DOCUMENT RESUME

ED 465 605		SE 066 327

AUTHOR	Newman, William J., Jr.; Hubbard, Paula D.; Abell, Sandra K.
TITLE	Teacher Explanations for Discourse Variations in Elementary Science Methods.
PUB DATE	2002-01-00
NOTE	35p.; In: Proceedings of the Annual International Conference of the Association for the Education of Teachers in Science (Charlotte, NC, January 10-13, 2002); see SE 066 324.
AVAILABLE FROM	For full text: http://aets.chem.pitt.edu.
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Discourse Analysis; *Discussion (Teaching Technique); Elementary Education; Higher Education; Inquiry; *Methods Courses; Preservice Teacher Education; *Science Education

ABSTRACT

The development of a scientifically literate society is dependent upon effective communication. Accordingly, the Benchmarks for Science Literacy, which defines science literacy goals for United States students K-12, contains an entire section on communication skills. One of the skills described in the Benchmarks is that "students should be able to participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarifications or elaboration, and expressing alternative positions." The ability of students to achieve this goal is dependent upon a teacher's ability to incorporate such opportunities into lessons. Teachers need the experience of proposing answers, explanations, and predictions and communicating the results as often accomplished by classroom discourse. Classroom discourse is necessary for teachers to determine what students understand and misunderstand, what they are thinking, and what they are learning. A teacher preparation program must model and teach how to facilitate high quality classroom discussion. To do so, science methods instructors must examine, understand, and explain their own roles, intents, and actions during classroom discussions. One of the first steps in improving the preparation of teachers' skills in leading discussions is to understand and explain science classroom discourse as it occurs in science teacher education courses. (Contains 60 references.) (MVL)

Teacher Explanations for Discourse Variations in Elementary Science Methods

by

William J. Newman, Jr.
Paula D. Hubbard
Sandra K. Abell

TEACHER EXPLANATIONS FOR DISCOURSE VARIATIONS IN ELEMENTARY SCIENCE METHODS

William J. Newman, Jr., Purdue University
Paula D. Hubbard, Purdue University
Sandra K. Abell, University of Missouri, Columbia

Teacher Explanations for Discourse Variations in Elementary Science Methods

The development of a scientifically literate society is dependent on effective communication. Accordingly, the *Benchmarks for Science Literacy* (the Benchmarks) (American Association for the Advancement of Science [AAAS], 1993), which defines science literacy goals for United States students K-12, contains an entire section on communication skills. One of the skills described in the Benchmarks is that "students should be able to participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarifications or elaboration, and expressing alternative positions" (p. 297). The ability of students to achieve this goal is dependent on a teacher's ability to incorporate such opportunities into lessons. Moreover, the National Science Education Standards (National Research Council [NRC], 1996, 2000) state the importance of learning to teach through inquiry. As part of learning through inquiry, teachers need the experience of "proposing answers, explanations, and predictions; and communicating the results" (NRC, 1996, p. 23), often accomplished via classroom discourse. Additionally, classroom discourse is necessary for teachers to determine what the students understand and misunderstand, what they are thinking, and what they are learning (NRC, 2000).

The nature and the function of the discourse can determine the extent to which classroom discussion is inquiry-based, which is a critical characteristic of science education (NRC, 1996, 2000). "The discussion leader must find a way to teach that is neither too dominant nor too reserved" (Brookfield & Preskill, 1999, p. 194). Teachers need to demonstrate how to challenge, clarify, and elaborate ideas; yet, they need to "allow the children to take more control of what is said, when it is said, and how it is said" (Bloom, 2000, p. 90). For this to occur, teachers need to help students understand the nature and functions of classroom talk (Bloom)

We believe that a teacher preparation program must therefore model and teach how to facilitate high quality classroom discussion. To do so, science methods instructors must examine, understand, and explain their own roles, intents, and actions during classroom discussions. Thus, one of the first steps in improving our preparation of teachers' skills in leading discussions is to understand and explain science classroom discourse as it occurs in science teacher education courses.

Literature Review

The study of discourse is often framed within a sociocultural approach to learning, which claims that individual thinking is situated in cultural, historical, and institutional contexts (Wertsch & Toma, 1995). Studying language involves understanding not only the words, but also the intentions of those engaged in the dialogue. According to Bakhtin (1981), "Language is not a neutral medium that passes freely and easily into the private property of the speaker's intentions; it is populated—overpopulated—with the intentions of others" (p. 294).

Lotman (1988), a semiotician, has argued that functional dualism is characteristic of all texts (including utterances, written words, and nonverbal texts such as costumes). In Lotman's view, texts have both univocal and dialogic functions, where the univocal focuses on conveying meaning and the dialogic on generating meaning. Wertsch and Toma (1995) apply this notion of textual dualism to the analysis of classroom discourse.

> It is reasonable to expect that when the dialogic function is dominant in classroom discourse, pupils will treat their utterances

> and those of others as thinking devices. Instead of accepting them as information to be received, encoded, and stored, they will take an active stance toward them by questioning and extending them, by incorporating them into their own external and internal utterances, and so forth. When the univocal function is dominant, the opposite can reasonably be expected to be the case. (p. 171)

Nystrand (1997), in thinking specifically about classroom discussion, illustrated how functional dualism occurs through two types of discussion, dialogic and monologic, which require different epistemic roles for students. Dialogic discussions contain statements that "respond to previous utterances at the same time they anticipate future responses" (p. 8). Such discourse is "structured by tension...as one voice 'refracts' another" (p.8). Bakhtin (in Todorov, 1984) required the dialogical semantic relationship to be structured by "two verbal works, two utterances, in juxtaposition" (pp. 60-61). The utterances express the author and the respondents and thus establish multivoiced discourse.

In contrast, during monologic discussions, teachers "'prescript' both the questions they ask and the answers they accept, as well as the order in which they ask the questions" (Nystrand, 1997, p. 12). Teachers often thwart dialogue by evaluating student answers instead of responding to ideas. Lemke (1990) and others have referred to this discourse genre as Triadic Dialogue or QAE (question, answer, evaluation). In Bakhtinian terms, "there is no second voice alongside that of the author" (in Todorov, p. 63); others' utterances are framed within the voice of the original author creating a singular context and a singular semantic orientation.

In efforts to apply these theoretical frameworks, science educators have studied multiple aspects of classroom discourse. These include conceptual understanding as expressed in discourse, types of discourse in science classes, the nature of argument, and the influence of teacher knowledge on discourse. The studies have examined elementary, secondary, and collegiate classrooms, and have found, regardless of the level, that opportunities for discourse in the science classroom are limited. For example, researchers have studied student conceptual understanding in the context of classroom discourse at the elementary (Varelas & Pineda, 1999), middle (Varelas, 1996), and high school levels (van Zee & Minstrell, 1997). Others have focused on the nature of teacher questions and response strategies (e.g., Tobin, 1984; van Zee & Minstrell, 1997). However, these studies virtually ignored the types of discourse present in science classrooms and the roles and intents of the teacher.

