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"Maestro, What is 'Quality'?": Language, Literacy, and Discourse in Project-Based Science

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Abstract: Recent curriculum design projects have attempted to engage students in authentic science learning experiences in which students engage in inquiry-based research projects about questions of interest to them. Such a pedagogical and curricular approach seems an ideal space in which to construct what Lee and Fradd referred to as instructional congruence. It is, however, also a space in which the everyday language and literacy practices of young people intersect with the learning of scientific and classroom practices, thus suggesting that project-based pedagogy has the potential for conflict or confusion. In this article, we explore the discursive demands of project-based pedagogy for seventh-grade students from non-mainstream backgrounds as they enact established project curricula. We document competing Discourses in one project-based classroom and illustrate how those Discourses conflict with one another through the various texts and forms of representation used in the classroom and curriculum. Possibilities are offered for reconstructing this classroom practice to build congruent third spaces in which the different Discourses and knowledges of the discipline, classroom, and students' lives are brought together to enhance science learning and scientific literacy. © 2001 John Wiley & Sons, Inc. J Res Sci Teach 38: 469–498, 2001

Recent curriculum design projects have attempted to engage students in responsive or authentic science learning experiences in which students engage in inquiry-based research projects about questions of interest to them (Goldman, 1997; Krajcik, Blumenfeld, Marx, Bass, & Fredricks, 1998; Merino & Hammond, 1998; Warren, Rosebery, & Conant, 1989). Typically, the features of what is often called project-based pedagogy include (a) questions that encompass worthwhile and meaningful content anchored in authentic or real-world problems; (b) investigations and artifact creation that allow students to learn apply concepts, represent knowledge, and receive ongoing feedback; (c) collaboration among students, teachers, and others in the community; and (d) use of literacy and technological tools (Cognition and Technology Group, 1992; Krajcik et al., 1998; Mercado, 1993).

Project-based pedagogy engages children in textual and experiential inquiry about authentic questions, and so can be considered discourse enabling. That is, project-based pedagogy affords

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students and teachers opportunities to investigate, talk, read, and write about questions of interest to them. This approach thus can be said to represent an excellent way to learn science (National Research Council, 1996). Indeed, such a pedagogical and curricular approach seems an ideal space in which to construct what Lee and Fradd (1998) referred to as instructional congruence, or ''the process of mediating the nature of academic content with students' language and cultural experiences to make such content (e.g., science) accessible, meaningful, and relevant'' (p. 12). At the same time, however, the extensive discourse demands of the inquiry activities in project-based pedagogy can be difficult for students because teachers and students alike bring many different language and literacy practices to their classroom work. These language and literacy practices are embedded in various Discourses, or ways of knowing, doing, talking, reading, and writing, which are constructed and reproduced in social and cultural practice and interaction (Gee, 1996; Heath, 1983). [Gee (1996) referred to these ways as ''Discourses,'' using the upper-case ''D'' to distinguish this use of the term from a mere stretch of language, which he identifies as ''discourse.'' Any stretch of language (discourse) is always embedded in a particular way of knowing (Discourse) so the distinction may at times seem artificial, but for the purposes of this article we do distinguish between the discursive, or technical demands of speaking, reading, and writing (e.g., decoding, defining terms) and the Discursive, or cultural demands of negotiating different ways of knowing, doing, speaking, reading, and writing (e.g., knowing how to write a technical report on a science inquiry as opposed to writing an opinion piece on science issues).] This concern about the possibility that project-based pedagogy may ask students to navigate different ways of knowing, doing, reading, and writing (Discourse), as well as technical language and concepts associated with talking, reading, or writing (discourse), is especially important in light of the calls of science for all (Lee & Fradd, 1998; McLaughlin, Shepard, & O'Day, 1995), and in light of recent critiques of the standards designed to further that charge (Rodriguez, 1997).

Intrigued by the idea that project-based pedagogy may be both discourse enabling and dependent, and because project-based work is often offered as a way to engage all students in science learning, we undertook an analysis of the language, literacy, and Discourse demands represented in a particular project-based curriculum and its enactment. Specifically, we wanted to know whether the written curriculum and a teacher's enactment of it scaffolded students in engaging in the many different Discourses required for deep learning in project-based pedagogy. In this article, we present our analysis of the competing Discourses (Gee, 1996) at work in one project-based classroom and curriculum. We focus on the Discursive demands made on students from non-mainstream backgrounds and their teacher as they engaged in this project-based curriculum, and we provide some evidence regarding how students responded to those demands. We do not intend the analysis to serve as an indictment of our curriculum development and research or of the teacher represented here. Instead, we intend to illustrate the complexities of developing and teaching science-for-all curricula in project-based classrooms, and we argue that the Discourse issues we raise have implications for all science classrooms, regardless of pedagogical or curricular orientation.

Language, Literacy, and Discourses in School Science: Theoretical and Empirical Perspectives

We operate from the perspective that cognition is mediated by social interaction and cultural practice and that language, literacy, and discourse are both tools and products of cognitive, social, and cultural practice (Scribner & Cole, 1981; Vygotsky, 1978). Because science is an endeavor conducted within social and cultural interactions, scientific knowledge production and

science learning are likewise mediated by social interaction and cultural practice, and thus, are also highly dependent on language and literacy (Lee & Fradd, 1998). By extension, science knowledge production and learning are also embedded in particular ways of knowing, doing, reading, and writing, or Discourses.

Gee (1996) argued that Discourses are situated in cultural models and ideologies that are shaped by the practices of different groups. Discourses are generated not only from particular group practices, but also draw from particular "funds of knowledge," or knowledge that is produced within specific home, work, and community interactions. The funds of knowledge from which a scientist draws may be different from those accessed by a science teacher, which may be yet again different from those accessed by a 12-year-old student who lives in an urban setting. Studies of science learning and the development of scientific literacy need to acknowledge both the knowledges and ways of knowing valued by the learners, the learning context, and the discipline.

Gee's conception of the relationship between culture and Discourse refers not only to ethnic experiences and relations, but also to the many other ways that people group themselves or are grouped by others. That is, Discourses can also be drawn from disciplinary, peer, social class, community relationships, among others. What is more, these relationships often intersect in points of convergence and conflict. If one situates this conception of Discourses in secondary schools settings, it can be argued that content-area classrooms represent communities that privilege particular ways of using language—Discourses—to carry out inquiry. Students in those classrooms bring everyday Discourses to their content learning. When one adds the idea of project-based pedagogy to these communities, one introduces yet another Discourse, that of collaboration, authenticity, and inquiry, a Discourse which may or may not conflict with the Discourses privileged in the content area classroom, the discipline, and the students' and teachers' lives.

Although several different intersecting Discourses can be at work in any one classroom, at least three are particularly salient for this discussion: disciplinary or content area, classroom, and social or everyday Discourses. These Discourses represent distinct ways of knowing, doing, talking, reading, and writing, and yet they overlap and inform one another in important ways. For example, the Discourses of classroom instruction are informed by what teachers and students believe about the nature of knowledge in the discipline (cf. Moje, 1995). Similarly, the ways that students take up classroom or disciplinary Discourses are shaped by the social or everyday Discourses they bring to the classroom. We discuss each of these three categories further in the following sections.

Disciplinary Discourses

Engaging in reading, writing, and talking about science is often difficult for middle-school students because science discourse and practices are new to them (Hicks, 1995/1996; Krajcik et al., 1998; Lee & Fradd, 1998; Santa & Alvermann, 1991). As Lemke (1990) illustrated, the discourse of science represents a specialized system of language that rests heavily upon themes and concepts that are not immediately apparent to the novice science learner. Moreover, becoming a member of a scientific discourse community can be challenging for students as they encounter different ways of talking, reading, and writing (Discourses) in their science classrooms (cf. Hicks, 1995/1996; Moje, 1995).

School science learning in general requires students to bring practices of prediction, observation, analysis, summarization, and presentation to their science reading, writing, and oral language practices (Lee, 1998; Lee & Fradd, 1998). At the secondary school level, in particular,

young people are expected to apply previously learned basic language, literacy, and technology skills to the comprehension, interpretation, and application of disciplinary knowledge. These scientific literacy and language practices are even more important in project-based science in which students search for and synthesize information across texts and other people (Blumenfeld, Marx, Patrick, & Krajcik, 1997; Goldman, 1997). Literacy events, like science events, are shaped by and contribute to social practices, purposes, and contexts. Thus, being literate in science—or any other social activity—has implications that extend beyond the ability to make meaning from or about scientific text. Scientific literacy serves as a tool for and signifier of both school and social success, and thus can be considered an important tool for gaining or denying access to opportunities for success.

