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Inquiry in Interaction: How Local Adaptations of Curricula Shape Classroom Communities

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Abstract: In this study, we seek a better understanding of how individuals and their daily interactions shape and reshape social structures that constitute a classroom community. Moreover, we provide insight into how discourse and classroom interactions shape the nature of a learning community, as well as which aspects of the classroom culture may be consequential for learning. The participants in this study include two teachers who are implementing a new environmental science program, Global Learning through Observation to Benefit the Environment (GLOBE), and interacting with 54 children in an urban middle school. Both qualitative and quantitative data are analyzed and presented. To gain a better understanding of the inquiry teaching within classroom communities, we compare and contrast the discourse and interactions of the two teachers during three parallel environmental science lessons. The focus of our analysis includes (1) how the community identifies the object or goal of its activity; and (2) how the rights, rules, and roles for members are established and inhabited in interaction. Quantitative analyses of student pre- and posttests suggest greater learning for students in one classroom over the other, providing support for the influence of the classroom community and interactional choices of the teacher on student learning. Implications of the findings from this study are discussed in the context of curricular design, professional development, and educational reform. © 2004 Wiley Periodicals, Inc. J Res Sci Teach 41: 905–935, 2004

During the past two decades, the education community has increasingly paid attention to the social context of learning. In particular, many scholars have begun to investigate how an individual's learning and development are tied to her social participation and interaction (Greeno et al., 1998; Hall & Rubin, 1998; Lemke, 1990; Sfard & Keiran, 2001). Although we have made

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great strides in understanding how social forces shape an individual's cognition and development, we still have much to discover about how individuals and their interactions with others shape and continuously reshape those very social forces (Engestrom, 1999).

In this article, we document the intellectual environment in which student learning takes place. In particular, we describe classroom interactions by specifying the ways teachers use their classroom discourse to form, maintain, and change the community of their classroom. Two analyses of discursive practices are presented that address different but interrelated aspects of how classroom cultures are established. First, we examine what the classroom communities are oriented toward. What are the objectives of the classroom activities, and how do these goals that tie the community together get established? Second, we analyze how the teachers typically position themselves within the classroom community. Do they, more often than not, align themselves with the students as a co-inquirer, or do they repeatedly take up a position of authority apart from the ongoing work? As we address this second issue, we will explicate the participation structures that emerge within classrooms to establish classroom roles and to achieve the community's goals.

Our discussion of classroom communities is grounded by a comparison of two teachers as they implement an inquiry-based science curriculum called Global Learning and Observation to Benefit the Environment (GLOBE) (2002). Particular attention will be given to the ways in which these two teachers use discourse within the classroom to create two very different communities. While it is widely recognized that that participation structures are of vital importance to the character and quality of learning, we do not understand enough about how these interactions patterns get established as the classroom norms. One of our goals is to illuminate some key dimensions in the process of the formation and maintenance of classroom norms. Further, we hope to begin to draw some crucial connections between the organization of classroom talk and the opportunities to learn. Using pretest and posttest analyses, we investigate the learning outcomes of students in the two classrooms and consider the ways in which patterns in two contrasting classroom communities may contribute to differences in outcomes.

Social Participation, Communities, and Learning

Communities of Practice

The view of learning as participation is embraced in Lave and Wenger's model of situated learning (Lave, 1996; Lave & Wenger, 1991; Wenger, 1998), which links learning to participation in communities of practice. The communities of practice (COP) perspective suggests a shift away from an exclusively individualistic, psychological view on learning toward a perspective of learning involving participation in social interactions within the context of a community. Furthermore, there is a shift away from an exclusive focus on teaching toward a view that closely reexamines the learning process from this new perspective.

These shifts are relevant to our analyses of classrooms. First, in our analyses of the classrooms we closely examine the social context, assuming that the particulars of the social context make a difference to what and how well students learn science. Second, although we focus much of our attention on the teacher's contributions to the whole class discussions, we do not analyze the teacher's talk in terms of the quality of its scientific content. Instead, we explore how the teacher's interactions create or hinder opportunities for student learning and the epistemic nature of what might be learned (Lemke, 1990).

It has been argued that the notion of community and in particular the concept of communities of practice has been used too loosely in the educational research literature (Lineham & McCarthy, 2001; Riel & Polin, 2004). The appeal of the framework, as an alternative to individual cognitive

of teaching and learning, has been applied to a wide variety of social groups that share little in common beyond the fact that they all share an explicit goal of socializing the members. Certainly the first half of the COP concept, community, is a broad and often ambiguous term that can appropriately be applied to a range of social groups from ideal communities, such as nations (Wertsch, 1991) to microcommunities such as classrooms (Barab et al., 2000; Brown & Campione, 1994; Kafai & Ching, 2001; Roth & Bowen, 1995; Roth, McGinn, Woszczyna, & Boutonne, 1999; Scardamalia & Bereiter, 1994). It is when the notion of community is combined with theories of practice that the analytic construct of COP becomes a meaningful and valuable framework for analysis, and provides a set of categories and relationships that one can use to understand how a social group coheres together and is structured by shared norms, routines, and roles to accomplish a set of shared goals and joint activities.

It is, however, useful to ask whether the COP framework is an appropriate tool to understand classrooms in general and, if so, what types of classrooms (Roth et al., 1999). Riel and Polin (2004) recently suggested that most classrooms are better thought of as task-based communities as opposed to communities of practice. Riel and Polin (2004) distinguishes task-based communities in that these types of communities are organized around specific tasks and work together for a limited period of time to produce a product. She contrasts task-based communities with COPs, claiming that the latter are organized around a broader set of shared goals and a characterized by voluntary, but sustained, participation in the activity system.

While we agree that the field needs to continue to refine our understandings of learning communities and communities of practice, we argue that the COP perspective, at least for the classrooms analyzed here, is an appropriate and useful theoretical framework that allows us to examine some consequential characteristics of the organization of these two classrooms, including ways that support or hinder inquiry in the classroom. Lave and Wenger (1991) themselves cite the need for further elaborations of their construct when they stated, '' The concept of 'community of practice' is left largely as an intuitive notion, which serves a purpose here but deserves a more rigorous treatment. In particular, unequal relations of power must be included more systematically in our analysis . . . . It would be useful to better understand how these relations generate characteristically interstitial communities of practice and truncate possibilities for identities of mastery'' (p. 42).

In our application of the COP perspective to our study of two classroom communities, we draw on and attempt to elaborate two of the core concepts of the COP framework. First, we analyze the shared object of activity that motivates individuals to engage in coordinated activity together and that defines the community. Second, we examine the rules, roles, divisions of labor and unequal power relations made present and negotiated in social interaction. Further, we attempt to connect these two dimensions of the community to learning by examining how they define legitimate knowledge and legitimate participation within the community.

While it is true that in the short-term aspects of the study classrooms are organized, to varying degrees, around the type of tasks Riel and Polin (2004) used to define task-based communities, these tasks are embedded—are shaped by and shape—the communities larger motives and objectives. These classroom communities, even when engaging is short-term tasks, are still characterized by voluntary and sustained participation. Students do drop out, but most find and take up recognized positions within the classroom, whether they are the unmarked position of the ''good student'' or the marked position of the ''disruptive'' student (Davies & Hunt, 1994). Furthermore, even the smooth production of teaching as usual, which has the appearance of institutional control, the activity of the community is a joint, social production in which one's role, position, and actions are very much negotiated (Davies & Hunt, 1994; Goodwin & Goodwin, 1987; McDermott; 1993).

It is a separate question if the particular organization of the community conforms with and leads to the type of learning and activity that, as outside analysts, we value. From a particular ideology or set of values a community can be seen to be dysfunctional. This does not mean, however, that its organization is not legitimate or that analyzing it as community of practice is not appropriate. We argue that two core characteristics of a community of practice—sustained participation around a shared object and negotiated rules, roles and positions that structure joint activity—are present in the classrooms we analyzed. While the way these two characteristics are embodied in the classroom differs from the types of communities that have been used to establish the COP framework, these characteristics are still present and consequential.

For example, the generational structure of classrooms is distinctly different from other types of communities such as apprenticeship. It could be argued that, in the classroom, no old-timers are present and, as a result, classroom communities are qualitatively different from the more canonical communities of practice. However, although the generational structure is indeed different, we would argue it is still present in even age-graded classrooms. First, the teacher is a very notable old-timer in the community with a particular asymmetrical relationship to the students that allows him or her to establish norms and practices within the classroom. Second, despite this asymmetrical power, the norms, rules, roles, and practices of a community are very much negotiated and are never static. Third, classrooms are not hermetically sealed off from the other communities of schooling. Students do not enter a new classroom with no idea of what to expect—by the seventh and eighth grade, they can rightly be considered old timers within the larger practice of school. By being part of the institution of school, the particular structures of any classroom community are informed by and borrow from the structures and practices of that larger activity system. Bells, rows of desks, and recognizable activities such as recess and desk work all help the members of a new classroom enter into the negotiation with some idea of what to expect and what is expected of them.

