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Science Literacy and Academic Identity Formulation

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Abstract: The purpose of this article is to report findings from an ethnographic study that focused on the co-development of science literacy and academic identity formulation within a third-grade classroom. Our theoretical framework draws from sociocultural theory and studies of scientific literacy. Through analysis of classroom discourse, we identified opportunities afforded students to learn specific scientific knowledge and practices during a series of science investigations. The results of this study suggest that the collective practice of the scientific conversations and activities that took place within this classroom enabled students to engage in the construction of communal science knowledge through multiple textual forms. By examining the ways in which students contributed to the construction of scientific understanding, and then by examining their performances within and across events, we present evidence of the co-development of students' academic identities and scientific literacy. Students' communication and participation in science during the investigations enabled them to learn the structure of the discipline by identifying and engaging in scientific activities. The intersection of academic identities with the development of scientific literacy provides a basis for considering specific ways to achieve scientific literacy for all students. © 2004 Wiley Periodicals, Inc. J Res Sci Teach 41: 1111–1144, 2004

The purpose of this article is to report findings from an ethnographic study of a third-grade classroom in a public elementary school focusing on the co-development of science literacy and academic identity formulation. Through analysis of classroom interactions, student written products, and research interviews, the ethnographic research team identified changes in students' literacy abilities over time and the development of students' academic identity. Current research on identity development has been tied a variety of different factors, including the discourse processes and practices constructed within the classroom community over time (Ballenger, 1997).

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This article will show how students within this classroom developed, constructed, and co-constructed their own as well as others' identities as scientists within and across classroom events. Specifically, this report examines how, within a classroom context, individual identities were formulated by both the teacher and students through particular ''classroom discourse'' about science that was spoken into existence. The classroom discourse about science was then used during the science activities to connect the threads of students' scientific understandings into a tapestry of classroom knowledge. This scientific knowledge was drawn upon by members of the classroom community to exemplify ''actions of scientists'' throughout the academic year.

To address the issues of the academic identity formulation and scientific literacy, our theoretical foundation is built upon two areas of research: sociocultural and situated cognitive studies of students' development of academic identities (Lave, 1988; Lave & Wenger, 1991; Lemke, 2001) and studies of scientific literacy acquired by students as they learn science (American Association for the Advancement of Science [AAAS], 1993; DeBoer, 2000). Sociocultural theory posits the interwoven nature of learning and development within and among students as they engage in the concerted activities of a classroom community (Vygotsky, 1978). From this perspective, learning science entails participating and communicating in socially appropriate ways within a particular community of practice (Kelly & Green, 1998). Students take action and interact with others to construct the contextual knowledge of the classroom. Their learning of and about science is therefore inseparable from the surrounding environment in which it takes place.

Sociocultural Framework for Analyzing Classroom Activity

For sociocultural researchers (e.g., Cole, 1985; Lave, 1991; Penuel & Wertsch, 1995; Wertsch, 1998), students and teachers are viewed as constructing educational contexts through human activity, nested in larger social contexts that are inextricably connected to one another. Individual interactive action is bound up in the immediate classroom culture in which it resides. As these individuals participate in the activity of the classroom, they impact the environment that is, in turn, impacting and changing the way they see themselves within the world. In other words, the reality (cognition, consciousness, and identity) that exists within classroom contexts is the sum product of the social interactions engaged in by members of the classroom and is not isolated within the minds of the individuals. This classroom activity is impacted by the larger school and district culture, which in turn is highly affected by the larger city, state, national, and global culture. Thus, while classrooms may be considered as microcosms of activity that have roles, norms, and values of their own, they should also be considered to be operating within a socially comprised world. In these ways, students' academic identities are constructed as a coordination of perspectives, in which others' images of oneself and of one's own self-images are co-constructed. The situated and constructed nature of identity suggests that these sociocultural processes permeate into structures of individual cognition (Penuel & Wertsch, 1995).

Developing Academic Identities Through Classroom Discourse Practices

The question of identity formulation has been posited from antiquity to the present, using a number of differentiating theoretical and philosophical frameworks. The young, according to Plato, are like delicate green shoots that spring from nature. Their shapes may be set and their natures ''hardened'' into distorted and twisted trunks or into finely upright and well proportioned trees (Anderson, 1934, p. 17). This statement begs the question of whether Plato was attempting to address the issue of identity formulation or whether he was simply expressing the importance of early educational training necessary for the cultivation of virtuous citizens. The field of education is now more than ever paying closer attention to more interpretive perspectives of cognition concerned with the ''sense-making'' processes of everyday life. Theoretical frameworks that have proliferated throughout the fields of psychology, anthropology, linguistics, philosophy, sociology, and education, view culture itself as a place where individuals acquire the symbolic systems necessary to construct meaning and make sense of their world.

According to a sociohistorical perspective (Vygotsky, 1978), robust knowledge and understanding are socially constructed through talk, activity, and interaction around meaningful problems, tasks, and tools. Therefore, the language that is spoken within a classroom context becomes a means for not only enhancing a student's conceptual knowledge base about a specific topic of interest, but also serves as the catalyst in the formulation of his/her academic identity within a classroom culture. From this perspective, it is possible to argue that students acquire knowledge and conceptual understanding in varied ways that are related to a plethora of sociohistorical elements of the culture in which they reside. In a dialogue with another, the interlocutors transcend, to a greater or lesser degree, their prior definition of themselves and actively formulate a new sense of identity. This formulation is not only constructed for the service of the other; it is just as importantly constructed for the self. As the formulation of academic identity is negotiated over time, among students and teachers, the students' perception of self are altered to meet the demands and expectations that they, in union with their educator and peers, have thus far negotiated. Culture therefore, is woven and formulated into a complex public tapestry that is experienced by all those present within a particular social context. It is through the dynamic and social nature of the language within classroom contexts that students come to make sense of the world in new ways. The language of the classroom thus serves as the central material resource for students and teacher(s) to formulate their own as well as each other's identities. In his recent book, Wenger (1998) presents socially defined identities as they occur in communities of practice (Wenger, 1998, p. 151):

> An identity, then, is a layering of events of participation and reification by which our experience and its social interpretation inform each other. As we encounter our effects on the world and develop our relations with others, these layers build upon each other to produce our identity as a very complex interweaving of participative experience and reificative projections. Bringing the two together through the negotiation of meaning, we construct who we are.