As cross-cultural studies have illustrated, however, such skills associated with Western science and scientific literacy (Akatugba & Wallace, 1999; Lee, 1998; Michaels & O'Connor, 1990; Schliemann & Carraher, 1992) are not necessarily valued or practiced in all cultural groups. Michaels and O'Connor (1990), for example, illustrated how the cultural practices of a Haitian student—practices that did not include demonstrating understanding by explaining one's reasoning process—led teachers and researchers to believe that the child could not reason or did not understand the reasoning behind the problem. This example provides a useful illustration of the ways that disciplinary Discourses are linked to the instructional and interactional Discourses typically valued or practiced in classrooms. The ways of knowing in science that promote demonstrating one's reasoning or logic are enacted in classroom instruction and interactions as classroom teachers routinely ask students to demonstrate and explain their understanding (cf. Heath, 1983; Michaels & O'Connor, 1990).

Instructional and Interactional Discourses

Teachers' and students' cultural and language practices shape classroom instructional and interactional Discourses. If the interactional Discourses that students learn in their homes do not match those valued in school classrooms, students may not be ''communicatively competent'' (Hymes, 1972) and may struggle to learn both disciplinary concepts and norms for classroom practice (Gumperz, 1977; Gee, Michaels, & O'Connor, 1992; Phillips, 1972). These Discourses can draw from interactional practices ranging from how one acknowledges questions posed by an adult authority figure to expected classroom participant structures (e.g., whole-class or small-group arrangements) (cf. Cazden, 1988; Green, 1983). Instructional Discourses may also include the language of instruction that revolves around how to use textbooks, where to record class notes, and when and how to answer questions, among others. A number of sociolinguists have illustrated that such practices are among the most invisible and most assumed in school learning .

Project-based pedagogy presents unique demands in terms of the classroom Discourses it promotes. Delpit (1988) argued that many students from non-mainstream backgrounds come to school expecting and needing traditional interactional discourses in classrooms that center the teacher as authority and the instruction as rule-based and uniform. Thus, project-based pedagogy—with its emphasis on authenticity, sustained inquiry, and collaboration—introduces a classroom Discourse that may be unfamiliar or even contradictory to the Discourses to which students have become accustomed or which students believe will afford them opportunities for future success in the ''culture of power'' (Delpit, 1988, p. 122).

In addition to issues of differences in cultural practice that lead to the development of different Discourses, many students in urban schools live in homes where standard English is not a dominant language (Lee & Fradd, 1998). English language learners may have proficiency in English language but not have proficiency in the ways of talking, reading, and writing necessary

for classroom success, particularly in the disciplines they encounter as they move into secondary school settings (Cummins, 1984; Lee & Fradd, 1998). Wong-Fillmore (1992) demonstrated that two basic language skills are required for the learning of academic subject matter: an understanding of the spoken language of instruction and of the language of textbooks.

If the Discourses of science and of secondary classrooms represent a challenge to understanding the language of instruction and text for students whose first language is English (cf. Goldman, 1997; Lemke, 1990), we must acknowledge the even greater cognitive demands on students for whom English is not a first language (Merino & Hammond, 1998). Thus, project-based instructional Discourses may be especially challenging and, without scaffolding, may constrain learning opportunities for English language learners and for students whose first language is English.

Social/Everyday Discourses

Perhaps the most well-known examples of social or everyday Discourses come from Heath's (1983) study of the literacy practices of three communities in the North Carolina Piedmont. Heath demonstrated that these three communities each had different "ways with words" outside school, and that these different ways had important implications for their school and social success. In the community she called Trackton, for example, young people grew up reading and writing in groups, and learned to consider those who engaged in literacy as a solitary activity as somewhat unusual. The written word in Trackton was routinely supplemented by or embellished with the spoken word, and community members valued creativity, fluency, and lyricism. By contrast, members of the community labeled Roadville emphasized literal understanding of written text, and rewarded close readings and the following of rules in literate interactions. These different Discourses for literate practice were a function of an interaction of social class, race, and geography; in short, they were mediated by the complex configuration of each group's cultural practices. More important, they were different from the Discourses typically practiced or valued in the schools that served each community.

Although fewer studies of Discourses drawn from everyday interactions with science can be found in the literature, the work of Moll and colleagues (Moll, Veléz-Ibañéz, & Greenberg, 1989; Moll, 1992) on the funds of knowledge about science available to young people in their homes and communities provides a sense of the ways of knowing, doing, talking, reading, and writing about science that young people bring to their classroom interactions (cf. Collazo, 1999a). Funds of knowledge research indicates that although youth have ample stores of knowledge about the natural world available in their everyday interactions, the Discourses that they use to make sense of and communicate this knowledge are often distinctly different from those valued in science and in science classrooms. In addition, their teachers are often unaware of, or sometimes dismiss, these funds. As a result, students' funds of knowledge about scientific phenomena are rarely articulated to scientific funds of knowledge and scientific Discourses. As Lemke (1990) illustrated, this lack of articulation of different knowledges and ways of knowing and talking about that knowledge can hinder deep conceptual learning in science as students and teachers use the same words but mean very different things. Such distinctions among social or everyday Discourses and those Discourses that tend to be valued in schools support the argument that discursive scaffolding should be woven into science instruction.

In urban secondary schools, multiple ethnic, peer, home, and community Discourses meet multiple content and pedagogical Discourses, resulting in complex interactions among the literacy and language practices and Discourses enacted in such classrooms. Thus, teaching and learning in diverse settings are especially challenging. Teaching science to all, then, becomes

more than a matter of engaging students in inquiry. Teaching science to all requires that teachers and curriculum developers engage students in explicit discussions of and practice in recognizing the many different and competing Discourses at work in their learning lives. Furthermore, a recognition of the many different Discourses at play in any classroom setting—and particularly in project-based pedagogy—underscores the importance of working toward what Lee and Fradd (1998) called ''instructional congruence.'' We draw from Gutiérrez, Baquedano-López, Tejeda, and Rivera (1999a) to argue that these many different discourses can be viewed as a resource for helping students develop stronger understandings of the natural world, both in science classrooms and in their everyday lives. For Gutiérrez and colleagues, the hybrid nature of these different Discourses is used to generate a ''third space'' that provides the ''mediational context and tools necessary for future social and cognitive development.''

Given the argument that school learning is embedded in multiple and sometimes competing Discourses, it is important to ask what Discourses are engaged or demanded by project-based curricula, and how these Discursive demands shape students' opportunities to learn science. What strategies do we need to embed in projects to support teachers' and students' negotiation of Discourses and, ultimately, their learning of science content and of scientific literacy or Discourse? In what ways can curricula be designed to support both the learning of science content and scientific literacy or discourse by addressing differences in Discourses? Guided by these questions, we present in this article an analysis of the Discursive demands of curriculum and classroom practices for students in one seventh-grade classroom as they used reading, writing, and talking to conduct their science inquiry projects. Drawing from our analysis, we offer ideas for what we would do differently in the future to generate what we call ''congruent third spaces'' that teach students how to navigate competing Discourses and generate new Discourses.

Design of the Study

Our data collection for the classroom enactment portion of our inquiry revolved around one seventh-grade science classroom in a two-way bilingual immersion school located in a large urban center in the Midwest. The school, which at the time of the study served Grades Kindergarten through 7, is a public school of choice that offers students the opportunity to learn in both Spanish and English. Most of the students in the school come from homes where Spanish is spoken as a first language. Families in the community served by the school work mainly at blue-collar jobs, and several heavy industries are found across an interstate highway that runs north of school. The neighborhood commercial district is a growing, vibrant area with many small businesses and restaurants; a popular entertainment area known as Mexican Town borders the community. Many of the students came from the immediate community, although some students came from across the urban area.

Although the school expresses a commitment to two-way bilingual education, the language policy for seventh and eighth grades is that all instruction will be conducted in English. This policy stems from the pressure school administrators and teachers feel to prepare their students for the educational experiences they will encounter in the area high schools, none of which offer bilingual programs.