Other researchers have tried to delineate the types of discourse that occur in science classrooms. Lemke's landmark study (1990) demonstrated teachers' over reliance on the monologic in science classrooms, by documenting a preponderance of Triadic Dialogue. Gee (1997) identified types of science talk—Designing, Discovering, and Explaining—that occurred in a second grade classroom. Both Lemke and Gee argue for making science language a more explicit part of classroom practice. Kelly and Chen (1999) extended this argument by examining oral and written texts in high school physics. They demonstrated that student use of scientific language was related to the context of the classroom—both the social practices that had been established and the nature of the discourse activity.

Another line of research in the discourse literature has examined the nature of argument in science classrooms. Driver, Newton, and Osborne (2000), among others, posited that argument is central to science education. Researchers have examined both students' abilities to engage in argument and the opportunities they are provided to do so. Sorsby (1999) found that elementary students can argue orally to clarify, reconcile, and persuade. Bloom (2000) confirmed this in a study of middle level students' argumentation about density. In a study of high school genetics (Jiménez-Aleixandre, Bugallo Rodríguez, & Duschl, 2000), students did develop arguments during a problem solving task, using more claims than justifications or warrants. In an examination of student and teacher questioning, van Zee, Iwasyk, Kurose, Simpson, and Wild (2001) asserted that student questions occur more frequently when specifically elicited during the discussion, when a KWHL chart is constructed as part of the discussion, during brainstorming experiences, and during guided closure. Student generated inquiry discussions can be elicited by assigning facilitator roles to the students and explicitly describing the desired discourse to the students (van Zee et al., 2001). Unfortunately, such opportunities for argument in science classrooms are often limited (Newton, Driver, & Osborne, 1999).

A number of studies have examined the ways in which teacher knowledge and classroom discourse influence opportunities for learning science. Carlsen (1992, 1993) found that a teacher's subject matter knowledge affects the types of discourse that occur in high school biology classrooms, with less knowledgeable teachers more apt to limit opportunities for dialogue. In biology and chemistry classrooms, Carlsen (1997) again documented that teacher subject matter knowledge was a factor in shaping the argument patterns that occurred. Cunningham (1997) demonstrated that teachers' sociological understanding of science influences how they "structure their classrooms to convey messages to their pupils about students' abilities to do science and the sources of scientific information" (p. 24). For example, in a study of a high school chemistry teacher (Moje, 1995, 1997), the social norms the teacher built communicated that science is precise and authoritative, with only specific styles of discourse allowed. Crawford, Chen, and Kelly (1997), in the context of a high school physics course, found that students appeared to know less and were less willing to offer explanations to what they perceived as a knowledgeable audience (teachers) versus a less knowledgeable audience (fifth graders).

Thus it becomes clear that teachers have high levels of control over the types of discourse that occur in science classes.

Science education researchers have also documented the functional dualism of discourse in science classrooms. Mortimer (1998) examined the oral discourse in a high school science class in the context of discussing models of matter. He found that the alternation of what he called authoritative (Lotman's univocal) and persuasive (Lotman's dialogic) was an important feature of classroom talk. In a microanalysis of a high school discussion about density, Mortimer and Machado (2000) claimed that this alternation allowed students to "move successively from ignore to perceive, negate, admit, and compensate for a disturbance" (p. 438). Scott (1999) also found a dialectic relationship between authoritative and dialogic functions in high school science discourse related to chemical reactions. Scott regarded the authoritative/dialogic functions as two dimensions along a continuum of classroom discourse, believing that "individual student learning in the classroom will be enhanced through achieving some kind of balance between presenting information and allowing opportunities for exploration of ideas" (p. 14). However, he provided no guidelines for what the proper balance should be.

The science education research literature on classroom discourse is thus rich and varied. Most of it, however, has been undertaken within the context of high school science. If we want to help build a culture of dialogue in science teaching, we also need to understand discourse in the context of teacher education. Few studies of discourse have been conducted in undergraduate science teacher preparation programs. Koballa (1984, 1985) examined student persuasive communication in science courses for preservice elementary teachers and its influence on attitude changes toward energy conservation. Van Zee (2000) analyzed student-

student interaction during a science discussion in an elementary science methods course. She determined that practices of teacher quietness and distributed authority fostered inquiry.

While these studies looked at discourse function, they did not examine the monologic/dialogic nature of the discourse per se. Furthermore, they focused only on discourse related to science content. The necessity for our research stems from the void in the literature regarding discourse in an undergraduate teacher education setting, from both the perspective of the types of discourse that occur and the intentions of the instructor in guiding the discourse. Additionally, the need exists for the study of discourse in both the contexts of science and pedagogy instruction.

Research Design

This study was theoretically framed by a constructivist perspective (Schwandt, 2000). Our research was guided by the relativistic ontological assumption that realities are multiple, constructed, and holistic (Lincoln & Guba, 1985). Reality is a socially and experientially constructed entity and its form and content depend on those who hold the construction (Lincoln & Guba, 2000; Schwandt, 2000). Within the constructivist framework exists an epistemological belief that the inquirer and the object of inquiry are interactively linked, influence one another, and become inseparable (Lincoln & Guba, 1985, 2000). Additionally, the methodological perspective of a constructivist paradigm is that inquiry is hermeneutical and dialectical. Investigators and participants participate in dialogue among themselves and with the data to develop "more informed and sophisticated reconstructions" (Lincoln & Guba, 2000, p. 170), interpreted using hermeneutic techniques. Because "understanding is always interpretation and hence, interpretation is an explicit form of understanding" (Gadamer, 1994, p. 307), varying constructions were compared, contrasted, and eventually understood through a dialectical interchange. The final rendering, "one interpretation among multiple interpretations of a shared or individual reality" (Charmaz, 2000, p. 523), includes the etic construction of the investigators informed by the emic constructions of the participants and is more sophisticated than any antecedent constructions.

In accordance with the constructivist theoretical framework, we utilized an interpretive research design (Denzin & Lincoln, 2000). The design permitted flexibility "to allow for discoveries of new and unexpected empirical materials and growing sophistication" (Denzin & Lincoln, p. 368). An important aspect of our interpretive research design was self-study.