In the cases we will describe, the culture of the classroom is opened up for renegotiation by the introduction of a new curriculum—new to both the teachers and the students. It is an opportunity for the community to redefine itself in relation to a new set of goals and for it to redefine what it means to be a member of the class. Therefore, we believe the COP framework is an appropriate starting place for our analysis. In the remainder of this section, we focus on the research literature that defines the particular aspects of the social structure and interactions that inform our basic assumption that classrooms are communities and that the particular structures of the community shape and delimit the identities for participation and mastery.

Social Interaction: The Link Between Communities and Individuals

The COP perspective is well complemented by views that explicate the ways in which individuals appropriate the practices of a community (Cobb, 1999; Rogoff, 1990; Wertsch; 1985). Joint attention and structured social interaction may link the planes of analysis examining practices of the community and the ways in which individuals understand these practices. Furthermore, Vygotsky's (1978) notion of the zone of proximal development (ZPD) is a central concept that grounds our understanding of how an individual's learning is shaped through social participation. ZPD calls attention to the ways in which an individual can perform beyond what s/he is capable of doing alone when collaborating with others who are more capable. Many studies have since documented the ways in which children's thinking changes in response to the guidance provided by others (e.g., Hall & Rubin, 1998; Hedegaard, 1992; Rogoff, 1990; Wertsch & Stone, 1999).

A key aspect of these studies is the importance of joint attention and the ways in which social interaction becomes the model for individual action. Of particular interest to our analysis of science classrooms is the ways in which engaging in activity with others, especially more capable

others, provides the novice with access to the whole task and the conceptual discourse to understand one's own activity (Wells, 1999). This is important because, as mentioned in our previous discussion of the ZPD, it allows the novice to engage in competent activity that they would not be able to successfully complete without aid. Not only is successfully engaging in meaningful activity important to create and maintain engagement and motivation, it also provides the model for what autonomous competence will look like (Wertsch & Stone, 1999). In particular, this model stresses the ways that the more capable others make the frame, goal, and practice for the activity transparent to the novice (Wells, 1999).

A focus on social interaction is also a critical aspect of the current study. The ways teachers organize activity and discourse in their classrooms has profound effects on how students come to understand science (Lemke, 1990; Roseberry, Warren, & Courant, 1992; Stodolsky, 1988; White & Frederiksen, 1998). A conceptual understanding of science involves more than just the acquisition of a stable body of scientific facts. It involves an understanding of the process of doing science and the adoption of a set of epistemological assumptions about the nature of scientific knowledge (Crawford, Kelly, & Brown, 2000; Duschl, 1990; Kelly, Chen, & Crawford, 1998). Interactions within the classroom, and particularly interactions between the teacher and the students, are one of the most important aspects of teaching and learning. For example Fairbrother, Hacking, and Cowan (1997) found that an explicit orientation toward getting the right answer in laboratory experiments led teachers to oversimplify the content and students to doctor their results. From this perspective teachers can be seen to be continually engaged in a form of language socialization, which is directed at bringing children into school-based intellectual practices that are intimately connected to how a student comes to understand the scientific content of the lesson (O'Connor and Michaels, 1996). Therefore, analyses of activity systems and discourse are critical for understanding how classrooms are constructed and then shape students' access to learning (Gutierrez, 1994; Roth et al., 1999; Sandoval & Daniszewski, 2004).

Although published lesson plans may provide teachers with directions and suggestions, teachers and students both contribute to the construction and negotiation of these lessons in ways that are not constrained or predicted by the curriculum. Teachers, in particular, are constantly making conscious and unconscious decisions that impact how a science activity unfolds. Inquiry teaching can be particularly difficult because it demands that the teacher and the students constantly negotiate and balance between the sometimes conflicting goals: (1) having the students pursue their own ideas using their own, often invented, strategies; and (2) having the teacher help the students learn the concepts and skills that the teacher and the curriculum, as more competent members of society and the discipline, want the students to learn (Hammer, 1997). The openness of these negotiations has implications for the goals and form of inquiry-based instruction (Wells, 2000). It implies that inquiry experiences can be woven into the regular fabric of classroom activity, creating the potential for teachers to transform classroom activities that they already use to teach science into activities aligned with an inquiry-oriented epistemology (Sandoval & Daniszewski, 2004; Tabak & Reiser, 1997). However, there is also the potential for teachers to transform inquiry-oriented activities into more traditional, school-like, activities (Brown, 1992).

Cobb's research in mathematics education has done much to connect social-constructivist theories, described above, directly to the particular forms of social organization within classrooms. In his work, he differentiates three levels of social organization that pertain to how students grow into their classroom culture or community. At the broadest level, he identities the classroom norms for participation. For example, a typical norm in one of his teaching experiments is for the students to explain their answers and reasoning publicly (e.g., Cobb, 1999). He goes on to note that particular disciplinary content areas have specialized discourse structures that are intimately tied to

understanding and use concepts within that domain (Cobb, 1999; cf. Kelly et al., 1998). This level of norms addresses the fact that some answers and justifications are more acceptable for a given community. For example, what counts as an adequate solution during a dinner conversation may not be an acceptable answer during math class. Because his work is within mathematics classrooms, he calls this level of social organization sociomathematical norms. At the most specific level, Cobb differentiates sociomathematical norms from the specific ways in which tools and procedures are used to achieve mathematical goals. This level of organization he calls mathematical practices. It is this level that addresses what is most commonly thought of as math, routine ways of interacting with material and conceptual tools to achieve recurring goals.

Our analyses, similar to Cobb's framework, focus on the ways in which language is used to create different classroom normative purposes and socioscientific[1] norms. We concentrate on these two levels because they characterize the classroom community at a level of description that is not closely tied to the specific science content of the lesson, and thereby provide a more general account of the communities. Further, our analysis of the normative purpose has obvious connections to the ongoing debates and empirical studies about the importance of and exact nature of authentic science activities in classrooms (Buxton, 2001; Rahm, Miller, Hartley, & Moore, 2003; Roth & Roychoudhury, 1993; Smith, Maclin, Houghton, & Hennessey, 2000). In our analyses, we will pay special attention to the role the teacher plays in establishing the community's norms during public discussions. Although we recognize the importance of small group work and private activity (cf. Enyedy, 2003), we limit most of our analysis here to public talk for two reasons. First, the talk is public and therefore accessible to all the participants in the classroom in ways that small group conversations are not. In fact, Barab Hay, Barnett, and Keating (2000) demonstrated that one function of public talk is to make local ideas accessible to all the community members and thereby promote knowledge diffusion. This makes public talk a particularly interesting place to look for the formation and maintenance of community norms. Second, the teacher has a privileged role in whole class discussions and we are interested in examining the ways that this asymmetrical position is used to establish community norms that are beneficial or detrimental to conceptual learning.

Participation Frameworks and the Structure of Classroom Talk

Of particular importance to our analyses is the notion of participation frameworks. Participation frameworks are "the rights and obligations of participants with respect to who can say what, when, and to whom (Cazden, 2001, p. 437)." Thus, they involve one person overtly controlling or attempting to control a great deal of the activity of other people in the interacting group (Phillips, 1972, in Erickson and Mohatt, 1982). People use their understandings of what type of activity they are doing and what their role is to limit what they do and say—what people do and say has direct implications for the meaning that they take away from their experience. For example, a classroom may be organized in a traditional manner where the rights, roles, and responsibilities of the students are very limited, such as in the recitation script. In this common form of classroom discourse, teachers ask questions that can be answered briefly, quickly, and without outside resources; the student responds and the teacher evaluates the response as correct or incorrect (Mehan, 1977; O'Connor & Michaels, 1996; Wells, 1993). Students and teachers are quick to recognize when they are in this language game and regulate their conversational turns accordingly. Research has shown that participation structures, such as the IRE recitation script, have direct implications for what the students understand their activity to be about and for what they understand the discipline to be about. In the case of the recitation script in science classrooms, it encourages students to adopt an epistemology of science such that knowing science is equated

with memorizing a static body of established facts that are either true or false. Erickson and Mohatt (1982) go on to point out that these participation structures also establish clear vertical peer relations.

Moore and Maton (2001) introduce the concept of epistemic devices to describe one way to conceptualize relationship between participation structures and students' emergent epistemologies. Building on Basil Bernstein's (1990) notion of a pedagogical device, Moore and Maton (2001) define an epistemic device as the means whereby groups establish and negotiate what knowledge is legitimate, how that legitimacy is determined, and who can make knowledge claims. Particular epistemic devices can emphasize power relationships within a community (as is the case for IRE) or can emphasize intrinsic aspects of the knowledge claims (such as the inclusion of empirical evidence). Thus these pedagogic devices, enacted through classroom discourse, are a major force in establishing the epistemic language games of the science classroom (Sandoval & Reiser, 2004). These epistemic games establish a pedagogic social context and set up the need for and value of different cognitive competencies and identities that ultimately influence what students learn (Morais and Neves, 2001) and what they think the practice of science is (Sandoval & Reiser, 2004). Morais and Neves (2001) detail a number of significant dimensions of pedagogic social context—from the way the teacher frames the task to the evaluation of the student's contributions. Additionally, they rigorously examine how each dimension relates to what students learn. While their findings paint a complex picture of the interactional space that teachers must navigate, much of the science education community has come to value the type of discourse environments that emphasize students producing and evaluating knowledge claims (Bell & Linn, 2000; Sandoval & Reiser, 2004; Scardamalia & Bereiter 1994).