The teacher of the seventh-grade class, whom we call Maestro Tomas, was a native Spanish speaker of Dominican descent who had been reared in both the Dominican Republic and the United States. All but one student in the class of 32 were Latino or Latina and some were relatively recent immigrants to the United States; 27 of these students demonstrated some level of proficiency in both Spanish and English. The remaining five students had very recently

immigrated from Spanish-speaking countries, and so we identified them as Spanish-dominant, English language learners. Initially, Maestro Tomas adhered closely to the language policy of the school that argued for all-English instruction in the seventh grade. At midterm, largely as the result of the classroom researcher's urging, Maestro Tomas began to offer a form of sheltered English science teaching in which he gave instructions and made assignments in Spanish and also encouraged students to brainstorm and draft writings in Spanish as well as English. The result was that both the students and Maestro Tomas engaged in fluent code switching throughout their classroom interactions and the five Spanish dominant English language learners gradually moved from the margins of the project-based interactions to greater participation in the project activities and reports.

The research and development team was composed of two Latinas, two Latinos (one of whom was Maestro Tomas), and two European Americans, one male and one female. All Latino and Latina members are fluent Spanish and English speakers, whereas the European American team members are monolingual. The curriculum project was developed for use in the school district at large, and is currently being used in 17 middle schools in the district. From the inception of the curriculum project, curriculum developers, classroom teachers, classroom researchers, and school administrators have been working to develop language activities and computer technologies to enact project-based science pedagogy that focuses on content related to force and motion, weather, chemistry, ecology and environment, and biology.

The units that are the focus of this article engaged students in projects designed to address two questions (each comprising a unit of study unto itself): "What is the quality of air in my community?" and "What is the quality of water in our river?" The two projects occupied a majority of the class time over the year, with the air project beginning in the fall and extending into the early winter and the water project beginning in the early spring and running through the end of the school year.

Classroom data collection was conducted primarily by Collazo, but was supplemented by Moje and other team members, particularly when collecting interview data. Data were collected at least 2 days each week in one class period over the course of the entire school year. Formal and informal interviews with the teacher were conducted outside of classroom time; formal, focus-group interviews were conducted with students immediately following the school year, and follow-up individual interviews were conducted with three students over the course of the next school year. In addition, the classroom researcher met with the teacher to debrief and plan during each visit. Maestro Tomas, Collazo, and Moje also corresponded via electronic mail; these messages served as contextual data to help us make sense of the primary data.

Primary data sources included participant observation documented in field notes, formal and informal interviews with the teacher and students, and artifact collection (Patton, 1990). In terms of artifacts, student writings and curriculum work sheets were of particular importance. All classrooms sessions were audio taped, and several were also videotaped. Another level of data collection included an electronic discussion of the analyses with Maestro Tomas, who has since taken a position teaching at a different school. This discussion took place over the summer and first semester of the following year.

Data collection focused on both the teacher's and students' literacy and language practices, the classroom environment, and teacher–student interactions. Although whole-class observations were made, particular attention was given to focus students identified on the basis of their participation in the projects (both those who exhibited high and low participation levels were recruited), ethnicity, language abilities, and gender. We used methods of constant comparative (Strauss, 1987) and discourse analyses (Gee, Michaels, & O'Connor, 1992; Fairclough, 1992) of clasroom interaction and the curriculum texts to examine the data for information regarding the

demands of this particular classroom enactment and of the written curriculum. In this article, we primarily report the findings of our constant comparative analyses of Discursive demands.

To accomplish the constant comparative analyses three of the six team members read and reread all field notes and video transcriptions, engaging in open coding in which we searched for recurring patterns connected to our research questions, to which we could assign general codes, such as ''literacy event'' ''cognitive demand,'' ''cultural demand,'' and ''participant structures.'' As a result of first-level coding, we collapsed cognitive and cultural demand categories into one category we labeled ''Discursive demand'' as we realized that we were struggling to distinguish between an activity that required cognitive processing versus one that required cultural knowledge of a particular way of knowing or reading.

We then examined each of the excerpts to which we had assigned these codes as we engaged in axial coding. In the axial coding stage, we examined the nature of different events or demands that we had noted. For example, we examined each of the literacy events that we had coded and attempted to hypothesize about how they were used within the classroom: What Discourses framed these events? How did the teacher or curriculum intend them to serve as tools for science learning? How did the students make sense of and take up the events? This stage required that we develop a coding rubric in which we broke each classroom moment into chunks of interaction, distinguished by the different participant structures that we could discern in the field notes and videotapes (i.e., teacher-led discussions with written text on chart paper; teacher-led discussions with no written text; teacher-led discussions with picture text; student-led, small-group talk about text; student-led, small-group talk about a particular inquiry activity, etc.). We next characterized the types of literacy events and demands that accompanied each structure (see excerpt of analysis rubric in Table 1). In the final stage of selective coding, we began to connect systematically the various codes to one another to develop an overarching theme and the supporting categories or themes that could describe the classroom enactment of the curriculum. We present the results of our analyses in the next section.

The Demands of Competing Discourses in Project-Based Science

Our analyses of the Discursive demands of the curriculum enactment in this one classroom yielded a number of themes, but the dominant theme was one of competing Discourses. In both the written curriculum and Maestro Tomas's enactment of it, multiple Discourses and experiences coexisted with little integration of these Discourses and experiences into one another. In many cases the various Discourses at play in this classroom and curriculum were in competition or conflict with one another, rather than in a productive interaction that led to the construction of a congruent, hybrid third space (cf. Gutiérrez et al., 1999; Lee & Fradd, 1998). Despite the best efforts of the research and development team (which included Maestro Tomas), the students and Maestro Tomas often used the same words, but talked, read, and wrote across each other.

The clearest example of competing Discourses can be illustrated with an excerpt of the interaction that first led us to code for different Discourses (and also contributed to the title of our article). The interaction occurred during the first lesson of the unit on water quality, a unit that followed approximately 12 weeks of inquiry around air quality in the community. The following excerpt, drawn from field notes, illustrates the discursive and Discursive struggles that confronted Maestro Tomas on a daily basis in this science classroom. The interaction begins with Maestro Tomas introducing the driving question for the unit:

> Maestro Tomas: *Cuál es la calidad del rio?* [What is the quality of the river?] He then explains (in Spanish) that the class will be studying the river to learn

Table 1
Excerpt of analysis rubric from two segments of instruction on 24 September 1998

Interactional and Participant Structures	Linguistic Events	Cognitive Process Demands	Discursive or Practice Demands
Segment 1			
Poster at front of room. Statement, drawing, question, answers in note form for students to copy; demonstration linked to poster notes; poster serves as stand-in for teacher; teacher ostensibly removed from participant structure but still in control of the discourse and activity.	Notes written on paper to be read by class: Pressure—concept—related terms and phrases: change, ''air pushes liquid out''; ''equal inside the straw and outside''; liquid moves up.''	Copying notes; decoding words; defining terms; linking terms to larger concepts.	Recognizing signal to take notes; recognizing this activity as a demonstration of science concept; translation of terms from everyday to science Discourse
Segment 2			
Poster at front: drawing of air tight bottle, no labels; picture with question for students to consider; experiment for studentsto try in small groups	Poster: syringe. ''What happens when your pour water in one syringe?'' No dialogue recorded—were instructions for the experiment given?	Copying drawing; translating information from drawing into linguistic representations ecoded in the question—Do students know what word ''syringe'' signifies both in oral discourse and in the written/drawn representation? Do they understand that the word water [as opposed to some other liquid] may be significant here? (Another liquid could be pressurized in a way that might affect the outcome of the experiment.) What does mean to say ''pour water in one syringe''? How does one ''pour water'' into a syringe?	Recognition that this poster is signaling that they should perform and activity and make an observation: What does it mean to observe in science? Have the students been taught about observation? What would it entail? (See boys' enactment of ''observation''). Cognitive demands will shape understanding of practices required and vice versa. Is any writing entailed in this observation? What would scientists do when observing?

about water quality. He states the driving question [What is the quality of water in our river?] in English. As he does this, one of the students stops him:

S: Maestro, what is ''quality''?

This data excerpt was especially helpful in revealing to us the complicated nature of ''talking science'' (Lemke, 1990) and of reading, writing, drawing, thinking about, and practicing science. Because the question was spoken in both languages, it was clear that the student's question did not revolve around issues of the two languages of Spanish and English, but instead revolved around differences in Discourses operating during the class discussion. With Maestro Tomas's probing, it became clear that this student was asking, ''What do you mean when you talk about quality?'' As a result of this question Maestro Tomas spent a class period working on what it meant to refer to quality, especially in science, and on how scientists determined quality. In the most explicit addressing of Discursive difference that we observed all year, Maestro Tomas discussed with students that quality differs depending on one's purpose, one's background, and one's position (e.g., as a scientist, an activist, an industrialist, a community member).