The two major purposes of teacher self-study deal with "refining, reforming, and rearticulating" education (Cole & Knowles, 1996, p. 1). The first purpose of self-study is personal professional development. Self-study of this nature aims at improving pedagogical practices. The second purpose of self-study is to enhance understanding of teacher practices, processes, and contexts. This form of self-study aims to advance knowledge about teaching and its settings. Obviously, the two purposes are not mutually exclusive, although, typically, one predominates. At a minimum, self-study requires "taking an inquiry stance towards our practice" (Raphael, 1999, p. 49). This requires developing teaching methods, practices, and curriculum, then implementing them, followed by studying them.

Paulsen and Feldman (1995) advocated using self-study to address the challenge of improving college level teaching. They concentrated on the need for faculty members to improve instruction by studying themselves and discovering how they "interact with their own environment" (Paulsen & Feldman, p. 9). Moreover, Paulsen and Feldman claimed, "the best source of informative feedback available to most instructors is themselves" (p. 9). Consequently, the advancement of university teaching requires self-study.

The self-study aspect of our design allowed for a strong emic perspective and an "insider's" individual interpretation of the research. In addition to standing alone, the emic perspective interweaved with the perspectives of the other members of the research team. The final constructions of our individual and shared realities were strengthened by the emic perspective gained from self-study.

Research Questions

As part of a teacher-as-researcher project and in an effort to better understand her own teaching style and efficacy, Hubbard undertook an informal self-study of her teaching during an elementary science methods class. From this initial study, she established that she used discussion techniques differently when teaching science content as compared with teaching pedagogical topics. To better define and understand these differences, Newman and Abell joined Hubbard in a formal study of her teaching practices in the elementary science methods course. We undertook a systematic inquiry of classroom discourse to examine the following research questions: How does classroom discourse in an elementary science methods course differ between teaching pedagogy and teaching science content? To what extent are pedagogy and science content taught dialogically and/or monologically in the undergraduate elementary science teaching methods course? How does the instructor account for such differences? The focus of this paper is on the final research question.

Research Setting and Participants

The elementary science methods course in the study is built on a reflection orientation (Abell & Bryan, 1997) that provides opportunities for students to build theories of science teaching and learning as they: (a) observe others teach, (b) reflect on their own teaching, (c) read expert theories, and (d) examine their own science learning. Students engage in both science content explorations and pedagogy activities in the class. We chose this setting because it was the course that Hubbard studied informally, and we previously have examined several different aspects of science teacher preparation in this course (Abell & Bryan, 1997; Abell, Bryan, & Anderson 1998; Abell, Martini, & George, 2001; Abell & Smith, 1994). The course section in this study was somewhat unusual in that it occurred as an intensive 8-week program during the summer with only 12 students, 9 females and 3 males. All of the students had just completed their third year in the teacher education program.

Role of the Researchers

Hubbard, the course instructor, taught elementary and middle school science for five years and had taught the methods class the previous two semesters. In addition to teaching the course, Hubbard participated in formal and informal interviews during the study.

Newman served a peripheral membership role in the course taught by Hubbard. In a peripheral membership role, researchers feel "an insider's perspective is vital to forming an accurate appraisal of human group life, so they observe and interact closely enough with members to establish an insider's identity without participating in those activities constituting the core of group membership" (Adler & Adler, 1998, p. 85). Newman taught high school science for 10 years and during that time regularly aided elementary teachers with science instruction. Moreover, he spent one year as supervisor of science for a suburban school district and has taught several teacher education and science courses at the university level. Newman regularly attended class, closely observed activities, took field notes, and interviewed participants without engaging in course activities. As the project progressed, Newman maintained the stance of empathic neutrality (Patton, 1990) so as to have minimum influence on the classroom functions. All three researchers participated in data analysis and writing.

Data Collection Techniques

We used a variety of data collection techniques in this study, including peripheral membership observation, interviewing, videotaping, audiotaping, and collection of documents.

Peripheral Membership Observation

Newman visited the classroom for six of the eight weeks the class met. The other two weeks, the students participated in field experience and met to prepare lessons. When Newman was in the classroom, he observed the class and took field notes that contained, but were not limited to, descriptions of the environment, participants, activities, researcher's feelings, interpretations, and reflections.

Interviews

Weekly informal discussions were used to ascertain the teacher's plans and goals regarding science and pedagogy instruction, specifically with reference to the use of discourse. Weekly follow-up discussions addressed the teacher's feelings and attitudes about the completed lessons. After each observed class meeting, Newman interviewed Hubbard regarding her use of discourse during the lessons with specific attention to science/pedagogy and monologic/dialogic issues. We developed interview protocols and reconstructed them following the guidelines for interview guide approach and standardized open-ended interview from Patton (1990). We also conducted informal student interviews as necessary to better address our research questions.

Videotaping

Videotaping of the lessons began once Newman was established in the classroom as a peripheral member. One camera, focused on the instructor, recorded all classroom activities. Additionally, we used the videotapes to elicit teacher responses during interviews.

Audiotaping

We used three recorders during classroom observations, one for each group of students. When the class met in large group discussions, we used one recorder to supplement the field notes and videotape recording. We also recorded all post-class interviews.

Collection of Documents

We collected copies of lesson plans, relevant handouts, and student work deemed important to the study.

Data Analysis

Multiple data sources, field notes, class transcripts, and interview transcripts, were used throughout the study and allowed triangulation. Field notes and transcripts of classroom discourse were the primary data sources. Data analysis began in conjunction with data collection and continued through the write-up phase of the project. In the analysis of the discourse data, we used constant comparative methods (Glaser, 1992), reading and rereading the data and comparing segments for similarities and differences using coding which reflected the concepts each segment exemplified (Patton, 1990). This process of open coding progressed until no new concepts emerged from the data. We revisited the data once it was coded to ensure that the coding was focused to the research questions guiding the study. Each research team member independently analyzed the data. We then came together as a team and discussed patterns, offered confirming and disconfirming evidence, and generated assertions grounded in the data.

The techniques used to analyze and interpret the data are rooted in the philosophy of hermeneutics and appropriate given the theoretical frame of constructivism. The study was hermeneutical in the sense that the participants (especially Hubbard) were interpreting teaching situations, and the researchers were interpreting the teacher's interpretations to establish deeper understanding and collective meaning (Patton, 1990). Interpretation and understanding are dialectically linked; thus, the participants' interpretations are influenced by their beliefs, values, and prior experiences. Analogously, our interpretations of the participants can be understood only in the light of our own beliefs, values, and prior experiences.