In our analysis of the power relations and participation structures of the classroom, we will attend closely to the ways in which the teacher positions herself and the students. While asymmetrical power relations are important to consider; they are not binary. No single participant, not even the teacher, has unequivocal power. Power relations are continually negotiated and in different respects a student can be seen to be powerful and powerless at the same time (Davies, 1996; Davies & Hunt, 1994; Lineham, & McCarthy, 2001; Ritchie, 2002). The act of positioning refers to the assignment of roles to participants within the interaction that establish the relevance and meaning of the person's actions within the activity (Ritchie, 2002). A person can position him/herself or be positioned by others. Additionally, these positions, place one in roles that fit within pre-established roles, power relationships, and divisions of labor that delimit the competencies and identities that students can adopt within the classroom and what they take away from that experience.

In the remainder of this article, we adopt the perspective that classrooms are communities that establish norms for participation in order to coordinate the joint activity of the participants. First, we will outline our methods and research questions. Second, we will analyze several key dimensions in the process of the formation and maintenance of classroom norms that occur in two classrooms engaged in the same lessons. Third, we will examine the differences in learning outcomes of these two classrooms. Finally, we will discuss the implications of our findings for research, educational reform, and professional development.

Methods

Research Questions

One defining aspect of a community is the object of activity—a common orientation toward a collective purpose that drives and unifies individuals into a coherent group. Our first research

question involves examining the purpose and meaning of the classroom activities: what is the object of activity and how does that object get established? Furthermore, different members of a community often have different relationships toward the community's goals. Therefore, our second research question examines the participation frameworks of the teachers and students within these two different classrooms. What are the participation frameworks in the classroom, and how are they established and maintained through interaction? This involves examining the relationship between the teacher and students, including the rights, roles, and responsibilities of each participant. Finally, we explore the implications that different classroom organizations have for students' conceptual understanding. More specifically, how may differences in the two classroom communities influence student learning?

In the following sections, we provide the general context of our study, outlining the methods used to answer these three research questions. Then, we will describe and analyze classroom interactions and examine learning outcomes.

Setting and Context

Two teachers and 54 students in a combined elementary and middle school in an urban area of Los Angeles implemented an environmental science curriculum, GLOBE, for 3 months. GLOBE is an international K-12 curriculum funded by the National Science Foundation to promote learning environmental science as students engage in authentic science activities. GLOBE links students, teachers, and scientists in a coordinated effort to learn about the earth's environment through observation, data collection and analysis. Students collect environmental data in their local area and transmit their data via the Internet to an international database. Students then have access to data displays that are based on the combination of their data and the data collected by other schools around the world. Ideally, from these activities students learn how to conduct rigorous scientific experiments analyze data, and draw conclusions based on their findings. Finally, the GLOBE program puts students in contact with scientist mentors who are using the GLOBE data in their own scientific research and provide feedback to the students about their data and analyses.

The students in this school are predominately Latino/a (97%) with a high percentage of English Language Learners (61%). The school itself is located within an industrial area, sandwiched between a paint factory, and abrasive treatment facility, and a cemetery. Because of its location, it is not a community school—most students are bussed in from neighboring residential areas. Despite this, there appears to be a strong community of parents that take an active role within the school.

The two participating teachers were both very experienced, each having nearly 20 years of classroom experience, much of it at their present school. Both teachers spoke Spanish fluently, and in interviews spoke of being committed to the community and to building personal relationships with their students. From our interviews with the teachers, we learned that both teachers had similar pedagogical values and beliefs that could be fairly described as social-constructivist—with an emphasis on active learners, reflection through dialog, and student activism. Both teachers were also new to the GLOBE curriculum, having gone together to the same 4-day GLOBE training session. Further, after the training, both teachers expressed concerns about how well they really understood the science content of GLOBE. In response, we provided both teachers the same amount of additional support (weekly meetings before and during the unit) and in-class technical assistance with the computers and laboratory equipment.

Where the two teachers differ is in their professional identities. The two teachers' identities and the way that this shapes their teaching are explored more fully in Muir and Enyedy (2002).

However, for the present analyses some information about the teachers' beliefs, histories, and identities will help explain our findings. Per the teachers' requests, students referred to the first teacher, Ms. Cook,[2] by her surname and the other teacher, Jessica, by her first name. Ms. Cook self identified herself as a math teacher, while Jessica self identified as a science teacher. Ms. Cook's math background and pedagogy predisposed her to value and emphasize the scientific process over the content. For Ms. Cook, there are always multiple paths to answers and she does not believe there is one right way. She thinks it is important for her students "to try their ways, and for their ways to be validated, questioned also, but validated definitely." For Ms. Cook, the point or the take home message of one of the activities we analyzed is explained below:

> It's not how to measure the soil and water, or the water in the soil. What I would hope that they would walk away with from there is that there's a lot of ways to do things. That all ways are valid, and there's always a better way. And we can always learn from each other. That's basically [it], really, when you come down to it.

Jessica, on the other hand, had numerous experiences as a lay scientist volunteering to work with professional scientists on their research. From these experiences, she developed a different orientation toward science in which the emphasis was also on the process, with the understanding that there is no one right answer. However, her view of the scientific process emphasized that the students were expected to follow procedures and not to deviate from the protocol—if the protocols are not done correctly then the conclusions are not valid. In her interview Jessica explains, "But in science particularly, whether you get a certain result or another result, neither one is right. If you've done the protocol, or you've done the activity correctly, whatever result you get is the result you get. There is no right or wrong."

Before this study, the classes had been studying biology—most recently, the brain. This curriculum was not focused specifically on inquiry-based learning. GLOBE presented the possibility of a substantially different way of organizing these two classroom's science activity. As such, it also presented an opportunity to change or reorganize the community's existing norms within this new context.

The teachers' decision to implement GLOBE was part of the schoolwide effort to integrate technology into their everyday practice. This focus on technology was sparked by a donation of more than 80 computers by a major computer corporation. A month before implementing GLOBE, the teachers attended a 4-day training session. Both classes engaged with GLOBE activities for 45–90 min per day during the last 3 months of their school year. Beginning two months prior to and lasting throughout the implementation, the teachers and members of the research team met once a week for two hours to plan the activities, practice the protocols, and reflect on the progress and difficulties the teachers and students were encountering.

The teachers decided to focus on atmosphere and soil protocols because of limited access to water and the lack of land cover. For the atmosphere unit, students completed protocols to monitor the maximum and minimum temperature, cloud cover, humidity, and ozone levels. For their investigation of soil, students completed soil characterization, soil moisture, and soil temperature protocols.

Classroom Observations and Videotape Analysis

We explore the objectives and participation structures of the classrooms through a detailed analysis of video taped lessons. For twelve weeks, four researchers videotaped in two science classes videotaped 2–5 times per week. Most days, two researchers videotaped to get different

foci. As participant observers, the researchers had minimal interactions with the teachers and students. The interactions were typically initiated by teachers and students, reflecting their view of the link between the curriculum and researchers. Videotape was shot continuously with the camera moving as little as possible during whole class discussions in an effort to view interactions throughout the room as they unfolded. During small group work, one group was typically followed with each camera.

Our video analysis combines methods described by Erickson and Schultz (1997) with conversation analysis—in particular the close interactional analysis of the dynamic context of talk and activity laid out by Goodwin and Heritage (1990). Through the examination of videotapes and then transcripts, we examine how different participant frameworks (Goffman, 1981; Goodwin, 1990)—established through discourse—set up particular roles, rights and responsibilities within the classroom.

To complete detailed analyses and create the cleanest possible comparison between the two teachers, we chose to only examine parallel lessons—lessons that on paper, at least, were the same. By limiting our focus to parallel inquiry activities, we seek to problemitize the notion of the ''same task'' when they are found in different classroom communities. In doing so, we draw on the method for studying cognitive tasks laid out by Cole (1996), in which the ''same task'' is made to happen in different settings. Through analyses of these settings, we examine exactly who is making these tasks happen and if these are even, indeed, the same tasks at all. Further, we restricted our analyses to inquiry activities, excluding all the days of the curriculum that were primarily spent collecting environmental data and inputting the data into the computer. Through this process, we chose three lessons (six videotapes) to use in our analyses. During these lessons, students investigate soil and water temperature, humidity, and soil nutrition.

These six tapes were viewed, content logged, and eventually transcribed. The content logs were used as an index of all the major occasions on the tape, and to identify episodes for closer analysis and transcription. After selecting the lessons, we examined the interactions within one of the four lessons to produce an initial coding scheme that elucidated the structure of the community in this particular activity (Charmaz, 1983; Erickson, 1992; Glaser & Strauss, 1967; Hall, 2001). After using these cases to identify issues of analytic interest, we returned to the rest of the parallel lessons to test our conjectures against this larger data corpus (Erickson & Shultz, 1997).