That this question came after an entire project unit on air quality underscores Lemke's (1990) point that teachers and students, especially in the content areas, often talk across each other because the words that they use not only have technical meanings but are also embedded in particular Discourses and funds of knowledge. Maestro Tomas acknowledged this difference in an end-of-the-year interview. However, although he addressed the scientific Discourse surrounding the word *quality* with his students, he also in some ways dismissed their Discursive understandings of the word quality, viewing these understandings as stereotypes to be corrected:

Maestro Tomas: But I mean, you still have to prepare them, you know, what quality means, because to them, *they have these stereotypes which are somewhat accurate*, but somewhat. . . . They think the river water is bad, that nothing can live in it. You ask them to rate it from 1 to 5. . . . I'd say about 1, but you know, something can live there. We can't drink the water, but you can't maybe even swim in it, but stuff lives in it. So, therefore, is it that bad? No . . . And quality for what? Is it for drinking? Very little drinking water in the world is drinkable without some kind of treatment. . . . So all of those things are going to *cloud judgment*. . . . Yet there's some background because they know what they see in the media and to them, oh, it's just terrible. Everything, our air is terrible, our water's terrible. Well, not really. . . . We need to define, you said it was a creek, you can swim in it. Can you use it for cooking? Can you use it to wash your car? . . . Because that's very different. You could use water in the river, it could be very bad for humans, but you could still use it for cooking or for cleaning your pots and pans.

Author A: And what happens when you boil it?

Maestro Tomas: Well, that's what we talked about, *those of us that have lived in Latin American countries*, because *we can relate to that*, you had to boil it. [emphasis added]

Maestro Tomas was at times able to bridge the space between everyday and scientific Discourses, and seemed especially effective when the issues under discussion connected to life in countries outside the United States. For example, in the above excerpt, Maestro Tomas indicated that he talked with students about the water quality in their home countries. He described the process used in his home to purify water, thus linking the upcoming science project

with both their home and ethnic practices and, potentially, their everyday Discourses. It is significant that in this interview with Maestro Tomas at the conclusion of the water quality unit he positioned himself with his students when he talked about their conversation regarding water purification in other countries. Maestro Tomas's naming of himself as one of the group, identifying himself with his students, was important to his ability to construct a third space in which students' experiences, practices, and Discourses were brought to bear on the ''official script'' (cf. Gutiérrez et al., 1999), or the science under inquiry. In an earlier part of the conversation, Maestro Tomas assumed a more expert position, in which his role was to cast aside students' experiences (''stereotypes'') because such experiences would ''cloud their judgment'' and get in the way of their inquiry. Note the different way that he refers to students and, implicitly to his relationship with the students, in this excerpt:

> Maestro Tomas: But yet there's some background because you know, yeah, *they* know what *they* see in the media and to *them*, it's just terrible. [emphasis added]

These alternate positionings as teacher/scientist/expert or fellow community member seemed critical to Maestro Tomas's abilities to construct instructional congruence, or a third space that wove different Discourses together without sacrificing or dismissing the importance of either set of experiences and ways of knowing the world. When he connected personally with students' experiences, he was better able to merge these Discourses (referring to students and himself as ''us''); when he maintained the position of science teacher/science expert (talking about students as ''they'' and ''them''), making the links was more of a challenge. What is especially significant here is Maestro Tomas's own struggle to bridge the competing Discourses at work in his life, those of science teacher, scientist, and Latino. Maestro Tomas valued scientific Discourse but recognized the role that community, family, and everyday (or media) Discourses played in his own and students' lives. He also struggled to integrate the instructional Discourse called for in project-based pedagogy, as illustrated repeatedly in informal and formal interviews wherein Maestro Tomas would make comments such as, ''I know this isn't constructivist teaching, but sometimes kids need to learn information that I can tell them,'' or ''Why should we take the time to have kids generate questions when they will just come up with what I would give them anyway?'' These comments indicate Maestro Tomas's struggle to integrate the Discourses of traditional teaching that he was familiar with in his own learning experiences, and the Discourses of project-based pedagogy.

Finally, it is important to note that whatever Maestro Tomas may have done with the discussion of quality, his efforts would have been constrained by the fact that the project's driving question itself is rife with competing Discourses. As we analyzed the discourse and Discourses around this question, we turned to student-constructed questions, as a way of examining the Discourse they used to talk about water and air quality. Student questions fell into several categories, with the majority of the questions focusing on why people continue to pollute air and water, when so much evidence exists to demonstrate the negative effects of pollution on the community. Students framed questions such as: Why do people keep polluting? How does pollution happen? and What can we do to stop people from polluting? These questions stand in marked contrast to the driving question of the curriculum, which uses the word *quality* (never used by students) and focuses on the factors that affect quality. Despite the research and development team's efforts to embed the science learning of this project in authentic, community-based concerns by connecting the question to the community's water source, the question is nonetheless an amalgam of scientific and classroom Discourses. It is, at some level, a scientist's question because it focuses on the factors that affect water quality, rather than on why water

quality is an important community issue or what role community members play in shaping water quality.

However, in many ways, the question does not mirror the Discourses of professional scientists because it is a broad question, not aimed at a specific problem related to water quality. That is, scientists would typically approach a particular problem, framed within a particular context, and set about to conduct inquiry related to that problem. Thus, it can be said that the driving question of this curriculum is framed within science *classroom* Discourse, in which students are presented with a question that is designed to help them focus on concepts already studied by scientists. In effect, the question asks students to connect to their community experiences and Discourses to address a question that relates to scientific experiences and Discourses, but is not actually framed in the Discourse of the discipline or in the Discourses of the community.

The quality excerpt, related teacher and student interview data, and student artifacts revolving around classroom discussions of quality reveal some of competing Discourses at work in the classroom, as well as the complexities in addressing these Discourses while offering a curriculum that advances deep and meaningful science learning. Our further analyses of the data revealed the extent of the Discursive conflicts and demands present in the curriculum and classroom pedagogy. We found that the pattern of competing discourses was enacted in two areas: (a) the nature of classroom texts and literacy practices, and (b) the nature of classroom instructional Discourse.

First, the literacy practices and texts offered in the curriculum or enacted by Maestro Tomas were generally framed in language that invited students to bring everyday and social experiences to bear on the classroom activities, but the activities were aimed at a kind of information gathering, dissemination, organization, and display privileged in scientific Discourse. In general, everyday experiences were elicited, but were to be used to build scientific Discourses. Thus, competing Discourses were at play within the literacy practices and texts used to engage students in the inquiry projects.

Second, the instructional Discourses implicit in the project-based curricula and in Maestro Tomas's talk and classroom practice required negotiation across multiple Discourses. This negotiation presented high demands for students as they engaged in scientific and everyday inquiry. In the following section, we present data exemplars that illustrate the Discourse and discursive demands of the literacy, language, textual, and instructional practices.

The Competing Discourses of Literacy, Language, and Text Practices in the Classroom

Because we were interested in both Discourse and discursive demands, our analysis began with the recording and categorizing of various literacy and language events included in both the curriculum and in classroom practice. This first-level analysis demonstrated that both the curriculum and Maestro Tomas's pedagogy made extensive use of print resources. All of the official activities with print that we observed were engaged in for the purpose of gathering, communicating, disseminating, organizing, and displaying information. We thus categorized literacy, language, and textual practices related to the projects as informational tools.

Specifically, we found that although the curriculum does not emphasize the use of print text, and indeed discourages the regular use of a science textbook, the curriculum makes extensive use of texts generated or obtained by the curriculum developers. Other than Maestro Tomas's written class notes, which constituted the most dominant—and complicated—print text of the classroom, curriculum texts were the most extensive print reading material that students encountered in the classroom. Such texts included a class play, excerpts of published textbooks

or Internet texts, and curriculum worksheets that accompanied the texts or project activities. At least one worksheet of some kind was included with each session in the curriculum; consequently, students read worksheets on an almost daily basis. (Worksheets were provided in both Spanish and English.) Each of these texts presented students with competing Discourses (ways of knowing), as well as with demands related to the discourse, or technical language of science.

Curriculum Texts and Practices. The following excerpt from the classroom play, The *Awful 8* (*Los Ochos Detestables*), illustrates how curriculum texts made both discursive and Discursive demands in the opening lesson of the unit, What Is the Quality of Air in My Community? The play begins with an introduction by two newscasters, played by students in the classroom:

> Connie: Hi! I'm Connie Lung.
>
> Harry: And I'm Harry Wheezer. We're here at the Environmental Protection Agency to cover a late-breaking story. Eight of the world's worst air pollutants are picketing the EPA to protest clean-air legislation.
>
> Connie: In tonight's special report, we'll give you the scoop on where these pollutants come from and the ways they can hurt people and other living things.
>
> Harry: Our first interview is with the Particulates.