After mapping the videos and discussing the data, we established three major discourse focal points for detailed analysis: demonstrations, open-ended discussions, and class consensus discussions. For each discourse format, we selected an example in which science seemed to be the predominant content and an example in which pedagogy seemed to be the predominant content. We then transcribed the six segments and determined speaking patterns, who spoke when and how often. After establishing tentative categories for function of each utterance, we individually recoded each transcript. Each researcher developed new codes as needed, which were later added to the coding scheme. This iterative process of individually recoding and collectively interpreting the data continued throughout the study. Using patterns of speaking, functions of utterances, and vocality, we labeled sections of each transcript identifying to what extent the section was science and/or pedagogy and monologic and/or dialogic. Upon completion of analysis for science/pedagogy and monologic/dialogic, we coded the classroom and interview transcripts for intent.

Results

Distinguishing between science and pedagogy was not simple in an elementary science methods course (Newman, Hubbard, & Abell, 2001a). The two content areas were so intertwined that they were difficult to differentiate. Moreover, what appears to be one content area could be identified as the other based on the intents of the participants and/or the perspectives of the students or researchers.

Similarly the monologic/dialogic distinction was not always clear. When a high incidence of teacher voice was observed, the resulting discourse was not necessarily monologic. Analogously, a large proportion of student voices did not always indicate dialogic discourse (Newman et al., 2001a). Moreover, speaking patterns alone were insufficient tools for analyzing the research questions; issues of function, voice, and intent became important in describing the discourse. Given all of these variables to consider, we were unwilling to delineate a discourse sample as purely monologic or dialogic. Thus, we agree with Scott (1999) that the monologic/dialogic nature of discourse is better described as a continuum than as a dichotomy (Newman et al., 2001a).

Three whole-class discourse formats occurred regularly in the course, in both science content and pedagogy contexts: open-ended discussions to share ideas, discussions to reach consensus, and demonstrations. In earlier work (Newman et al. 2001a; 2001b), we identified the discourse characteristics of six class discussions, one of each format for science and pedagogy. A summary of these results precedes each of the following sections to establish the necessary context for the instructor's explanations of the discourse.

Open-ended Discussions

The two talks that represent open-ended discussion were a science talk (Gallas, 1995) about the moon and a pedagogy talk, a discussion about science talks as an instructional strategy. These segments were easily designated as science content and pedagogy, respectively, but the line between monologic and dialogic seemed blurred (Newman et al., 2001a). Both segments initially appeared dialogic; however, after deeper analysis, we identified the pedagogy segment, in spite of multiple speakers, as containing significant monologic characteristics because we had difficulty establishing whose voice, the teacher's or the students', was emphasized (Newman, et al., 2001b).

Because the students directed the talk and discussed ideas that were important to them, Hubbard described the science talk as involving student voice more than teacher voice. In a later interview, she also acknowledged the concurrence of her intents and the students' intents, "After the class finished, I was pleased with the outcome. I felt that it had been a good day because the students' goals for the day had aligned with my goals for the day, and together we had achieved them." Hubbard's intent of engaging the students in dialogic discourse and the students' willingness to comply with this plan resulted in a generative discussion.

Hubbard's intent for the pedagogy open-ended discussion was for the students to socially construct knowledge about using science talks as an instructional strategy. The students had already participated in the moon science talk and had seen a video of a teacher leading a discussion. When contrasted with the science talk, the teacher role differed dramatically. In a post-class interview, Hubbard stated,

> I had hoped that the students would speak as freely about pedagogy as they did about their ideas about the moon, but there was not the same vigor in the discussion. I never achieved the goal I had intended because the students had something else in mind.

> The discussion moved rapidly to a discussion of classroom management with these types of talks or with science in general.

Hubbard acted in the role of the teacher rather than of a participant during this discussion because she spent much of her time steering the discussion towards instructional strategies and away from classroom management. Accordingly, this discussion was less dialogic than the science talk (Newman et al., 2001b).

When explaining the differences between the science talk and the pedagogy talk Hubbard began by addressing her content knowledge as related to the science talk.

> The science talk was very dialogic because I know a lot about the moon and I knew I could just sit back and let them try and figure some stuff out because I understood enough to figure out how to teach them. Additionally, my goal was not that they come away with total understanding, and I was okay not being able to answer some of their questions due to the fact that I know I learn more each semester, and I feel comfortable not knowing everything and having to look it up.

She then noted a connection between her relatively high level of understanding about the moon and the students' lack of understanding.

> Oddly, during the science talk, they were completely dialogic, but knew little about the moon. I believe this is due to my content comfort level again. First, they perceived my comfort with the situation. (I think this is a big deal no matter the age level.) If the teacher is calm, smiling and basically at ease with the students, they have freedom to figure out the material. If they perceive that you are stressed, they wonder what they have done wrong. So in this case, students' lack of content knowledge didn't matter because mine was strong and comfort took over.

Hubbard also remarked on how a teacher can work around the difficulties presented when students lack desired science content knowledge.

> I do believe that a lack of science understanding can be compensated if the teacher is number one, aware of the lack of knowledge (like I know they don't know the moon) and number two, if the teacher is comfortable with that and number three, if the

> students perceive that the teacher is comfortable with the students taking time to figure it out with no fear of retaliation or grade lowering, etc. This is true about the science talk with the moon. However, I have been in classes (as a student) where this was not the case. It became hostile and monologic.

When focusing on the pedagogy talk, Hubbard shifted her attention from her students' science experiences to their lack of teaching experiences.

> The pedagogy talk about science talks is huge with regard to the students' lack of experience in teaching. They have so few teaching experiences that their main focus (as is and probably should be the case with young teachers) is on management. As a result, our intents are not aligned and some monologue ensues as I attempt to have them go deeper. Eventually I think I gave in because we were running out of time for this part of my lesson and I'd hoped they'd wrap it up. But if you notice there is some "barreling" on their parts as they try to run me down (much as I try to run them down at times when I want my way) and they talk until I give in!

In Hubbard's view, the students were unable to get to the important part of the discussion, at least from the teacher's perspective, of the uses and purposes of science talks as a teaching strategy. The students became entrenched in their need for understanding how to deal with classroom management and discipline issues during whole class discussions. The students were so adamant about this need that Hubbard was verbally "run down," and her efforts to shift the direction of the discussion resulted in higher monologic character than planned.

Differences in the nature of the two talks are grounded in two major themes, content knowledge and student experiences. While the students lacked knowledge about both science and pedagogy, Hubbard felt this issue only restricted the pedagogy talk. She indicated that the students' lack of pedagogical experiences in addition to their lack of pedagogical knowledge lead to the more monologic character of the pedagogy talk. In contrast, the students have more experiences as science learners than pedagogy learners and thus were able to adapt during the science talk despite their deficit in content knowledge. Another possible explanation might be that the students could not redirect the discussion to "how do you" issues during the science talk because they were participating in an inquiry study about the moon, and thus were personally experiencing those issues. A third issue, time constraints, is mentioned in Hubbard's explanations regarding the pedagogy talk. This issue seems linked to the differing intents, the teacher's intent to discuss a pedagogical tool and the students' intent to discuss classroom management.

