immediate evaluation by the teacher without further solicitations for student ideas. Time pressures may be one reason why we did not observe more extended student responses in teachers’ enactments of the two lessons. Ms Moran stated that “these things [science talk] are influenced by how much content or how many parts of an activity should be completed by the end of class”. Therefore, it would appear that when time is limited active science talk is likely to be short changed.

Discussion

This study set out to describe how lessons meant to foster extensive student science talk would be implemented within the classroom and what role teacher beliefs might play in their approach towards the lesson. Both lessons were clearly teacher dominated and coincided with previous research suggesting that students do not regularly explain the reasoning behind their responses when contributing ideas to a discussion (Jiminez-Aleixandre, Rodriguez, & Duschl, 2000). Given the dominance of triadic discourse focusing on factual information in classrooms throughout the history of science education (Cazden, 1988; Lemke, 1990; Mehan, 1979) and being mindful that the experiences teachers bring with them to the classroom influence their instruction (Fradd & Lee, 1999; Lortie, 1975), teachers' intrinsic belief systems must be considered. Even when teachers are aware of what it means to provide students authentic opportunities to practice science talk and consider active student-driven talk to be ideal in certain instances, many reasons are cited for the limited responses of students during whole-class discussions. A study by Kennedy (2005), for example showed that teachers frequently limited the amount of student input in class discussions because it slowed down the coverage of material. Aguiar, Mortimer and Scott (2010) also recognize that there is a tension that exists between teaching science, an inherently authoritative domain, in a dialogic way. These tensions were clearly felt within the teachers that participated in this study. The teachers themselves however noted that they didn't necessarily feel that they had the required skills needed to facilitate what considered to be more ideal forms of science talk. This would suggest that professional development focusing on improving teacher skills in this regard could help teachers feel better prepared to foster student talk during lessons.

Perhaps the most intriguing finding of this study are the beliefs that teachers held about the students. The resistance they felt by students to engage actively in discussions seemed to dissuade them from pursuing this type of talk more frequently. Also, the belief that the lack of student experience with active science talk was a predominant reason for its limited appearance in the classroom seemed to lessen the potential role that the teacher had in fostering this ability throughout the year. Such a belief seems to be a self-fulfilling prophecy. Because students don't have experience with the type of science talk that diverges greatly from the IRE pattern, they will be unable to participate in extensive class discussions.

Making science talk a feasible strategy for teachers given the limitations they currently perceive to exist is an important focus that must be addressed by professional development and teacher preparation programs. Furthermore, establishing science talk as a skill that can be fostered in students at all levels rather than something that should have been acquired at some point in science education is imperative.

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