The play continues in this vein, with each of the eight pollutants engaging in an interview with the reporters. At one point, a new group of pollutants, the Toxins, is introduced:

> Harry: You Toxins are made up of all kinds of poisons. How do you get into the air?
>
> Toxins 1: Hey, man, we come from just about everywhere. Chemical plants, dry cleaners, oil refineries, hazardous-waste sites, paint factories . . .
>
> Toxins 2: Yeah, and cars and trucks dump a lot of us into the air, too. You probably don't know it, but gasoline is loaded with us toxins.
>
> Toxins 3: Wow, that's for sure. There's benzene, toluene—all kinds of great stuff in gas.

Such texts make potentially extensive discursive demands on student readers. That is, in addition to decoding demands presented by this text (which could be high for students who are learning English as they are also learning science), the students must either have knowledge of words such as *particulates* or must have inferential knowledge and abilities so that they can define the words in the context of the materials. (The play was offered in Spanish, but Maestro Tomas had the students perform the play in English, in accordance with the English language focus of seventh-grade science instruction at the school.) In the second excerpt, they are challenged to see the semantic and syntactic relationships between terms such as *toxin*, *poisons*, *gasoline*, *benzene*, and *toluene*, while also performing a particular genre (the narrative play) and reading aloud (again, a particularly demanding discourse practice for those who are becoming fluent in English or for students who simply struggle with reading).

When one maps out the relationship between such terms, it becomes evident that this mapping demand requires fairly complex cognitive processing and a strong sense of the Dis-

course of science and its emphasis on categorizing and naming scientific phenomena in particular ways. One would, in fact, need to understand the relationships between the terms ''poison'' and ''toxin,'' as well as have a sense of how the words *made up of* function in the sentence, to know, for example, whether a toxin was a poison, a poison was a toxin, or whether the words were intended to be seen as synonymous. For a student who is able to map out the relationship, the questions, ''What is a poison?'' and ''How do they affect our air quality?'' are not necessarily answered. Nevertheless, the primary function of this text and others like it in the curriculum was to introduce to students key information in the form of terms, concepts, and relationships.

What makes this text potentially even more demanding, however, is that embedded in the text are competing Discourses, or ways of knowing, doing, reading, and writing. The text, for example, employs a genre (narrative) not typically privileged in scientific Discourse. The idea behind using the narrative genre was to engage students in an amusing play on the science concepts they were to learn (J. Singer, personal communication, June 2000). Although this strategy is appealing, it is also problematic because students are required to negotiate two different Discourses: that of science and of popular culture. For students to make sense of this text, they needed to know, for example, the genre of a newcast as well as the names of two formerly popular national newcasters who are no longer regularly on the air. Students also needed to understand the act of picketing as a form of protest. In this community, picketing was a well-known practice, which raises yet another competing Discourse for students to negotiate: In the play, the picketers are the villains, the ''awful eight pollutants.'' As a result, the text has the potential to construct negative reader and subject positions in which students or their family members could be aligned with negative actors (the picketers), even as the text is used to connect to students' everyday Discourses. Thus, the curriculum introduced competing Discourses, but privileged the scientific (via pre- and posttesting, writing assignments, and final projects).

Curriculum activities that called for students to write their own texts also invoked two Discourses and funds of knowledge, while privileging the scientific. For example, the series of worksheets shown in the Appendix (beginning on page 495) was used after the play. The worksheets asked students to predict possible evidence of sources and effects of pollution around their school and then to take a walk (as a class) around the school and observe for evidence of pollution. (They were to complete the same activity at home that evening.) The next set of worksheets served as a summary of what the students learned in the play. For each pollutant represented in the play, students were to write whether they thought the pollutant affected the air in their community and to provide evidence from the school and home observations they had made. Finally, the students were asked to draw a picture of their observations showing the ''things that may be affecting the quality of air,'' ''things that may show the effects of polluted air,'' and the ''pollutants that might be in the air.'' These worksheets, like all of the activities provided in the curriculum, represent a rich resource of information about pollutants in the students' lives. However, these activities are each framed in the Discourses of science (observe, evidence, sources, effects, and hypothesis) and do not in and of themselves connect to the Discourses and experiences of students' everyday lives. Students are, in effect, asked to draw from everyday knowledge and experience, and to convert that knowledge and experience into scientific Discourse and discourse. We do not wish to suggest that these two Discourses and funds of knowledge cannot be brought together in productive ways; that is, in fact, the goal of constructing congruent third spaces. We present this analysis as an exemplar of the curriculum's tendency to elicit community and everyday Discourses without scaffolding students' or the teacher's integration of community experiences and Discourses with scientific Discourses demanded in the activities.

The Maestro's and Students' Texts and Literacy Practices. In addition to texts generated by the curriculum developers, Maestro Tomas introduced a number of significant texts in his enactment of the curriculum. Maestro Tomas regularly asked students to read excerpts from a textbook that he found useful (a sixth-grade–level text), as well as articles from news and electronic media. As indicated above, however, Maestro Tomas's written notes—recorded on large sheets of brown butcher paper taped to the chalkboard—were the privileged text of the classroom. On these sheets Maestro Tomas would record information from classroom lectures and recitations, instructions for demonstrations and investigations, homework assignments, and journal assignments. During classroom work, Maestro Tomas used these notes extensively, moving back and forth between his oral comments and questions, the written notes, and students' responses and questions.

Writing events included both rote (note taking, bell work, defining vocabulary) and applied or interpretive writings, such as observations of scientific phenomena during laboratory investigations, opinion pieces related to scientific phenomena under study, and family interviews. In general, the reading and writing events focused on extracting, obtaining, summarizing, or clarifying information. Some of the writings, however, included some interpretive, or aesthetic, aspects, often added by the students without the teacher's direct exhortation to bring an aesthetic sensibility to the work. For example, Maestro Tomas asked students to respond—in English or Spanish—to this prompt midway through the study of air quality:

> Imagine a factory opens in your neighborhood. Write a story about what would happen to the neighborhood and how would the air be affected.

The students responded to this kind of assignment enthusiastically, but they also responded in ways that would more appropriately be labeled creative writing rather than scientific or even informational writing. Of the 32 papers produced by students, all were written as journal-like responses, suspense stories, and journal entries written by fictional characters; 23 were stories or fictional journal entries, whereas the other nine were straightforward responses to the question, written as if an entry in a journal. In one instance, a student created a fictional daily journal of a character living in the 1950s:

> June 4, 1956: Today is the day they open the chemical plant. Everyone is exited. But not my neighborhood.
>
> June 5, 1956: The air out here is not so good. My mom say's we can't go outside and play because we might get sick. We sometimes have to were a oxygen mask when we go some were.
>
> June 6, 1956: Many people are complaining. Some workers are on strike because air in there smell's bad.
>
> June 7, 1956: My family and I had gone on strike too. I am a little sick by the air but I can live. But the plan won't shut down.
>
> June 8, 1956: 25% of the people are sick, it's mostly the kid's. The whole neighborhood is on strike. But still the plant won't shut down.
>
> June 9, 1956: Finally the city has going [joined] us. But now 50% of the neighborhood is sick. When will this stop? I'm in bed because I'm real sick. Now my family is mad with the plant.
>
> June 10, 1956: My sister has died from the pollution. My family is now going to take action. Time to sue.

> June 11, 1956: The company is shut down. The neighborhood is a lot more better than it was. The plant is known as the first amusement park in [name of city], [name of state].

Of the nine nonfiction pieces, only one made specific reference to the science the students had learned, but the references were superficial. These texts were striking in their similarity; the following represents a typical example:

> If a factorie moved in to my niehborhood there will be a problem. It would case people to move out and it would make the air palluted. It would hold toxins. have more traffic too. The room would take up space.

Although little specific science content is included in this writing, it is interesting to note that the student had prepared a concept map, albeit a rough one, before writing the paragraph. The construction of concept maps is a key part of the project work, which suggests that some aspects of the classroom instructional Discourse were brought into at least one student's literacy practice, although scientific discourse/Discourse was not.

One of the nine made specific reference to real-world settings, but it did not include any science-specific language:

> Seed I don't like it but there is one by the neighborhood and thats what I don't like that because you talk to us about the air pollution and thats what I don't like about here that why sometimes I prefier to stay inside because there is to much ugly air.