Class Consensus Discussions

The discussions we selected for this discourse focal point had the purpose of reaching class consensus on a specific topic after the students had talked about it in small groups. In the conversation we labeled as pedagogy, the class discussed the use of portfolios in a science classroom. In the other conversation, labeled science, the class discussed their understanding of earth-moon processes.

Although punctuated by frequent instructor comments, this pedagogy talk appeared to be high in dialogic character. Most of the questions were open-ended and Hubbard's contributions were more as a participant leader rather than teacher (Newman, et al., 2001a). At the beginning of the discussion, Hubbard expressed her two instructional goals for her students: (a) communicating what they learned about a student, Ray, by looking at his portfolio; and (b) determining what other information and artifacts they would like in the portfolio to better understand Ray as a student. After completing the first goal, the discussion strayed from Hubbard's intended goal of determining other artifacts the students would like to have in the portfolio, and the discourse converted from highly dialogic to highly monologic. Hubbard explained the transition as a function of her lack of comfort with teaching pedagogy, especially portfolios (Newman et al., 2001b).

In contrast to the portfolio discussion, the science consensus discussion about the moon was almost entirely QAE (Newman et al., 2001b). Throughout this talk, Hubbard constantly asked questions that had only one answer and tried to get the students to figure out what she already knew and to say the answer aloud (Newman, et al., 2001a). After having students model three main points and "feeling they were comfortable with them," Hubbard gave the students a problem to solve in small groups. After this small group discussion, an open-ended, student-controlled whole class discussion ensued about what the students thought and why they believed their constructs.

Both of these class discussions contain transitions between highly monologic and highly dialogic character. Hubbard tried to explain the discourse extremes and transitions.

> With talking about Ray's portfolio, it begins dialogic when we are on comfortable ground. They had experience looking at work and evaluating what the student knows. However, when asked to apply this or step further, they were unable to do so and wanted to go back to what Ray knew. I fought this with questions, which led us to a more monologic discussion because they just didn't know how to meet my expectations. They knew how to evaluate from other experiences, but they could not determine what else was needed for complete understanding of the student.

In an interview with Newman, Hubbard discussed her own experiences and content understanding regarding portfolios.

> The portfolio discussion is a good example of how my content knowledge influences discussions. I'll agree with you now that I do know more than I think I do, however, a lot of this dialogue came as a result of my own comfort with my self-perceived lack of knowledge. I felt like it was okay to not know about portfolios because everyone has a different view. It's kind of like saying you have to understand favorite colors. Well, duh, you can't, everyone

> is different. I can list several choices, and I'm okay if people disagree.

In post-class interviews, Hubbard expressed that she did not understand the portfolio process. During the analysis process, however, Newman and Hubbard discussed her extensive experiences with portfolios and debated whether her comfort was with her lack of knowledge or with her understanding of the inherent flexibility of portfolios. Her current view seems to support the latter.

For the science consensus discussion on the moon, Hubbard described the purpose of the discussion as "providing the students with the tools I felt they needed to modify their constructs about the moon; the discussion was not aimed at their social constructions of knowledge." She controlled the talk and the activities in which the students participated in "an attempt to provide them with the science content, facts they needed to progress." Hubbard explained the change in the class discussion dynamic as, "I had achieved my goal, they now had the science to progress and could have a generative discussion."

The consensus discussions explanations are framed around content knowledge and student experiences. The pedagogy talk began very dialogically because both Hubbard and her students were comfortable with the content. Hubbard, regardless of which perspective is addressed, she knows little or a lot about portfolios, was comfortable with her level of understanding. The students are accustomed to assessing student work and were comfortable discussing this pedagogical content. The talk shifted to more monologic character when the students had to apply their roles as teachers and their content knowledge to a new scenario, determining other necessary components for the portfolio. They had little or no experiences doing so, and thus the discussion changed character. The monologic quality of the science talk resulted from Hubbard's determination that the students could not move on without being provided more science content with which to work. Once she felt they had this content knowledge she allowed for dialogic discourse.

Demonstrations

The demonstration examples chosen for analysis included a pedagogical technique, interviewing students, and a science demonstration about atmospheric pressure. As would be expected in a demonstration, these two episodes both emphasized the teacher's voice over that of the students. Accordingly, the demonstrations themselves were highly monologic in nature (Newman et al., 2001a) and readily addressed Hubbard's goal of demonstrating how teachers could use each type of demonstration. After the pedagogy demonstration, Hubbard did not provide an opportunity for the students to discuss what they witnessed nor did she even ask them to evaluate what had occurred. She moved on to the next topic without any assessment of their experience. In contrast, immediately after the science demonstration, she gave the students the chance to talk in their small groups about what happened and why. Moreover, after the small group discussion, the students shared their ideas as a class. However, examination of the discourse following both demonstrations indicates that the students' intents did not align with the instructor's (Newman et al. 2001b).

Following the interview demonstration, Hubbard intended for the class to evaluate the interview of the student using articles they had read. However, the students became more concerned with how they would conduct their interviews of elementary students later in the week. Instead of looking at the articles and evaluating the interview process, the students reread their assignment and tried to understand the criteria for the project.

The science demonstration initially included no student voices. During the introduction Hubbard lit a candle in a pan of water and covered it with a glass. While science demonstrations are often QAE, Hubbard did not even seek the students' predictions prior to or ideas during the demonstration. While we readily identified the science demonstration, like the pedagogy demonstration, as monologic (Newman, et al., 2001a), it became difficult to classify the science demonstration as science or pedagogy after learning the instructor's intent. Hubbard identified her goals for the science demonstration as pedagogical, wanting her students to examine how the demonstration could be used for assessment. Even though she stated her goal, the students did not acknowledge her pedagogical intent in their discussions and instead focused on trying to make sense of the science (Newman et al., 2001b).

When trying to explain the discourse during the interview demonstration, Hubbard focused on the competition between her educational intent and the students' sense of urgency about an upcoming assignment.

> The interview demo was so interesting because I saw myself get sucked into their intent, but I was fighting all the way on the inside. This made it so that there really wasn't dialogue, and we went to their intent, finding out directions and how it would be graded. My intention of discussing the purpose and pedagogy never even came to light on the video…in fact, everyone else in the world just has to trust that was my intent based on my word because there is NO evidence of that! (Except my frustration!). I know they didn't learn as much as they could have that day. Time constraints became the issue during this class. I wanted to provide the students with the last segment of class time to work on their interview protocols since some of the students would be conducting interviews the next day. I couldn't get them to examine the interview, so I knew I just had to make my point and move on.