Again, our focus is on (1) how the community identifies the object or goal of its activity, and (2) how the rights, rules, and roles for members are established. Initially, we describe the ways the teachers established a context for each of the activities and the ways that the objective of the activity was (or was not) made explicit in interaction. Second, we examine transcript segments to identify the ways the discourse patterns teachers use to establish rules and roles within their classroom communities. This is done with an eye toward analytically reconstructing the ''lesson framework'' or organization and discourse strategies related to the classroom community.

In contrasting the two classroom communities, it will become apparent that one teacher, Ms. Cook, is more aligned with the pedagogical values and practices that we as researchers brought to bear in analyzing the data. It is important to remember that our analyses and findings stem from a sociocultural theoretical framework that values making learning personally and socially relevant, and that views the learning process as fundamentally social. Our analytic constructs and even our assessments of student learning reflect these theoretical orientations and assumptions. For example, we devoted an entire section of the assessment to open-ended inquiry skills and weighted these questions on an equal basis with our assessments of their science content knowledge. Thus, any positive and negative evaluations of the teaching practices of these two teachers should be recognized as coming from a theory-laden, subjective position.

It is not our intent, however, to position one teacher as better than the other. In our opinion both teachers are making rational and sensible choices based on their beliefs, values, understandings of the science content and curriculum, and the particular, daily circumstances of their classrooms. However, we do want to follow the ramifications of these choices in terms of how they shape the classroom community and the ways that they affect student learning.

The trustworthiness and reliability of the methods used in this article come from two sources. First, we examine patterns of interaction that occur throughout the implementation of the curriculum with a specific focus on three days. In other words, these interaction patterns are not limited to a single case or context. Initial conjectures were tested against these multiple data sources for both confirming and contradictory interpretations. Second, other researchers reviewed the interpretations of the cases in informal and formal data analysis sessions. These sessions produced additional evidence for an interpretation, as well as alternative interpretations, which were then tested against the data.

Environmental Science Test Analyses

After our qualitative examination and comparison of the two classroom communities, we present the learning outcomes for students in the two classes ($n = 54$ students). Prior to the implementation of the GLOBE curriculum, the students were given pretests that assessed their scientific understanding of the domain and their understanding of the tools and procedures of inquiry (e.g., graphing, reading maps, measurement error). In addition to examining descriptive statistics, an analysis of variance was computed to compare the means test scores of the two classrooms.

Results

To minimize the need to describe several different inquiry contexts, the examples presented in this article all come from a single lesson that was implemented by both teachers. For this lesson the GLOBE teacher's guide states the purpose of the activity is to measure soil bulk density, soil water content, soil pH, and to determine soil fertility (i.e., by measuring the amounts of nitrate, nitrogen, phosphorus, and potassium in the soil). The soil the students are analyzing has been taken from different areas, including the yards of some of their homes. To accomplish these goals the students submit the soil to a series of tests using pH paper, various solutions, and color charts. Prior to performing these tests, all the water was removed from the soil by placing the soil in a kiln the day before.

The segments described below illustrate our conjectures about the nature and differences between these two classroom communities engaging in the ''same'' activity. Though we use only examples from one lesson (the soil kits) in these results, as we will demonstrate within the discussion section, these are typical of interactions found within other lessons as well.

Establishing the Object of the Community's Activity

To investigate the object of each community's activity, we document what teachers and students do during the lesson. Furthermore, in order to determine how classroom goals are established, we examine how the lesson was framed, including the organization of tasks and how the tasks are connected. Then in the following section, we will examine the roles of various members of the classroom community.

Ms. Cook: Organizing Tasks within a Web of Activities. Ms. Cook frames the soil kit lesson within the context of other related science lessons. In fact, Ms. Cook begins the science class with a reference to the previous day when they had determined a method for removing the water from the soil and had carried out the procedure. Ms. Cook links activities by pulling out part of the task that was done previously, saying, ''We did it yesterday at this time, right?''

By relating the activity to yesterday's lesson, Ms. Cook demonstrates that today's lesson is a natural extension of what they discovered yesterday and what they still do not know. This has implications for what the students come to understand as science. Since their own activities are framed as continuous and interconnected, and since their understanding of the content is constructed from their own actions, students are less likely to see the science content as isolated and compartmentalized. By framing the community's activity around a question stemming from the students' prior activity, Ms. Cook establishes an object that orients the community toward genuine inquiry and creates the conditions for conceptual learning.

At the beginning of the activity, Ms. Cook also clearly states one of the teaching objectives of the lesson: ''our idea is to see how much moisture is in the soil.'' Not only is the objective explicit, but the object is a genuine question that can be answered through the students' investigations. Moreover, Ms. Cook tells students to determine the amount of moisture in the soil on their own and then in five minutes, she will give them the ''real formula.'' Ms. Cook asks students to use whichever strategy they used during a previous activity, the sponge experiment, before she will give them the formula stated in the GLOBE protocol: ''As a matter of fact in probably about five minutes, I will give you . . . I'll give you a formula. But I want you to try to figure out, see who can come closest to that real formula that they have on . . . on moi . . . finding the soil . . . the moisture in the soil, okay.''

Students work in small groups, transferring their own procedure for measuring the amount of moisture in the sponge to measuring the moisture in the soil. These invented procedures reflect the students' intuitive models of the soil, water, and the process of evaporation. Then, Ms. Cook engages the whole class in a discussion and critique of their different solutions. The genuine inquiry actually begins here, because now the students begin to realize that the situation is problematic. By discussing and debating the various solutions, they start to see the strengths and weaknesses of the ways they were approaching the problem. For example, some of the students forgot to take into account the weight of the container in their procedure.

After members from the small groups share their answers, Ms. Cook produces the official procedure for measuring the water that is trapped in the soil:

> Now it makes logical sense to do what a lot of you did, 'cause a lot of you came up and explained your methods to me. Thank you for doing that. I appreciate it. It makes sense to say, ''okay, I measured the wet and then, I measured the dry and I'm just gonna subtract the two.'' The difference, subtracting, of course, the can, the weight of the can, it's gonna give you how much water was in it . . . . In the protocol, they want us to use this formula because they want everybody that's doing this to do it in a certain way. So you take your weight of your wet and you subtract the dry weight. And then you divide it by the dry weight ( ) subtracting the weight of the can . . . and, then you times by 100, and what do you think we're gonna get? . . . . We're gonna get the amount of water.

Notice that Ms. Cook refers to logic and appropriateness of the methods that students invented. Then she presents what is listed in the official protocol. In juxtaposing the students' methods, which she has cleaned up to have the same basic structure as the official method (which we have underlined), she is helping to establish the continuity of the two methods.

After the formula is discussed (about midway through the period), Ms. Cook introduces the soil kits and students work with the kits in small groups. Importantly, because of the way Ms. Cook frames and establishes the object of activity, the soil kits and protocol have become a tool for answering their question, and not an end in and of itself. By beginning with a genuine question, she produces a cycle of activity that reinforces the continuity of their own activity and the interconnections between the knowledge they construct. This forms a basis for an understanding of science where ideas are not isolated, nor are misconceptions merely replaced with scientific ones, but where students transform their intuitive understandings through active and critical thought and experimentation.

Jessica: Organizing Tasks in Isolation. Jessica organizes the soil kit lesson in a different manner. In fact, the organization or frame of the lesson is only implicitly available. There is no clear introduction to the activity at all, and there is no reference to the class' prior activities or larger questions. Instead, Jessica begins the class by handing out the soil kits and having students work with their small groups during the entire period to complete the kits. No introduction is given and instructions are interspersed during the period.

In addition, Jessica does not state a teaching objective during the lesson. However one can infer the objective from the way the lesson began—to complete the task by the end of the class period. In contrast with Ms. Cook's class the object for this is a discrete activity with no obvious connection to what they did yesterday, and with no purpose other than because it was assigned. Establishing the normative purpose for the community in these terms has implications for what the students learn, particularly about epistemology of science.

The lack of an authentic question is combined with an emphasis on following directions. During small group work, Jessica continuously circulates among the students stressing that they need to finish the laboratory by checking student progress but not checking the meaning the students were constructing. Consistent with her own beliefs about science and the importance of performing the experiment correctly so that the results are reliable, Jessica stresses the importance of reading and following directions through her directives. Directives are speech actions designed to get another to do something (Goodwin, 1990), i.e., finish the kits.

The following sequence is typical (based on the percentages shown in Table 1 and our field notes) of the interactions between Jessica and her students during the soil kit activity (directives or references to directions are underlined):

Jessica: The instructions are here.
Girl 1: We did that already.
Girl 2: The color is—No, I didn't read it.
Girl 1: We don't know yet.