This response is notable because it is written in a conversational format with the teacher and it is based in the student's actual experience. However, like the others, this piece did not serve as a space for linking in deep ways the ideas about air quality learned in science class to the everyday experiences that students had.

In fact, despite Maestro Tomas's focus on writing and reading as informational tools, and despite the enthusiasm and creativity that students brought to the writing of these papers, only 11 of the 32 pieces incorporated terms or phrases drawn from the project work. Such terms and phrases included references to toxins, particulates, sulfur, carbon dioxide, chlorofluorocarbons, acid rain, smog, and ozone (terms they had learned in the play). Five included references to asthma as an effect of polluted air. Almost every paper included some inaccurate or overgeneralized information. For example, as illustrated above, the student who created a fictional daily journal constructed a scenario in which a factory opened in a community and 6 days later his sister died from the negative effects of pollution produced by the factory. What is more, the family sued the factory the day after his sister's death, and the following day the factory was closed. Both of these details indicate a lack of deep understanding of both how pollutants actually affect the quality of air and of the social and political dimensions of environmental quality concerns. And, as mentioned previously, only one of the writings made obvious connections to students' real-world experiences, and this connection was not developed by the student or by subsequent classroom practice.

These differences in how students and teacher interpreted the writing assignments, assignments often made in an attempt to connect the science to students' lived experience and community practices, illustrate the pattern of competing Discourses as embedded in the classroom instructional Discourse. Whereas the literacy practices generated by the curriculum and teacher were information-based, the students took up these practices in more creative, expressive, and personalized ways, at least in part because the assignments were framed within

Discourses associated with language arts classes or everyday discourses that emphasized narration (e.g., ''Write a story,'' ''Pretend a factory closes''). The discourse of classroom instruction in this case (write a story) signaled to students that they should privilege neither the discourse of science nor the discourse of their everyday, real-world experiences, but rather that they should create a fictional piece that incorporated terms and ideas that they had learned. They drew, in effect, on the discourse of language arts or English classes to make sense of the assignment, which had the effect of backgrounding both their scientific and everyday experiences. In each of the activities assigned by the teacher, we found that students were given no exhortation or guidance to write in the discourse genre of science. In neither project unit were the students afforded the opportunity to practice the kind of writing a scientist might do as part of her or his inquiry about air or water quality. We also found no evidence in student writing artifacts or oral formal presentations (videotaped) that the students had integrated the discourse of science with their everyday discourses.

In an attempt to make such a connection, Collazo urged Maestro Tomas to ask students to interview their family members early in the air quality unit about the quality of air they had experienced in different locations throughout their lives. Interview questions constructed by the research team included (a) What do you know about air quality? (b) Do you think air quality is good, bad, or fair? (c) Why do you think that? (d) Compare the air quality in your home state/country with the quality of air here; compare the quality of air 20 years ago with the quality of air now.

Like the other assignments, the interview assignment was informational in nature and was immersed in scientific Discourse, although it was couched in everyday experiences. Questions focused on evaluations and comparisons of air quality and asked routinely for evidence to support these judgments. Thus, although designed to elicit everyday knowledge and discourses, and framed less in scientific Discourses than the curriculum materials, the interview questions accomplished much the same purpose as the other informational activities. What is more, analysis of the responses indicates that many contained inaccurate information, which put Maestro Tomas in an awkward situation of sending students out to solicit information from parents and family members, which he then had to challenge or correct in light of scientific evidence about air quality.

Such an activity had the unfortunate effect not only of setting up conflicting Discourses, but of dismissing the discourse and knowledges that parents and families had about air quality in their communities when contrasted with the discourse and knowledge provided by science. Although we do not wish to suggest that students should not be encouraged to question or challenge information and ideas learned through everyday experiences, it is important to recognize that such an activity can result in the negative consequence of young people learning to separate their everyday, real-world experiences from those of the science classroom. This seems particularly dangerous for students who come from non-mainstream, often marginalized homes and communities.

Finally, much of Maestro Tomas's discourse was embedded in a scientific Discourse in invisible ways. For example, students encountered this poster when they entered class one day:

> J
>
> *Observation:*
>
> Hot and Cold

Maestro Tomas prefaced the small-group observation activity he was planning for students by holding up a beaker and asking students what the beaker was made of. Students offered phrases

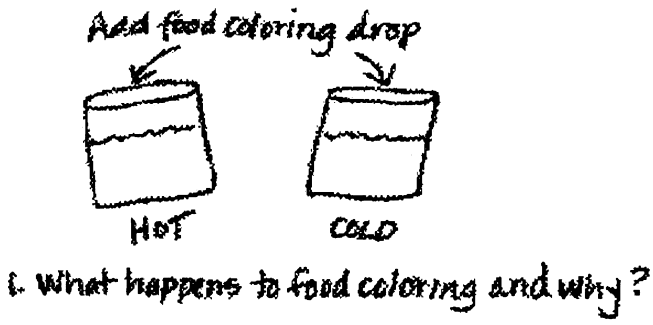

Figure 1.

such as ''sand, glass, petrolio.'' Maestro Tomas responded that he was looking for another word. Someone offered ''molecules,'' which is the word the maestro had hoped to elicit. He reminded them that everything is ''made up of molecules,'' and then walked to the poster paper and added the drawing in Figure 1. As he instructed students to engage in the investigation, Maestro Tomas told them that they should add one drop of food coloring to each beaker and advised them to ''Watch how the food coloring spreads.'' (Note that this language does not necessarily match the words written on the poster, words that were not read to the class.)

A number of Discourses are embedded in each of the different forms of representation (the print text, the picture text, and the oral text) illustrated above. For example, as students walked into the room, they were told in writing (provided that they could decode the English words) that they would be engaging in an observation and that the observation should be recorded in their journals (signaled by the ''J'' at the top of the paper). However, what does it mean to observe and to record the observation in a journal? Is observation of a scientific investigation the same as observation of passers-by in a shopping mall? What were the students to observe? After several readings of the transcript of this interaction, we realized that students were signaled in the first poster to observe differences related to temperature (signaled by ''Observation/Hot and Cold''). Even as relatively sophisticated readers who had the luxury of time to reread, we had missed the signaling sent by ''Hot and Cold'' written under the word ''Observation'' on our initial readings. Understanding any of these signals requires facility with both classroom instructional and disciplinary Discourses.

Although such activities, which were common in Maestro Tomas's class, represent significant Discursive and discursive demands for all students, students who were interacting in their second language were faced with a particularly demanding discursive challenge because of the extensive use of both oral and written language. After watching the five Spanish dominant students in the classroom struggle for several weeks, Author B encouraged Maestro Tomas to begin weaving more Spanish into the classroom discourse, especially when giving instructions and when introducing particularly important concepts. Maestro Tomas also began to encourage students to brainstorm and present in Spanish. These five students began to excel, as noted by Maestro Tomas, who suggested in an end-of-year interview that the students who were at most risk were those whose home and community discourses did not mesh well with the academic Discourses of school and of the science classroom, in particular. Maestro Tomas's comment indicates his awareness of the importance of opportunities to practice the language of different Discourses and yet, as he worked to negotiate the different discourses in his classroom, he struggled to construct congruent experiences from the hybrid discourses and knowledges available.

The difficulty of generating congruent third space explains the analysis that despite the research and development team's desire to make the language of science more accessible to students, we all—whether curriculum developers, researchers, or teacher—at times missed some of the best opportunities to merge everyday and scientific Discourses. There were a number of moments, for example, in which Maestro Tomas might have been able to integrate students' comments and questions, what Gutiérrez et al. (1999) called ''counterscript,'' into the official ''script'' that he and the curriculum offered. As a result, many important student questions and experiences were lost or relegated to counterscript, as in this example from field notes:

> Maestro Tomas is talking about chemicals used to purify waters, and particularly, swimming pools [in the unit on water quality]. He is asking each student to offer questions about water purfication. One of the male students, Jaime, leans over to another and says, ''*Cuando tu vas a la picina ó a la playa, Jorge, tu te tragas el agua?*'' [When you go to the pool or the beach, Jorge, do you drink the water?] Jorge responds: ''No, there's pee in it.'' The boys laugh a little, and go on to talk about other ways they contaminate the water, but the maestro does not hear or does not acknowledge their whispers and snickering.