As with the pedagogy talk, the monologic nature of the pedagogy demonstration is rooted in the time constraints that arose from differing intents.

The issue of differing intents also guided the science demonstration discourse, but with inversed results. Hubbard explained how her example of an alternative assessment strategy became a science talk.

> The science assessment demonstration is a great example of how their lack of science content kills my plans. WOW! I had hoped that we could use the demo to discuss alternative assessment—I even stated this goal in response to an expressed need for this, but like I said, it really doesn't matter to them! Then away we went! They had no idea what was going on scientifically, and I was so struck by their dialogic discussion that I let go! I think this doesn't follow my "rule" of becoming monologic [when intents differ] because I didn't fight it! They were quite capable and used to dialogue at this point in the class, and I let them go with their intent. I gave in without even considering trying to take over again. And I don't regret it! What an amazing discussion...although I will say that the "old fashioned" science teacher in me did try to interrupt and at least say "I DON'T THINK SO!!!" But by that time they had me so bamboozled that I'm not sure I could have explained it to anyone either!

Hubbard used the differing intents of her and her students, grounded in the students' lack of understanding the science content, to explain the monologic nature of this demonstration. The students complete lack of understanding of the scientific principles involved in the demonstration dominated the discourse and their exposure to previous science talks led them to conduct one of their own.

When comparing the two demonstrations, Hubbard focused on the extremely different discourse that occurred out of the same educational issue, teacher and students having differing intents.

> I think it is interesting to contrast these two situations because in one I fought it and it still went their way, but was much less productive. In the other, they won and it still was a productive class. By the same token, I'm not advocating just letting it go wherever they take you every minute, but perhaps I need to consider each situation more carefully before trying to regain "control."

In this comparison, Hubbard expressed her bias towards dialogic discourse being more productive and leading to better student understanding. Further comparison of the demonstrations revealed the reoccurrence of time constraints, student content knowledge, and student experiences as issues influencing discourse. Because she had other plans for the remainder of the class, time became an issue during the pedagogy demonstration. Hubbard was unwilling to let an unplanned dialogic discourse occur and interfere with the remainder of her lesson. In contrast, she readily surrendered the classroom plans for a science based dialogic discussion. She defends this with her amazement at the students' lack of science understanding and their need for the experience. She also refers to the students' lack of experiences with alternative assessment.

Discussion

Following participant speaking patterns during discourse analysis allowed us to initially frame and distinguish the differences between science and pedagogy instruction. Knowing the function of the utterances also became necessary to understand the nature of the speaker's voice. Yet, defining which utterances were teacher voice and which were student voice required knowing more than by whom and when the statements were made. The role and intent of the teacher and students as they spoke also required examination. The complexity increased as the perspective of the researcher, observer or participant, resulted in disagreements about the data and analyses.

The instructor accounted for discourse differences in three major ways: (a) time constraints, (b) content knowledge, and (c) students' experiences. Monologic discourse occurred most often when the instructor felt pressed for time, had a "low comfort level with the material," or determined the students did not have a basis for participating in dialogic discourse. She used the first two conditions to explain monologic discourse during both science and pedagogy instruction. However, she used the rationale of student experience only to account for monologic discourse during pedagogy instruction.

Time Constraints

Inadequate time for instruction occurred when the instructor's and students' intents did not align. While discussions based around misaligned intents often started dialogically, the discourse increased in monologic character as Hubbard tried to redirect the class towards her intents, often by resorting to a recitation strategy.

> My perception of a time constraint is often framed in my desire to get the class back on an even keel. Such as when the class intents differ from my own or I feel the class needs something, some piece of knowledge, to move on. Thus, I feel this sense of urgency to do 'it' now even if there is an hour left. Cheap closure.

The issue of perception when discussing time constraints further complicates the issue. Hubbard's statement illustrates that a "perception" of a time constraint may occur when there actually is plenty of class time remaining for the content at hand.

Monologic discourse resulting from time constraints occurred more frequently for pedagogy than for science. During the science demonstration, Hubbard "didn't fight the students" desire for a science content discussion even though that was not her stated purpose for the demonstration. Yet during the pedagogy demonstration and the pedagogy talk, Hubbard "battled the students to regain control" and ended their dialogic discourse by engaging in recitation. Hubbard explained this difference with her greater comfort level with science teaching than pedagogy teaching. This issue is discussed further in the content knowledge section.

In a post-class interview, Hubbard expressed her disdain for using time as an excuse, "Time is the issue, but I am tired of that as a reason. There must be more to it than time." Identifying the differing intents of Hubbard and her students helped her come to terms with this issue. She began to understand that time constraints are often the results of other issues and not simply restricting entities in and of themselves. Initially, Hubbard felt that because dialogic discourse required more class time than monologic discourse, it was often the root of her time issues. However, perceived time constraints arose from the interconnectedness of intents, comfort levels, class time, and the characteristics of discourse. Thus, it is difficult to ascertain which causes which due to the intertwined nature of all components.

Content Knowledge

Because she has had more preparation, both formal and informal, on how to teach science dialogically, Hubbard expressed "a greater comfort level with the material when teaching science" as opposed to pedagogy. Her experience teaching science at the middle school level also added to her greater comfort with science content. Additionally, she stated that for her, pedagogy is more "tacit knowledge" than science content. She was much more aware on an explicit level of how to teach science than how to teach the teaching of science. Accordingly, she tended to teach science more dialogically than pedagogy, allowing the students to explore their ideas when they "were in [her] comfort zone."

During several lessons, Hubbard felt the pedagogy she was trying to teach was restricted by the students' lack of science content knowledge; yet, she never expressed a concern that this issue restricted teaching science. Regardless, she stated that she finds this idea that lack of science content knowledge could interfere with pedagogy distasteful.

> I was and still am uncomfortable even saying that I believe that students have to have content knowledge before they can discuss pedagogy. I felt like this was a statement that is true in some circumstances and not in others. Once again, my fear that I don't know what I am talking about arose because I feared that others would say "that's ridiculous." Not to mention that I have made similar claims to my students when they insist that they must front-load their lessons with content "introductions" so that their students will know how to carry out and interpret the investigation. To me that is ludicrous; it is simply telling the students all the answers. But now I heard myself making a similar excuse.