Table 1
Frequency of exclusive and inclusive pronouns used during three analogous lessons

	Exclusive Pronouns		Inclusive Pronouns		Total Pronouns	
	N	%	*N*	%	*N*	%
Ms. Cook	675	80.3	166	19.7	841	100
Jessica	945	88.3	145	13.6	1070	100

Jessica: No, you, no. You're very—do it the way it tells you. Read (.) read it. And play with the color, the way it tells you to do it. It has specific directions. You need to follow every word like lightening will strike you dead. Okay.
Girl 1: Okay.
Girl 2: Duh . . . ahh (.) ahh.
Girl 1: She gets in my face . . . . Hold the tube.
Jessica: Okay, do that. Do what that says. Hold the tube, do it. Over . . . hold it over what it says.
Girl 1: Over. It turned brown.
Jessica: Yes.
Girl 1: It turned brown (.) turned brown?
Jessica: No you still didn't do it. Now honey (.) honey(.) that's not what it says and it isn't even in the picture like that. Hold the tube over the black boxes. That's what it says. Here you go.

The community in Jessica's classroom is organized around an objective that has more to do with school than with authentic science. Instead of using the soil kits as a tool to answer an authentic question, the task is an end in and of itself. To the extent that that such artificial objectives are consistently seen as the normative purpose of the community, the students may develop a diminished understanding of the nature of scientific activity that sees science as a collection of isolated facts and procedures with little relevance to their own lives.

Summary of the Organization of the Lesson. In our characterization of the two classrooms, we contrast how the participants portray the object or meaning of their ongoing work as a community. First, we notice a difference in the way continuity or discontinuity was constructed by the teacher. In the case of Ms. Cook, one activity organically gave rise to the next and connections between lessons were explicitly made in the public talk. In Jessica's classroom, the topics were framed as isolated tasks. Second, we identify a key difference in the object of activity for the two communities. In Ms. Cook's classroom, genuine questions orient and unite the students. As a result the protocols and experiments become tools that allow the community to pursue their inquiries. In Jessica's classroom, the object of activity is typically to complete the task—period.

These differences are important in the normative purpose (Cobb, 2002) of the classroom with differing implications for how participants will explore science. In one case the focus was inquiry and in the other procedures. Stemming from these different orientations the students carried out the same lesson in very different ways and likely constructed very different understandings of both the scientific content and what doing science means. Thus a difference in the normative purpose of a community's activity ultimately has implications for the degree to which a student's epistemology of science is aligned with the epistemology of the discipline.

Participation Frameworks During Science Activities

Built on these two contrasting objects for activity, our second set of research questions addresses the different relationships, roles, and responsibilities that the participants take on as they work together to accomplish their goals. Specifically, in this section we analyze how the teachers position themselves as part of the classroom community, either aligned with the students as a co-inquirer or in a position of authority apart from the ongoing work. While focusing on these two positions analytically dichotomizes the teachers and their roles, we recognize that the positions and roles within the classroom are fluid and dynamic. Even within a single lesson, the teachers

fluidly adopted many different roles and took up many positions. Further, these roles and positions were achieved and negotiated with the students dynamically, and not achieved via the will of the teacher alone. However, in analyzing the interactions, we seek to characterize the dominant roles that the teacher most commonly took up. We also explicate the participation frameworks that emerge within classroom interactions to achieve the community's goals. This involves an analysis of both the classroom norms and the divisions of labor that emerge between peers and between the students and teachers.

We are particularly interested in two specific ways the teachers use language to establish their relationship to their students. First, we are interested in how the teachers refer to students using either inclusive or exclusive pronouns, positioning themselves at times with their students as a co-inquirer and at other times apart from them. Second, we examine the degree to which the teachers retain or share agency with their students as evidenced by the degree to which they explicitly direct the activity of their students.

The position of speakers and addressees through the use of personal pronouns (also referred to as participant and nonparticipant deictics) is an important aspect of classroom discourse. Speakers often use pronouns to set up the roles they are taking on and the roles they are assigning to others (Wortham, 1996). In this case, ''they'' refers to the science experts, whereas ''us'' includes the teacher and students. These roles establish one's footing—the interactional rights and responsibilities one has within the given context (Goffman, 1979). The sum total of these rights, responsibilities, and relationships between participants is what we refer to in this article as the participation frameworks for the community (Erickson, 1982). Because these participation frameworks are not static, but instead can shift over time and even within a single conversation, pronouns become an important tool in establishing and maintaining participants' respective positioning (Goodwin, 2000).

In addition to examining deictics in analyses of classroom interactions, we completed a log containing the turn at talk, transcript, and the number of exclusive and inclusive pronouns per turn. The exclusive (e.g., you, yours, I, she, me, their) and inclusive pronouns (e.g., us, we, our, ours) were counted and tallied in order to determine the frequency of each.

During three analogous lessons (studying soil nutrition, temperature, and humidity), Ms. Cook used a greater proportion of inclusive pronouns while Jessica used more exclusive pronouns (see Table 1). This pattern was consistent across all three lessons.

Table 1 gives us an overarching view of the frequency with which these teachers use exclusive and inclusive pronouns; however, much more may be seen as we delve more deeply into the classroom interactions. The inclusive pronouns and exclusive pronouns served many different purposes. Inclusive pronouns, for example, sometimes related expectations of classroom rules, ''We don't do that.'' Inclusive pronouns also united the teacher and students as a group of learners or even as a group of humans (e.g., our body temperature).

At times, it may be clear when using exclusive pronouns makes more sense than inclusive pronouns (e.g., telling a personal narrative). But at times the use of inclusive versus exclusive pronouns is not clear cut. For example, Ms. Cook sometimes helps present herself as a learner through exclusive pronouns (instead of inclusive). For example, using ''I'' to show that she too is participating in the activity at the same level. Also, teachers may want to use exclusive pronouns to help students feel a sense of ownership with their work. At other times, a teacher may want to emphasize inclusive pronouns to help establish a feeling of unity within the classroom culture.

Ms. Cook's Positioning and Participation Frameworks: Co-Inquirers. Ms. Cook uses inclusive pronouns to create a classroom community where the teacher is positioned with the

students as a co-inquirer. For example, during the opening of the soil kit lesson, Ms. Cook uses inclusive pronouns to establish a sense of community and then exclusive pronouns for specific, individual activities. In the transcript below, which addresses the previous day's activity, inclusive pronouns are in italics and noninclusive pronouns are underlined:

> What *we're* gonna do today is the soil that you brought in from home, *all of you* brought in soil. *We* put it in the kiln. Remember they called *us* and said I'm burning down Room 1, but *we* didn't burn it down which was wonderful. But anyway, the only thing *we* really actually did was evaporate all the, moisture . . . .

The heavy use of inclusive pronouns continues throughout the lesson, such as in the following excerpt from the discussion of the moisture formula:

> *Our* idea is to see how much moisture is in the soil. So after *we* did all of that experimenting with the baggies, Armando, with the sponges, *we decided as a group* that *we* were going to weigh the wet soil. And *we* weighed the can by itself. Correct? (2.55) Everybody weighed the can and weighed their wet soil.

By using inclusive pronouns, Ms. Cook helps all students feel they are a part of the project and working together as a unit. Yet the transcripts above also suggest that there is a division of labor within the classroom. For example, the students measure the soil and the teacher runs the kiln. In her narrative about the kiln, she excludes the students from being responsible for burning Room 1 down, but includes them in the success of evaporating all the water from the soil. More importantly, however, the ideas, procedures and goals are established as something they decide together as a group. Thus, the pronouns in this case are used to help establish the students' social identities as part of the community where they are on (somewhat) equal footing with the teacher.

Even though Ms. Cook's classroom is quite democratic when it comes to determining the object of their activity, vertical power relations still exist within the classroom. One of the privileged roles that Ms. Cook takes on in the classroom is that of an evaluator. This role is so common in classroom practice that it is at times taken for granted other than in a formal sense (i.e., report cards, grades). Yet throughout the class period Ms. Cook provides detailed assessments for her students in a variety of ways as she interacts with them.

In discourse analysis, assessments have a more general function than typically referred to in education literature. Both speakers and recipients perform assessments within the turn at talk as they evaluate persons and events being described during talk (Goodwin & Goodwin, 1987). Speakers may display an assessment by prefacing descriptive nouns, and displaying their involvement through nonsegmental phenomena such as intonation and nonsocial displays. Assessments may also occur in the midst of an utterance. Even though in much of the classroom activity Ms. Cook is positioned as part of the ''we'' that also includes the students, the use of assessments establishes that ultimately she has a different set of rights and responsibilities than the students. Thus, assessments are an important type of public talk that may be examined to identify the way power is used within the classroom.

Ms. Cook, through an assessment of a student's soil, shows her excitement of science through her dialogue with students:

> So just absolutely *incredible*? *Janet* (.9) I mean (.7) you must be living on a brick or something. This is soil from Janet's house. . . . Hopefully by afternoon we'll be able to measure it. Do you see it dripping? It's still dripping. *Wow.* Incredible. So, what does that tell us about the kinds of plants that are. . .

This assessment is tied into the lesson on soil. As seen from the above quote, Ms. Cook links the assessment of soil to students' home lives, providing a more personal, and perhaps meaningful, touch. Ms. Cook's positive assessments are highlighted with descriptive adjectives, such as ''absolutely incredible,'' ''wow,'' and more. Also, Ms. Cook provides further emphasis by raising her intonation, pausing, using hand gestures, widening her eyes, and directing eye contact at students in reference to her comments.