Such a conversation represents an opportunity akin to those Gutiérrez et al. described in which an elementary-grade teacher skillfully wove students' whispered or giggled questions and language about bodies together with academic language and Discourses about human reproduction. Such a conversation represents a number of similar conversations in the seventh-grade classroom, conversations conducted in Spanish and in English, that Maestro Tomas did not bring into dialogue with the official scientific script.

Gutiérrez et al. (1999) argued that the weaving together of counterscripts (what we have been calling everyday Discourses) with official scripts (or in this case, scientific Discourses) constructs a third space ''in which alternative and competing discourses and positionings transform conflict and difference into rich zones of collaboration and learning'' (p. 5). Maestro Tomas was skilled at engaging students in everyday Discourses as he walked around the room, and when he made reference to the experiences many of them—including him—shared from life in other countries, but he was less fluent in translating these discourses into the Discourses of science. Opening the discussions to both Spanish and English midyear relaxed the official script to some extent, but Maestro Tomas was continually challenged by questions of how to merge the social and academic, or the everyday and the scientific Discourses, in ways that made the most of the project-based curriculum and that supported students' learning of words, themes, and Discourses necessary for fluent reading, writing, and discussing in the science classroom.

Conclusions and Implications

What it means to talk about scientific literacy is changing as a result of more diversity in both student and teacher populations and changes in pedagogy that encourage inquiry and discourse around that inquiry. In the written curricula and enactment we examined in this study, multiple ways of knowing and funds of knowledge came together in both curriculum and curriculum enactment to challenge both science teaching and learning.

First, prompted by a student's question about the meaning of quality, we analyzed the driving questions of the project-based curriculum to find that the questions themselves are embedded in multiple and competing Discourses. The teacher's enactment of the projects provided further complications because his own experiences—like those of any teacher—draw from multiple and competing Discourses. He continually negotiated the different Discourses of his experience.

In addition, as our analysis illustrated, a number of powerful and rich oral and written texts are used or generated as part of the project curricula we examine, but the meaning making of these texts across different Discourses (disciplinary, classroom, and everyday) was not scaffolded for students in either the curriculum documents or the enactment that we observed. In many cases, students were asked to make sense of texts as a way of introducing difficult technical terms, concepts, and themes. Moreover, we observed little attention to the specialized Discursive practices of science and science learning, so that Maestro Tomas and students we observed were at times talking at cross purposes and so that reading and writing assignments were made without attention to how such readings and writings would be enacted differently in science Discourse communities than they would be in communities focused on literary or creative meaning making. Finally, some of these texts drew on or included everyday and popular Discourses and funds of knowledge that students had to negotiate while trying to learn the science content and Discourses valued in the curriculum.

We do not intend this analysis to serve as a critique of the curriculum, our research and development team efforts, or Maestro Tomas's teaching. The curriculum represents a rich and powerful learning experience for students. Similarly, Maestro Tomas was making his best effort to carry out the complex tasks of project-based curricula in diverse language and cultural settings. Maestro Tomas had the challenge of teaching all his students—all of whom could be considered science language learners—the technical Discourses of science, and he was additionally challenged to meet the needs of five Spanish dominant English language learners within a context in which he was pressured to teach students in English. To meet those challenges Maestro Tomas had to be able to merge multiple Discourses, practices, and languages with the Discourses of science.

The curriculum provided a number of excellent ideas to help students call upon their lived or everyday experiences, but these ideas were framed in the Discourses of science (as they should have been) and did not assist Maestro Tomas in connecting these Discourses and knowledges to the students' everyday discourse and knowledges. In fact, the curriculum materials, although useful in calling up students' experiences, do not provide explicit scaffolding for students to make connections, even in the assignments intended to encourage students to apply the scientific ideas to their everyday lives or to life in their communities. It is particularly important to note that the ways that both the curriculum documents and Maestro Tomas put forward the assignments privileged either scientific Discourses (e.g., a worksheet to guide students' school and community observations in which students were instructed to note sources of pollution and their accompanying effects) or everyday and/or fictional discourses (e.g., the assignment to interview parents or to write a story about the closing of a factory). In many ways, the latter assignments were, in effect, assigned as language arts exercises, so that students were not encouraged or scaffolded to take up the science and connect it to their experiences outside the classroom (R. Bain, personal communication, November 18, 1999).

Our data on how students dealt with these demands suggest that a number of students were left out of the classroom oral and written discourse as a result of differences in both language and Discourses. We noted repeatedly in observations and informal interviews, for example, that students had little sense of what certain instructional codes were supposed to signal to them (e.g., ''N'' for ''record in notebook,'' ''J'' for ''record in journal''). We also have artifactual evidence (writing activities and end-of-unit presentations) that suggests that students were not integrating science Discourses or knowledges learned via the projects into their everyday Discourses and funds of knowledge. This lack of take-up on the part of students seems to stem from the literacy and textual practices that employed everyday Discourses and experiences but were embedded in scientific Discourse and constructed for the purpose of teaching scientific discourse (language and concepts).

What Does It Mean to Work toward Congruent Third Space?

What does it mean to draw from students' Discourses and knowledges—in particular, their everyday Discourses and knowledges—so that these Discourses and knowledges can become vehicles for constructing new understanding both in and outside the science classroom? How can curricula support teachers to construct this third space? Gutiérrez and colleagues (1999a,b) illustrated the value of drawing from disciplinary, classroom, and social Discourses and knowledge (what they call official script and counterscript), as did Lee and Fradd (1998) when they discussed instructional congruence in the development of scientific literacy for students from non–English language backgrounds. In this section, we build from these two related constructs to offer suggestions for developing congruent third spaces. We use aspects of the curriculum that drew from students' experiences and moments in which Maestro Tomas seemed ready to develop such spaces with his students to discuss what could be done to take the construction of third space a step further in another iteration of these air and water curricula.

To develop congruent third spaces for language, literacy, and science learning in diverse classrooms, four characteristics of classroom interaction seem necessary: (a) drawing from students' everyday Discourses and knowledges, (b) developing students' awareness of those various Discourses and knowledges (cf. New London Group, 1996), (c) connecting these everyday knowledges and Discourses with the science discourse genre of science classrooms and of the science community, and (d) negotiating understanding of both Discourses and knowledges so that they not only inform the other, but also merge to construct a new kind of discourse and knowledge. Maestro Tomas and the written curriculum achieved the first step of constructing congruent third spaces for the development of scientific literacy, but needed to take that first step further.

For example, in introducing the air quality unit, the curriculum calls for teachers to help students think about the importance of air in people's lives. As the excerpt below indicates, Maestro Tomas began the unit on air quality by asking students to think about elements that human beings require for life: food, water, and air:

> Maestro: How long could you live without food?
>
> [Students' responses include a range of lengths of time. Maestro Tomas writes "7–8 days" on a brown sheet of butcher paper for the class to see.]
>
> Maestro: How long can people live without water?
>
> Student 1: The people in the Dominican Republic still have water even with the hurricane damage.
>
> [This class discussion took place around the time a big hurricane hit the Dominican Republic.]
>
> Maestro: But they have to purify it.
>
> Student 2: I have to purify my water.
>
> Maestro: Water costs money . . . shelter costs money . . . food costs money . . . air is the only thing that is still free. How long can you go without air?
>
> Student 3: 30 seconds.
>
> Maestro Tomas has the students hold their breath and talk about how that felt. Then he segues to an introduction of the air unit by saying, "We are going to find out about polluted air."

As we can see from this data excerpt, Maestro Tomas, supported by ideas developed in the curriculum materials, constructed a context for introducing the air project. That is, the curriculum called upon the teacher to solicit students' experiences, and in so doing the curriculum and Maestro Tomas together brought aspects of students' everyday Discourses and their knowledges about air, water, and human life to the discussion. Despite this invoking of experience, neither Maestro Tomas nor the curriculum drew upon students' everyday Discourses or knowledge in deep ways.

To draw from students' experiences and knowledge bases, a teacher could acknowledge the students' interest in the hurricane in the Dominican as related to the driving question regarding the quality of air in the community. The teacher could begin by asking students to think about how such an incident (a hurricane or natural disaster in another country) could be related to their discussion of the air quality and their future discussion of water quality in their immediate communities. This is not a simple task, however. The teacher would have to help students think about an incident they were interested in (one that focused on water quality) without losing sight of broader goals for student learning about air quality. As Gutiérrez et al. (1999b) suggested, constructing third space is not about letting students run with their everyday Discourses (or counterscripts, in the language of Gutiérrez et al.). Rather, third space is constructed only when disciplinary, classroom, and everyday Discourses inform one another and build new knowledge and Discourse.