In a science methods course, science and pedagogy are often so intertwined, it is impossible to teach one and ignore the other. Thus, when teaching the pedagogy of science demonstrations, the science content involved can readily become the focus of the discussion. Analogously, when teaching science content, pedagogy issues such as classroom management can become the focus for the students. The balance between pedagogy and science is difficult for an instructor to set and maintain, and for researchers to determine.

Students' Experiences

Hubbard felt the students' lack of teaching experience greatly reduced her use of dialogic discourse during pedagogy instruction. Few of her students had science teaching experience and tended to bring only their experiences as students to pedagogy discussions. She felt the students' limited experience teaching restricted their abilities to participate actively in classroom discussions about pedagogy. Thus, she felt monologic discourse could be useful in the education of preservice teachers when the students lack the knowledge or experience to participate actively in dialogic discourse. Hubbard did state that she saw a slight increase in their desire and ability to participate in pedagogy discussions after the field component of the methods course.

Conclusions

The function of the discourse, generative versus authoritative, initiated by the instructor is linked to its nature, dialogic versus monologic. When the instructor wanted to convey meaning, discourse was authoritative and monologic. She often attributed this form of discourse to time constraints and/or lack of students' content knowledge with that particular topic. When she wanted students to inquire, discourse was generative and dialogic. The instructor attributed this discourse form to greater student content knowledge and more teaching experiences with the topics being taught. Another explanation for discourse differences, not identified by the instructor, might lie in the teacher's educational goals and plans.

Differing intents influenced the nature of the classroom discourse and the role that time constraints played with regard to discourse. The student's intents differed from the teacher's intents when she challenged the students to examine an issue from the perspective of a teacher. The student's inability to get beyond the student perspective precluded the teacher's goals from being achieved, regardless of her planned discourse strategy. Because the methods students never observe the instructor teaching children and the instructor can only observe the students teaching children for very brief periods of time, methods instructors are very limited in their ability to help their students in the role of teacher. Thus, our students will struggle to be effective science teachers until they gain experience teaching science and are able and willing to reflect from the teacher perspective.

Implications and Relevance to Science Teacher Education

Understanding what happens in a science methods course is an important step in creating a successful teacher education program. We have established that differences occur in discourse in our science methods course based on the content being taught. The instructor was less likely to teach dialogically during pedagogy segments than during the science segments of the lessons. Moreover, perceived time constraints, student content knowledge, and student teaching experiences also determined discourse form. Current learning theory, including distributed cognition, informs educators of the importance of dialogic discourse in the classroom (Brown, Collins, and Duguid, 1991; Salomon, 1996), as do national science education documents (AAAS, 1993; NRC, 1996, 2000). Moreover, educational goals, learning environments, and teacher roles have changed dramatically in recent years and have influenced educators' views of effective classroom discourse (Bransford, Brown, & Cocking, 1999). Understanding why discourse differences occur in science methods classrooms is important if preservice teacher educators are to improve their programs and promote inquiry in science classes. In addition to establishing why the differences occur, our research can lead to other important research projects such as determining if the students are aware of the differences in discourse and if the differences affect student achievement.

References

Abell, S. K., & Bryan, L. A. (1997). Reconceptualizing the elementary science methods course using a reflection orientation. *Journal of Science Teacher Education, 8*(3), 153-166.

Abell, S. K., Bryan, L. A., & Anderson, M. A. (1998). Investigating preservice elementary science teacher reflective thinking using integrated media case-based instruction in elementary science teacher preparation. *Science Education, 82*(4), 491-510.

Abell, S. K., Christensen, P., Enfield, M., Roberts, D., Smith, D., & van Zee, E. (2001, March). *Research into practice/practice into research: A symposium for teacher researchers.* National Association for Research in Science Teaching, St. Louis, MO.

Abell, S. K., Martini, M., & George, M. D. (2001) "That's what scientists have to do": Preservice elementary teachers' conceptions of the nature of science during a moon investigation. *International Journal of Science Education, 23*(11), 1095-1109.

Abell, S. K., & Smith, D. C. (1994). What is science? Preservice elementary teachers' conceptions of the nature of science. *International Journal of Science Education, 16*(4), 475-487.

Adler, P. A., & Adler, P. (1998). Observational techniques. In N. K. Denzin & Y. S. Lincoln (Eds.), *Collecting and interpreting qualitative materials* (pp. 79-109). Thousand Oaks, CA: Sage.

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy: Project 2061.* New York: Oxford University Press.

Bakhtin, M. M. (1981). *The dialogic imagination.* Austin, TX: University of Texas Press.

Bloom, J. W. (2000). *Creating a classroom community of young scientists: A desktop companion.* Toronto, ON, Canada: Irwin.

Bloom, J. W. (2000, April). *Discourse, cognition, and chaotic systems: An examination of students' argument about density.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.

Brookfield, S. D., & Preskill, S. (1999). *Discussion as a way of teaching.* San Francisco, CA: Jossey-Bass.

Brown, J. S., Collins, A., Duguid, P. (1991). Situated cognition and the culture of learning. In M. Yazdani & R. W. Lawler (Eds.), *Artificial intelligence and education.* Norwood, NJ: Ablex Publishing Corporation.

Bryan, L. A., & Abell, S. K. (1999). The development of professional knowledge in learning to teach elementary science. *Journal of Research in Science Teaching, 36*(2), 121-139.

Carlsen, W. S. (1992). Closing down the conversation: Discouraging student talk on unfamiliar science content. *Journal of Classroom Interaction, 27*(2), 15-21.

Carlsen, W. S. (1993). Teacher knowledge and discourse control: Quantitative evidence from novice biology teachers' classrooms. *Journal of Research in Science Teaching, 30*(5), 471-481.

Carlsen, W. (1997). Modeling scientific argument and maintaining law and order. *Journal of Classroom Interaction, 32*(2), 14-23.

Charmaz, K. (2000). Grounded theory: Objectivist and constructivist methods. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed., pp. 509-535). Thousand Oaks, CA: Sage.

Crawford, T., Chen, C., & Kelly, G. (1997). Creating authentic opportunities for presenting science: The influence of audience on student talk. *Journal of Classroom Interaction, 32*(2), 1-13.

Cunningham, C. M. (1997). Who knows? The influences of teachers' sociological understanding of science (SUS) on knowledge, authority, and control in the classroom. *Journal of Classroom Interaction, 32*(2), 24-34.

Denzin, N. K., & Lincoln, Y. S. (2000). Strategies of inquiry. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed., pp. 367-378). Thousand Oaks, CA: Sage.

Dillon, J. T. (1983). *Teaching and the art of questioning.* Bloomington, IN: Phi Delta Kappa Educational Foundation.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*(3), 287-312.