Often Ms. Cook provides more than just a brief, positive assessment. In the following excerpt, Ms. Cook creates a 'learning moment' out of her positive assessment of a soil sample in a discussion with the whole class:

Ms. Cook: This one, I love that. Who did this?
Girl: No name.
Ms. Cook: Oh, [inaudible name of student].
Girl: I did.
Ms. Cook: Mary, I loved your, really, really wet. It was wet as, look-it, it dried into little tiny. . .
Girl: Rocks?
Ms. Cook: *They're not really rocks* 'cause if I. . .. Oh wow, maybe they are rocks, no. If you do it really hard, it'll turn, okay?

Of course, Ms. Cook also provides full negative assessments. In the excerpt above, a girl suggests that Ms. Cook is holding rocks. At first, Ms. Cook responds no. As she says no, she also tests the girl's suggestion, taking the student's suggestion seriously. Then Ms. Cook starts to change her response by saying ''Oh wow, maybe they are rocks.'' Ms. Cook seems genuinely impressed with both the girl's suggestions and the soil. Then, Ms. Cook quickly returns to her original response, no, and explains that when you try hard, you're able to crumble the hard soil.

This provides more than just a negative response; it shows students how to determine the ''answer,'' while still validating the student's idea. In this way, Ms. Cook routinely uses negative assessments in a positive way to create further opportunities for learning.

Assessments are not merely one-way phenomena. Instead, assessments are interactive (Goodwin & Goodwin, 1987). In addition to examining the speaker, the reciprocal affect display may be examined. The recipient may respond to and participate in the assessment. The students respond to Ms. Cook's assessments in a variety of ways.

When assessing the soil from Janet's house, most of the students continue to look at Ms. Cook. As Ms. Cook refers to the soil and asks questions, Janet nods her head affirming the statements. (Janet does not typically volunteer to speak in front of the whole class and tends to speak very softly when she does vocally participate.) Ms. Cook continues to discuss the soil from Janet's house and draws in more students by opening up questions for a public discussion. Several other students get involved as they volunteer answers. Even as other students are participating, however, Ms. Cook keeps the primary focus on Janet by standing next to her and altering her eye gaze between Janet and the class as a whole. This example is indicative of the way that Ms. Cook uses her privileged role with the classroom community to include and involve students as a cohesive community engaged in the ongoing tasks and open questions around environmental science.

Ms. Cook's use of assessments is an important dimension in the participation frameworks of the classroom because it establishes a socioscientific norm for their class discussions. Through assessments, she reinforces that the class' purpose is inquiry and not the evaluation of student contributions as right or wrong. This establishes a norm of extended treatment of topics over

several conversational turns and an interactive dialogue that involves multiple participants, often on equal footing.

Jessica's Positioning and Participation Frameworks: Authority and Independence. The structures for participation in Jessica's classroom are arranged quite differently. Jessica positions herself apart from her students and their ongoing work. Through pronoun usage, a dichotomy is set up between Jessica and her students, with Jessica positioned within the curriculum through an authoritative position. For example, in providing directions for the soil kits, Jessica uses exclusive pronouns during her explanation of the activity. (In the following transcript, exclusive pronouns are in italics.):

> *Shhh. I* hope *you* (all read this part).
> [Holding the paper up and pointing to the directions.]
> That is vitally important.
> If you don't read every word you're going to mess up.
> (Where it says) Soil Sample and Preparation.
> *You* gotta read it.

These pronouns differentiate between the speaker and hearer. They draw a clear separation between the role of teacher and student, and they are one of the primary ways Jessica establishes her role within the classroom.

Similarly, Jessica uses address terms in a distinctive way of separating herself from the students. She tends to use endearing address terms that help create a maternal dynamic—*in loco parentis*—and reinforce the dichotomy between the social positioning of herself and her students:

- Yes, *Mister*, I think you have the right idea.
- Yes, *honey*?
- I need to know what you're testing for, *darlings*.
- Did you read it? It doesn't say wait 5 minutes, *sweetheart*.
- Now, *honey*, *honey*, that's not what it says and it isn't even in the picture like that.

Thus, through deictics involving a combination of maternal address terms and exclusive pronouns, Jessica positions herself apart from her students and their activity. Furthermore, her position of authority within the community creates the conditions for her to adopt one of the standard roles of a teacher within traditional classrooms, the role of an evaluator.

This role is evident in the differences among interactions, in particular the use of assessments, in Ms. Cook and Jessica's implementation of the GLOBE lessons. For example, when the students are carrying out the soil laboratory protocol, Jessica circulates around the classroom to monitor the progress of her students and negatively evaluates the progress made by two girls:

> Jessica: How are you coming? (3)
> Aren't you *done*? [Shakes her head no or in disbelief.]
> Girl 1: Marcia?
> Girl 2: No
> Girl 1: It's finally getting kinda pink.
> Jessica: Why not?
> Girl 1: Cuz we had to wait the 5 minutes.
> Jessica: No. Did you read it? [accusatory tone]
> It doesn't say wait 5 minutes, sweetheart.

During this turn-taking conversation, Jessica provides a negative assessment through her phrasing, intonation, and gestures. It becomes clear that, although framed as questions, Jessica has formed a judgment or evaluation: the group did not complete the task even though they ''should have.''

The disagreement sequence above involves the assertion (and reassertion) of Girl 1's position as she attempts to defend the group. First, she says that the vial is turning pink, insinuating that they are almost finished. Jessica overlaps, ''why not,'' continuing her accusation. Again, the student is defensive and reasserts that they had to wait five minutes (based on the directions). Jessica does not seem to accept these defenses and suggests that they did not read the directions, which as she mentions throughout the period, is critical.

The critical importance of the conversation above is that Jessica uses the assessment to judge the adequacy of the activity based on the directions instead of based on questions of inquiry. Jessica stresses the progress the students are making and the deviations they have made from the directions. However, there is no mention of what the color means in terms of the soil's characteristics. This exchange reinforces our assertion that the object of the activity in Jessica's classroom is to finish the kits. Here we see that the Jessica uses her authority and social role as an evaluator to reinforce his objective—evaluating the students in terms of their progress rather than their conceptual understanding.

Summary of Participation Frameworks. From the theoretical perspective of social-constructivism, a critical difference between these two classroom communities in the way in which instructional conversations are organized. Our analysis has focused on the ways in which the students and teacher were positioned in relation to one another during these conversations. In Ms. Cook's classroom, as illustrated above, the teacher positions herself with the students as a co-inquirer and learner. This positioning was most clearly visible in the way in which Ms. Cook used inclusive pronouns to draw the boundaries of the community to include herself within the group of students. This positioning was reinforced by Ms. Cook's use of assessments. In uniting herself with her students, Ms. Cook did not abdicate her responsibility as the teacher, but she used her privileged position to reinforce the object of the classes activity—genuine inquiry.

In contrast, the participation frameworks established in Jessica's classroom were quite different as Jessica positions herself apart from her students. Jessica's position in the classroom was marked and reinforced by the use of pronouns. In Jessica's case the majority of the pronouns were exclusive, helping to draw a boundary separating the teacher and students. Additionally, Jessica used endearing and maternal terms to specify in familiar terms the relationship, rights and roles of herself and the students. Finally, as was the case with Ms. Cook, Jessica used assessments to reinforce both her position and the object of the class' activity. In Jessica's classroom assessments were primarily used either to evaluate progress toward the completion of the task or to evaluate how closely the students had followed directions.

Pre-/Posttest Analyses

Pre- and posttest performance was analyzed to test our emergent hypothesis that the classroom culture established in Ms. Cook's class would contribute to better student learning outcomes. Items for these tests were modified from national and state standardized assessments (e.g., SAT-9, NAEP, TIMMS), the research literature, and SRI International's open-ended assessments used for the national evaluation of GLOBE (Means et al., 2000). At the end of the curriculum the students took the same tests as a measure of their learning.

Table 2
Means of pretest and posttest scores

	Ms. Cook	Jessica	Combined
Pretest			
N	23	27	50
Mean	5.522	7.074[a]	6.360
SD	1.592	2.556	2.284
Posttest			
N	29	31	60
Mean	12.000[a,b]	10.194[b]	11.067[b]
SD	3.094	3.381	3.344

[a]Significantly higher than the other teacher $p > .01$.
[b]Significantly different from the pretest $p > .01$.

Students were assessed both on their ability to choose or produce the correct response and on their ability to explain their reasoning. The test contained both open-ended and multiple-choice items. The range of possible scores was 30. The same member of the research team scored all the tests. A randomly selected sample of 20% of the tests were coded by two additional members of the research team, to test for reliability. Interrater reliability on this sample for the open-ended questions[3] of the combined tests was .80.

Student scores in both classes improved on the posttests. However, one can see from Table 2 that the tests were more difficult for these students than we intended. The mean score on the pretest was only slightly above 20%, and the mean posttest score only slightly above 36%. There are many possible explanations for the low mean scores. Perhaps, part of the difficulty was the high level of academic English comprehension and production required by the assessments that may have masked the conceptual understanding of the students, a majority of whom were English language learners. Nonetheless, a *t* test showed that the mean score on the pretest differed significantly from the mean score on the posttest for both classes. This suggests that the students did learn some amount of environmental science ($t = 8.45$, $p < .01$).