To engage in this construction of third space while remaining connected to the driving question of the curriculum, a teacher in this context could ask questions about what students knew about the hurricane, how they thought it might affect air quality, and what means the people of the Dominican would have for ensuring that their air was safe and their water potable after the hurricane had hit. All the while, the teacher could also use the curriculum materials as laid out, continually tying questions about how the hurricane had affected the Dominican Republic to the various curriculum activities. For example, students could use the observation worksheets (see Table 1) to discuss the possible pollutants that might be in evidence as a result of the hurricane. The teacher could also ask a variety of questions to connect students' knowledge of the hurricane with the driving question of the air curriculum and to preface the upcoming water curriculum. Such questions might have focused on the process people use to purify water, how those processes might be like or different from purifying air, and why those processes might be different. Such a conversation could lead to a discussion of the molecular differences between water and air, thus taking students into learning and applying the science concepts intended in the curriculum.

Another possible step might be to follow up on Student 2's comment, ''I have to purify my water,'' to find out why and how this student purified water. Teachers could then link the need to purify water locally to the need for clean air in the community by asking students to consider the ways in which air is similarly affected by both natural and human acts, and how they might learn about whether their air was of the quality that they needed to live healthy lives. Many of these questions could build connections among the various Discourses in the classroom. For example, teachers could ask, ''Are we certain that our current water supply is of the quality we'd like it to be? What about our air? What are some of the types of pollutants that could be found in air or water here? How would they have gotten here? What have we been learning about in this science class that would lead us to believe that we would need to purify the air/water in some way?''

These questions or prompts would help to construct a congruent third space for the oral discourse of the classroom but would not necessarily reshape the use of texts and the development of connections across various forms of representation and Discourses. To do so, teachers could engage students in a variety of reading and writing tasks that would engage them in the

construction and deconstruction of texts across Discourses. Such work could begin by asking students to write an account of the Dominican hurricane or of a natural disaster that they or their family members had lived through. Students could conduct interviews in which they question family or community members about their experiences with events that dramatically changed the quality of their environment in some way. To avoid the problems with interviewing that we described previously, teachers and students could design questions that would elicit descriptions of experiences, rather than evaluations of experiences based on specific content knowledge (cf. Collazo, 1999b). These narratives could then be used to pose Discursive questions about the narratives, such as: Based on what we have learned so far in science class, how might a scientist describe this event? What difference would it make if the scientist were a meteorologist rather than a chemist? If you had been a scientist with an international aid organization or research center (e.g., Center for Disease Control, Federal Emergency Management Agency), what concerns would you have had in the situation described in this narrative? If you had been another community member reading this narrative, what would be your concerns?

Simultaneously, students could read a variety of different published accounts of the Dominican hurricane and other natural disasters and use these accounts to analyze how the events are discussed in different Discourses. They could read newspaper and newsmagazine, Internet, radio and television, popular science, and scientific accounts of these natural events or disasters. They could compare across the accounts to analyze how scientific knowledge, author purpose, the context of the writing (newsmagazine versus a scientist's notebook, for example), and perception of audience played a part in the construction of the account. As they read several accounts, apply specific scientific concepts through various small-group investigations, and practice the terms necessary to talk knowledgeably about air (or water) quality, students could continually revisit the narratives they had constructed at the outset of the unit and practice writing new accounts, including accounts that privilege scientific Discourses, accounts that privilege individual narratives, and accounts that merge the scientific and everyday in an attempt to communicate to broad audiences or to come to new understandings of both scientific and everyday experience. Finally, they could construct a newsletter or newscast in which they draw on these various different Discourses to include different takes on the phenomenon of air or water quality in one document. Such a text might include texts that resemble both the human interest and science articles found in various newspapers and popular science journals.

Each of these suggestions is specific to the particular curriculum we studied in this project, but the underlying principle, that of explicitly connecting and integrating Discourses, experiences, and funds of knowledge, would remain the same across various science projects. The ideas we suggest require teachers and curricula to be explicit about the different Discourses at work in the classroom, teaching students, for example, how the language of science is often different from the language of everyday even when the same words are used (Moje, 1995, 1997). In addition, it is important to frame assignments in ways that signal to students the kinds of texts most appropriate for each assignment and to discuss why particular Discourses are more or less useful (whether for conceptual or political reasons) for achieving different purposes. Asking students to pretend or write a story would be appropriate if the teacher made clear that students needed to apply the science they were learning to a fictional context. A teacher could, for example, engage students in reading science fiction to analyze how authors of science fiction use (or do not use) scientifically accurate concepts to imagine different worlds, and then contrast the reading and writing of science fiction with that of reading and writing scientific reports. The building of such "metadiscursive" awareness, argued the New London Group (1996), is crucial to the development of critical literacy, or a literacy in which students not only navigate different Discourses, but also become aware of the power of discourse to position people in particular

ways and learn strategies for using Discourses skillfully. We assert that metadiscursivity is also crucial to the development of scientific literacy, as students learn skills for making sense of scientific Discourses while also constructing new knowledge that represents an integration of their experiences with those findings and theories generated in scientific discourse communities.

Cautions in Developing Congruent Third Spaces for Literacy, Language, and Science Learning

These findings represent the beginnings of a much larger research project, one in which we hope to engage students in activities that help them construct a third space that supports the integration of scientific and everyday Discourses. In many ways, the construction of congruent third spaces in classrooms requires the deconstruction of boundaries between classroom and community, especially for students who are often at the margins of mainstream classroom life. We are strongly committed to this boundary crossing and deconstruction because we recognize the importance of constructing spaces where students can bring their knowledge and everyday Discourses to bear on science knowledge and discourse and can construct new knowledge.

As we move toward that work, however, we must grapple with what it means to tear down boundaries between the students' classroom lives and their community, home, or peer group lives. Although we have encouraging examples of how to bring together classroom and community discourse genre, experiences, and funds of knowledge offered by scholars such as Moll (1992) and Heath (1983), we are concerned about what it means to integrate this different knowledge these and Discourses, especially in communities that are traditionally marginalized in society. Communities are rarely uniform and stable, and adolescents often challenge the Discourse valued in their own homes and communities (Moje, 2000). Moreover, as Lankshear (1997) noted, the enterprise of fast capitalism has promoted a breakdown of the boundary between public and private so that workers are, in effect, always at their jobs. We wonder if pedagogies that seek to merge students' everyday worlds with the worlds of classroom and discipline similarly trample on private spaces of young people and their families. We struggle with the question of whether our efforts to break down the boundaries between community and classroom will position youth as always at school. On the other hand, not making an attempt to merge Discourses allows the marginalization of some students to continue and fails to address the commitment to science for all. Thus, we believe that if we draw from the analysis presented here regarding the demands posed by a pedagogical approach often suggested as an equalizing method, we can find ways to negotiate our boundary crossing work so that youth will be always learning, but learning in places where their everyday Discourses and knowledge are valued, integrated with others, and expanded.

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Appendix

Possible Evidence: What things would you look for to determine if this pollutant was in your local air? (Include both possible sources and effects.)

SCHOOL

Sources	Effects

Observed Evidence: List the things (evidence) you saw during your school walk which suggest that this pollutant may be in the air. (Include both possible sources and effects.)

SCHOOL

Sources	Effects

For homework: Use a piece of notebook paper and make a table similar to the one above. Make observations at home and list evidence which suggest that this pollutant may be in the air

Pollutant Summaries

For each pollutant which you read about in the play "The Awful 8", write a brief summary (3 sentences minimum) which describes if you think this pollutant is present in the air of your community. Be sure to include the following in each summary:

1. name of the pollutant
2. If you think the pollutant affects the air in your community
3. Evidence you collected (recorded in your chart question 6) which supports what you think.

Pollutant:_____

_____

_____

_____

Pollutant:_____

_____

_____

_____

Pollutant:_____

_____

_____

_____

Pollutant:_____

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Pollutant:_____

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Pollutant:_____

Pollutant:_____

Pollutant:_____

Pollutant:_____

Using the information in your summaries, your group needs to develop a hypothesis on the quality of the air in your community.

Use the following example to help write your hypothesis:

The quality of air in our community is _____ (good, fair, poor) because during our walk we observed_____

School Walk Picture

Using the observations you made during your school walk and home observations, draw a picture of the objects (things you saw) which show the following:

1. things which may be affecting the quality of air in the community
2. things which may be showing the effects of polluted air
3. shows which of the pollutants may be in the air.

You may use either side of the paper. If you use a separate sheet of paper, staple it to this page.