Gadamer, H. G. (1994). *Truth and method* (2nd ed.). New York: Continuum.

Gallas, K. (1995). *Talking their way into science.* New York: Teachers College Press.

Gee, J. P. (1997, March). *Science talk: Language and knowledge in classroom discussion.* Paper presented at the National Association for Research in Science Teaching, Chicago, IL.

Glaser, B. G. (1992). *Basics of grounded theory analysis: Emergence vs. forcing.* Mill Valley, CA: Sociology Press.

Jiménez-Aleixandre, M. P., Bugallo Rodríguez, A., & Duschl, R. A. (2000). "Doing the lesson" or "doing science": Argument in high school genetics. *Science Education, 84*(6), 757-792.

Kelly, G. J., & Chen. C. (1999). The sound of music: Constructing science as sociocultural practices through oral and written discourse. *Journal of Research in Science Teaching, 36*(8), 883-915.

Koballa, T. R., Jr. (1984). Changing attitudes toward energy conservation: The effect of development advancement on the salience of one-sided and two-sided persuasive communications. *Journal of Research in Science Teaching, 21*(6), 659-668.

Koballa, T. R., Jr. (1985). The effect of cognitive responses on the attitudes of preservice elementary teachers towards energy. *Journal of Research in Science Teaching, 22*(6), 555-564.

Lemke, J. (1990). *Talking science: Language, learning, and values.* Norwood, NJ: Ablex Publishing Corporation.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry.* Newbury Park, CA: Sage.

Lincoln, Y. S., & Guba, E. G. (2000). Paradigmatic controversies, contradictions, and emerging confluences. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed., pp. 163-188). Thousand Oaks, CA: Sage.

Lotman, Y. M. (1988). Text within a text. *Soviet Psychology, 26*(3), 32-51.

Moje, E. (1995). Talking about science: An interpretation of the effects of teacher talk in a high school classroom. *Journal of Research in Science Teaching, 32*(4), 349-371.

Moje, E. (1997). Exploring discourse, subjectivity, and knowledge in chemistry class. *Journal of Classroom Interaction, 32*(2), 35-44.

Mortimer, E. F. (1998). Multivoicedness and univocality in classroom discourse: An example from theory of matter. *International Journal of Science Education, 20*(1), 67-82.

Mortimer, E. F., & Machado, A. H. (2000). Anomalies and conflicts in classroom discourse. *Science Education 84*(4), 429-444.

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

National Research Council (2000). *Inquiry and the national science education standards.* Washington, DC: National Academy Press.

Newman, Jr., W. J., Hubbard, P. D., & Abell, S. A. (2001a, January). *Examining Discourse in Elementary Science Methods: Differences Between Science Content and Pedagogy.* Paper presented at the annual meeting of the Association for the Education of Teachers of Science, Costa Mesa, CA.

Newman, Jr., W. J., Hubbard, P. D., & Abell, S. A. (2001b, March). *A comparison of science content and pedagogy discourse in elementary science methods.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, St. Louis, MO.

Newton, P., Driver, R., & Osborne, J. (1999). The place of argumentation in the pedagogy of school science. *International Journal of Science Education, 21*(5), 553-576.

Nystrand, M. (1997). Dialogic instruction: When recitation becomes conversation. In M. Nystrand, A. Gamoran, R. Kachur, & C. Prendergast, *Opening dialogue: Understanding the dynamics of language and learning in the English classroom* (pp. 1-29). New York: Teachers College Press.

Patton, M. Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Newbury Park, CA: Sage.

Salomon, G. (Ed.). (1996). *Distributed cognitions: Psychological and educational considerations.* Cambridge: Cambridge University Press.

Schwandt, T. A. (2000). Three epistemological stances for qualitative inquiry: Interpretivism, hermeneutics, and social constructionism. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed., pp. 189-214). Thousand Oaks, CA: Sage.

Scott, P. (1999, March). *An analysis of science classroom talk in terms of the authoritative and dialogic nature of the discourse.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, Boston, MA.

Shepardson, D. P. (1996). Social interactions and the mediation of science learning in two small groups of first-graders. *Journal of Research in Science Teaching, 33*(2), 159-178.

Sorsby, B. (1999, October). *The child's world and the scientist's world: Can argumentation help to bridge the culture gap?* Paper presented at the Fifth International History, Philosophy, and Science Teaching Conference., Como, Italy.

Tobin, K. (1984). Effects of extended wait time on discourse characteristics and achievement in middle school grades. *Journal of Research in Science Teaching, 21*(8), 779-791.

Todorov, T. (1984). *Mikhail Bakhtin: The dialogical principle* (W. Godzich, Trans.). Minneapolis, MN: University of Minnesota Press. (Original work published 1981)

van Zee, E. H. (2000). Analysis of a student-generated inquiry discussion. *International Journal of Science Education, 22*(2), 115-142.

van Zee, E. H., Iwasyk, M., Kurose, A., Simpson, D., & Wild, J. (2001). Student and teacher questioning during conversations about science. *Journal of Research in Science Teaching, 38*(2), 159-190.

van Zee, E., & Minstrell, J. (1997). Using questioning to guide student thinking. *Journal of the Learning Sciences, 6*(2), 227-269.

Varelas, M. (1996). Between theory and data in a seventh-grade science class. *Journal of Research in Science Teaching, 33*(3), 229-263.

Varelas, M., & Pineda, E. (1999). Intermingling and bumpiness: Exploring meaning making in the discourse of a science classroom. *Research in Science Education, 29*(1), 25-49.

Wertsch, J. V., & Toma C. (1995). Discourse and learning in the classroom: A sociocultural approach. In L. P. Steffe and J. Gale (Eds.), *Constructivism in education* (pp. 159-174). Hillsdale, NJ: Earlbaum.

SE066527

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

ERIC®

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Proceedings of the 2002 Annual International Conference of the Association for the Education of Teachers in Science

Editors: Peter A. Rubba, James A. Rye, Warren J. DiBiase, & Barbara A. Crawford

Organization: Association for the Education of Teachers in Science

Publication Date: June 2002

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY ____ Sample ____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY ____ Sample ____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY ____ Sample ____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1	Level 2A	Level 2B
[X]	[ ]	[ ]
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, → please

Signature: [signature]

Printed Name/Position/Title: Peter A. Rubba, DAP, World Campus

Organization/Address: Dr. Jon Pederson, AETS Exec. Secretary
College of Education, University of Oklahoma
820 Van Velet Oval ECH114
Norman, OK 73019

Telephone: 814-863-3248

FAX: 814-865-3290

E-Mail Address: par4@psu.edu

Date: 6/24/02

(over)