In comparing the learning outcomes of the two classes we see some revealing trends. Although the mean score of Ms. Cook's students were lower than Jessica's on the pretest ($t = -18.6$, $p < .01$), Ms. Cook's students' scored higher on the posttest ($t = -23.4$, $p < .01$).

As an additional method of viewing improvement, we calculated gain scores (posttest–pretest) and the corresponding mean scores. The average gain score for the combined classes is 4.6 points. In Ms. Cook's classroom, the mean gain score is 7.4 points and 2.6 points in Jessica's. Again, this demonstrates a greater improvement in Ms. Cook's classroom than in Jessica's.

However, the comparison between the two classrooms learning outcomes on the posttest was confounded by significant differences between the standardized test scores of the two classrooms. Although there is controversy about the degree to which Standardized test scores measure student potential to learn new material, Ms. Cook's students had significantly higher SAT-9 scores than Jessica's students ($t = 25.8$, $p < .01$).

In response to the differences in academic starting points, a general linear model was used to analyze the relationship among the variables. An Analysis of Covariance (ANCOVA) using the change in pretest and posttest scores (i.e., gain scores) as the dependent variable and the SAT-9 scores held constant as a covariate.

Based on this model, the teacher was a significant factor ($F = 8.1$, $p > .01$). This suggests that the teacher as a proxy for the classroom community is a strong predictor for the learning gains based on test scores (Table 3).

Table 3
ANCOVA: dependent variable: change (gain) in test scores

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected model	271.579	2	135.789	16.787	.000
Intercept	7.172E-02	1	7.172E-02	.009	.925
SAT-9 avg. score	49.270	1	49.270	6.091	.018[a]
Teacher	65.554	1	65.554	8.104	.007[b]
Error	347.834	43	8.089		
Total	1569.000	46			
Corrected total	619.413	45			

[a]Significant at the 0.05 level.
[b]Significant at the 0.01 level.
$R^2 = .438$ (adjusted $R^2 = .412$).

Discussion

While it is beyond the scope of this article to delineate every aspect of what it means to be a member of these two classroom communities, the analyses do demonstrate two important differences that may have had an impact on student learning: the object of the lesson and roles and rules of the teacher and students.

Object of the Lesson

Primarily through the ways that each teacher framed the activity, the objectives of the soil kit lesson differ in the two classrooms. Scholars have been arguing about the importance of engaging in genuine inquiry at least as far back as Dewey (1938, p. 112), who claimed that, "to set up a problem that does not grow out of an actual situation is to start a course of dead work, nonetheless dead because the work is busywork." As these case studies reveal, two possible framing of the soil kit were (1) as an isolated activity, and (2) as a relevant organization entity (Goodwin & Goodwin, 1996).

In Ms. Cook's classroom, the soil kit is positioned in a larger web of activity. There appears to be no clear endpoint between lessons. In the cases examined for this article, Ms. Cook often refers to previous activities and tasks when introducing new lessons. By framing the community's activity around a question stemming from the students' prior activity, Ms. Cook establishes an object that orients the community toward genuine inquiry and creates conditions for conceptual learning. Additionally, Ms. Cook makes several references to students' lives outside the classroom. In drawing the connections to their home lives, Ms. Cook helps establish a wider set of culturally relevant tools and resources that can be validly used to solve their academic tasks (cf. Barton, 1998; Gutierrez, 1994; Moll, 2000).

The classroom community in Jessica's classroom provides a different orientation. She frames the soil kit activity as an independent, hermetically sealed lesson. The entire science period consisting of the soil kit protocol, and only the soil kit protocol, defines what is relevant and valid. When she introduces other lessons or discusses science concepts, she rarely refers back to other activities. In so doing, Jessica compartmentalizes the activities and delimits the meaning that students may be constructing from the activity. To continue the quotation from Dewey (1938, p. 112), "Problems that are self set are mere excuses for seeming to do something intellectual, something that has the semblance, but not the substance, of scientific activity."

Roles and Rules of Teachers and Students

Each classroom developed a stable participation framework that the members of the classroom community used to coordinate their joint activity. The community of Ms. Cook's classroom includes the teacher, other students in their group, other classmates, and the researchers (who were videotaping). The subjects in Ms. Cook's classroom are usually the students as members of a group, not just individuals. Ms. Cook's discourse, particularly her use of inclusive pronouns, contributed to the development of a united group. Through her discourse and activity, she positioned herself as a co-inquirer with the students. She did not position herself as knowing all the answers. Further, her evaluations of her students were often made into learning opportunities. And instead of just disagreeing, Ms. Cook proposes and models an empirical test that the students could use to settle the issues—seeing whether the ''rock'' could be crumbled easily into dirt. The contents of Ms. Cook's contributions also serve to position her as a learner with her students. For example, in one case she mentions that she is taking a math class, which helps to establish herself as a learner and student.

Jessica, on the other hand, assumes a maternal role within the classroom. To begin, Jessica has students call her by her first name, adding a personal touch. Furthermore, she addresses students with endearing terms. Although these linguistic choices appear to put the teacher and student on a more level participant field by establishing a friendly and close relationship with the students, through a deeper examination of discourse we see a relationship that is markedly asymmetrical. This asymmetry is reinforced by Jessica's heavy use of directives emphasizes. This disparity between the roles of teacher and students in the end produces an aura of authority that runs as an undercurrent, and sometimes as a major theme, throughout the interactions of the classroom. Finally, Jessica further highlights the asymmetrical nature of her and her students' knowledge by taking on the role of an expert who is passing on the tasks and knowledge to her students. This role is consistent with that of a parent or grandparent—one where the elder imparts information to a younger generation. Although, of course, parent–child interactions and roles are much more variable and complicated than this idealization (Rogoff, 1990; Wertsch, 1985; Wersch & Stone, 1999).

We argue that the variability between the classroom cultures outlined in our analyses is consequential for student learning. The pre- and posttest scores suggest that the students in the two classes had different learning outcomes. Further, the differences between the two classes gain scores are exactly where one would expect—on the open-ended, inquiry-oriented questions. In Ms. Cook's classroom the average increase from pretest to posttest on the section of open-ended items was five points as compared with a two-point increase in Jessica's classroom. However, we are cautious about making any casual claims about the degree to which the differences that we saw in the two classroom cultures caused the differences on posttest performance. Many other factors may have contributed to these differences.

Additionally, we cannot be absolutely certain that the nature of the classroom communities we described based on our videotapes were the only relevant organizational frameworks for these two classrooms. Although researchers videotaped several days per week during the study, some of the science curriculum carried over into other class periods that were not videotaped. It is possible, but unlikely based on our twelve weeks of observing and videotaping, that the parallel lessons we analyzed were not the norm but the exception. Similarly, it is also possible the practices described within this article may not be typical of the way Ms. Cook and Jessica routinely organize their classroom for other activities—this was the first time they used this curriculum.

However, what we have attempted to show with our analyses were persistent patterns within the two classrooms. Finding such consistency across lessons and over many weeks suggests that

these two different classroom communities were indeed quite stable, and created two very different sets of ways to participate in environmental science. Further study is needed to establish a tighter connection between classroom communities and learning outcomes, and to understand the complex interactions between dimensions of classroom interaction and the impact they have on learning. However, we have articulated what we see as important similarities and differences between the classroom organizations, how these differences are related to our current theories of teaching and learning, and how these differences may have affected students' learning of the environmental science concepts.

Implications

From these analyses, we draw important implications for curricular design, professional development, and educational reform. The variability demonstrated in the local contexts of these two classrooms as teachers implemented the ''same lesson'' raises significant issues for both the design and evaluation of reform curricula and new technologies. This study demonstrates quite clearly that the implementation of a curriculum is not a dichotomous variable. It is not an all or nothing affair, but a matter of degree within an *n*-dimensional space that is not well understood. One dimension of this space is the classroom community. In the present study, we specified two important dimensions of any classroom community—its object (or normative purpose) and the rules and roles for participation.

Thus, before we can argue that curricular innovation is effective (or not effective), we need to carefully examine more than just the ideal structure of the intervention and the aggregate results on an assessment. We must also examine the local ways in which the activities were instantiated and enacted by real teachers and students. As Erickson and Gutierrez (2002, p. 21) stated:

A logically and empirical prior question to ''Did it work?'' is ''What is the 'it'?''—''What was the 'treatment' as actually delivered?'' Educational treatments are situated and dynamically interactive (see Cohen, Raudenbush, & Ball, 2002). They are locally constructed social ways of life involving continual monitoring and mutual adjustments among persons, not relatively replicable entities like chemical compounds or surgical procedures or hybrid seed corn or manufactured airplane wings. High-fidelity implementation is rare in education—for reasons of local exigency—and despite the accountability pressures and the wishes of experimenters to avoid this major threat to internal validity, there are real-world limits on how ''faithful'' the implementation will be even of the most structured of educational programs.

In this study, we have tried to examine carefully the consequential variations of the ''treatment'' to ''identify the specific mechanisms that generate specific outcomes within particular structural circumstances. . .a specification made possible from direct observation within the local situation of complexity and contingency'' (Erickson & Gutierrez, 2002, p. 23). Other recent studies have also begun to address this same issue. Squire, MaKinster, Barnett, Luehmann, and Barab (2003) document the ways in which a similar environmental science curriculum was adapted by local classroom cultures. These investigators argue that project level goals alone were poor tools to organize the classroom. Without local connections to the students' personal lived experiences, the students were not interested in the larger issues and transformed what could have been an authentic inquiry project into ''school science'' by breaking it down into individual activities that were addressed as isolated, stand alone challenges. Similar to our own findings, Squire et al. (2003) go on to note that classrooms organized around individual accomplishments, grades, and getting the ''right'' science content facilitated adaptations of the curriculum that made the innovative curriculum look more what many would characterize as traditional school. Finally, parallel to our own findings, Squire et al. (2003) go on to note that the classrooms that were not

focused on the science content, but instead fostered open, but critical classroom cultures of critique and collaboration, led to students who achieved academic success and adopted positive attitudes toward science (see also Crawford et al., 2000).

However, the two dimensions identified here and the dimensions identified by other studies (e.g., Morais & Neves, 2001) only develop a partial framework that needs to be further fleshed out in order to help us understand and characterize the ways that the context interacts with a designed curriculum in unanticipated and often undesirable ways. Other researchers have also argued for an elaboration of the critical dimensions of a community of learners (e.g., Crawford, Krajcik, & Marx, 1999). The consequential variation found in this study of two implementations of the ''same'' treatment clearly establishes the need for a set of implementation measures that would systematically describe the existing classroom community and the ways in which a new unit is implemented into and integrated within a local context.

Without a way of documenting and comparing theoretically similar, but actually quite disparate situations, we are likely to continue the all too common cycle of initial success followed by disappointing wide scale implementations. This eventually leads to unwarranted disillusionment with both the curriculum and often the learning theory upon which the curriculum was based (Brown, 1992; Cuban, 1986; Hall, 2001). By developing a full set of measures characterizing the aspects of classroom communities that effect instruction and learning, we may be able to help alleviate this cycle. Having a set of classroom community measures would allow us to more effectively evaluate the strengths and weaknesses of curricular and technological innovations. Without such measures, we are left either accepting the variability, blaming the tools, or blaming the teachers.

This last point, blame and disillusionment, requires us to make clear that we are *not* arguing in this article that Ms. Cook is a better teacher that Jessica in any objective way. However, we are arguing that the social frameworks and microcultures established in the classroom have a direct impact on *what* students learn. Given a particular set of goals and beliefs, it is possible to examine how well each classroom community was suited to them. Ms. Cook's classroom organization and culture was more conducive to learning during GLOBE activities. But this is based on beliefs regarding the legitimacy of the assessments we developed—that reify our assumptions and values of inquiry, debate, and conceptual understanding. This does not preclude the use of a different measure that would be just as valid but produce different results.

In many ways, the emphasis in Jessica's class on following the protocols specifically fit well with the goals of the GLOBE curriculum, which wanted the data collected by the students to be used for authentic scientific research. Much of the data collected by Ms. Cook's students, because of its lack of standardization, would be unsuitable for this purpose. One could argue that by ''real'' scientists not using the data, the teacher undermines one of the most significant motivating factors for the students to engage in these activities at all. From this perspective, the practices of Ms. Cook's classroom sacrificed authenticity to the scientific community for authenticity for the students. ''Successful'' and ''faithful'' implementations of an innovation may have as much to do with the fit between the ''ideal'' practices and the existing classroom organizations as they do with the abilities of the teachers.

Another major implication of this study begins with the premise that teaching is a multifaceted profession. It is a collection of local practices that often combines and juxtaposes conflicting beliefs about teaching, learning and the purpose of schooling as an institution that are held by teachers, students, principals, parents, curricula designers, politicians, and in this case educational researchers as well. To better understand why these two teachers designed their classroom communities in such different ways, one must look into the teacher's beliefs, goals, and professional identities (Muir & Enyedy, 2002). We maintain that both teachers are making

intelligent local adaptations of the curriculum, given their current understandings and situation. Over the course of the study, it became apparent that the teachers were struggling with multiple conflicting beliefs goals, knowledge, and institutional constraints.

Clearly, there are multiple, legitimate ways to organize any classroom, but each organization is well adapted to certain goals while less effective for others. Therefore, when setting out to redesign a microcultural to be more effective for a particular network of goals and values it is important to remember that cultural change is not designed out of whole cloth but occurs incrementally over time. Further, it is more likely that these changes will not be a smooth replacement of one practice for another, but that the internal coherence and the external connections to other systems of activity will be effected by these changes (Engestrom, 1987).

Considering how to promote sustainable change within the organization and cultures of classrooms brings the related issues of curricular design and professional training to the foreground. Even if we were able to identify the most important aspects of a successful classroom community and the most detrimental aspects of a dysfunctional classroom community, we would be left the problem of what to do with this information. Two obvious possibilities are a) to design studies with extremely tight controls that essentially constrain the curriculum to be enacted in a specific prescribed manner (this is the route opted for by designs such as Open Court), or b) to embrace the diversity and expand the professional development and training that accompanies innovations such as GLOBE to address the deep principles of the design and how they are effected by the organization and discourse practices of the classroom community. It seems quite likely that if two very experienced teachers, working closely with one another at the same school, can differ to the degree seen in these case studies, that novice teachers will show even greater variability. Moreover, novice teachers are less likely to have the skills and experience with the content and pedagogy to adequately deal with the complexities of fostering a productive community.

In light of the findings presented here that highlight the local complexity and contingency of the classroom microculture, we argue that the latter option that attempts to involve the participants directly in a discussion of productive classroom communities is the wiser choice in the long run. We found that having the community driven by an objective or task that was authentic to the students was a critical aspect of a productive classroom community. However, questions remain of how to design this into curricula or tools. In this case, the entire GLOBE program was premised on students doing authentic scientific research. And yet, in one of our classrooms we found that this type of authenticity was easily reduced to ''school science'' dominated by traditional student and teacher roles and relationships. Likewise, the GLOBE curriculum did not and mostly likely could not effectively constrain the participation structures and predefine the range of legitimate interactions within the classroom.

A growing group of educators are calling for designing for local adaptation through a process of participatory design (Randi & Corno, 1997; Squire et al., 2003). We wholeheartedly agree with this approach, but suspect that this design process is yet another social context that is not yet well understood. However, contemporary learning theories may provide a starting point for discussions about the implementation of curricula within different classroom communities. Learning may be viewed as an active process that builds on existing understandings. One could look at professional development and participatory design in the same light. Pedagogical reform depends on teachers wanting to change their practice and understanding alternatives. Therefore, if we wish for teachers to modify the ways in which they talk and interact with students, we need to design mechanisms for them to critically reflect on these aspects of their practice. As with student learning, success will come not from making the new participation structures explicit. Instead, success will be fostered by activities that help to highlight the critical and consequential structures of instructional talk,

promote and build in opportunities for teachers to reflect both about their current practices and new ones, and sustaining engagement within a community of practice that is oriented toward improving their teaching.

In fact, the most interesting part of our study—for both teachers—was when, toward the end of the unit, we started watching the videotapes with the teachers. In one such session Jessica began to reflect on how her practices were at odds with her goals. Saying:

> I have a tendency to want to be the one that knows it all. And rather than encouraging students to find their own answers and struggle with not knowing and trying to figure things out, I have a great tendency to want to impress them by how much I know. . .. And I don't like that in myself, but I do it. When I'm more conscious rather than less conscious, I don't do it. I encourage them to. . .I say, well, that is a problem. How are you going to deal with that? But most of the time that doesn't come out of my mouth. Most of the time, what comes out of my mouth is oh, well, why don't you try this or that or this or that, and I'm pushing them toward my answers.

As this line of research into the social context of learning and the critical dimensions of classrooms as communities for learning matures, it should continue to inform our professional development activities, providing specific and concrete ways to characterize and create communities of learners.

In this article we described two of these important dimensions of communities of learners within a school setting—the object of the communities activity and the participation frameworks that guide interaction. As a first step in fleshing out these dimensions, we contrasted two communities that developed strikingly different solutions in response to the same set of tasks. Further, we examined the consequential learning outcomes for these two different classroom organizations. The analyses of this article are just a first step in a much needed program of research aimed at creating a useful way to characterize a ''treatment'' as instantiated in a classroom community, which is vital to our field's theoretical and pragmatic progress.

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Notes

[1]We translate Cobb's sociomathematical norms as socioscientific norms to accommodate that our study takes place in the context of an environmental science lesson.

[2]Throughout this paper, we use pseudonyms to refer to teachers and students. The pseudonyms reflect students' use of surnames and first names to address and refer to teachers.

[3]Inter-coder reliability for the forced choice and calculation questions was, as expected, 100%.

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