Within a classroom context individual and collective identities are constructed through specific classroom discourse and activity as teachers and students interactionally define the cultural knowledge of schooling. In this way, classroom discourse serves to exemplify the situated nature of how a particular classroom community formulates and reformulates individual and collective identities in and through the discursive practices of the classroom. Importantly, one dimension of this acculturation into schooling concerns the communication of what counts as disciplinary knowledge. For example, Brilliant-Mills (1993) investigated how particular discourse practices were associated with mathematical inquiry (e.g., questioning, estimating, recording, reporting, interpreting results, and developing alternative methods and strategies) in a bilingual sixth-grade classroom. The study demonstrated how the language of mathematical inquiry was woven into the everyday lives of students.

In another model, Gee (2002) provides a theoretical account of identity as an important analytic tool for educational research. Gee's model provides four ways to view identity: (a) Nature-identity; (b) Institution-identity; (c) Discourse-identity; and (d) Affinity-identity. In this case, the differing perspectives on identity are presented by Gee as possible stands that may be present and woven together as a given person acts within a given context (p. 101). According to

Gee, what is at issue, when people accept, contest, and negotiate their own and each others identities, is always how and by whom a particular identity is to be recognized when people see each other in certain ways within social contexts (for further discussion, see Gee, 2002). Still other researchers have documented the difficulties experienced by students who may possess the academic ability to succeed in science but may not desire to take on aspects of the identities associated with school science community membership. Brickhouse and Potter (2001) examined the scientific identity formation of two young women of color in an urban vocational high school and how their identities influenced and responded to their school science experience. The researchers reported how these students experienced both marginalization and participation in school communities of science and technology practices (p. 977). The young women had to seek out school contexts where they were able to construct academic identities that allowed them to engage in school science. Consequently, through their social interaction, largely defined by language use and interactional activity, the students and teacher in this study established identity roles for participating within a particular scientific community of practice.

While we draw from a range of sociocultural theories regarding identity, we propose a view of ‘‘academic identity formulation’’ from a particular standpoint. Evidence from the studies and identity models presented suggest the need for a close examination of the discourse processes and contextual activity within classrooms to help identify ways that equity of access to scientific knowledge can be made more accessible to all students (Brickhouse & Potter, 2001). In this study, we are explicitly interested in how students' academic identities were formulated in and through the science language and activity that was co-constructed within this particular ‘‘community of practice’’ (Wenger, 1998).

In subsequent sections of this article, our research reviews the value of instructional practices in science and considers ways that scientific meaning, identity, and knowledge were locally constructed in and through the social interactions of the classroom. The science that took place within this context helped students develop specific ways of observing, thinking, experimenting, and co-constructing new ideas and theories about the phenomena they were studying during their science projects. As scientific knowledge and practice were central to the developing academic identity formulation, we now turn to a review of scientific literacy pertinent to this study.

Science Literacy as a Major Goal in Science Education

In this article, we consider the evolving notion of scientific literacy and its role in an ever-changing societal context. The term ‘‘scientific literacy’’ has come to mean many different things to many different people. Its most common meaning is regarded in light of what the general public should know about science and the attainment of an understanding of certain scientific concepts and ideas (for discussion, see DeBoer, 2000). According to the National Science Education Standards proposed by the National Research Council (1996), scientifically literate citizens should be able to evaluate the quality of science information on the basis of its source and the methods used to generate it. Moreover, scientific literacy should be manifest in different ways, such as appropriately using technical terms, or applying scientific concepts and processes with a certain capacity to pose and evaluate arguments based on evidence and apply conclusions from such arguments appropriately. Connected to the discourses of science are the understandings and use of science concepts, habits of mind, critical thinking, and epistemological commitments comprised in conceptions of scientific literacy (AAAS, 1993; DeBoer, 2000). While learning to connect the semantic relationships of scientific discourse poses challenges to young learners, these broad views of scientific literacy suggest that facility with scientific concepts and methods offers students opportunities to develop abilities to engage in inquiry, evaluate evidence, identify patterns, and think scientifically.

A number of critiques have been leveled against these notions of scientific literacy. First, one problem with scientific literacy as an educational goal is that it leaves unanswered the questions of who decides what is important scientific content and which groups within the general public have greater or lesser degrees of access to this type of knowledge (Apple, 1998; Hodson, 1999). Second, while scientific literacy is often couched in terms of conceptual understanding, inquiry processes, reasoning and communication skills, and social responsibility (AAAS, 1993), Eisenhart, Finkel, and Marion (1996) have argued that the reform proposals foreground conceptual understanding and conventional scientific practices at the expense of creating more socially responsible science by and for a diverse population. Third, scientific literacy has often been understood as an individual attribute, rather than situating literacy within collective praxis (Roth & Lee, 2002). Examination of pedagogy regarding scientific literacy needs to recognize the social nature of literacy demands. Such a view must acknowledge that individuals do not achieve a state of being ''scientifically literate.'' Instead, scientific literacy is relative to a set of particular circumstances that demand use of scientific knowledge and collective expertise in situated ways (Norris & Phillips, 2003). Fourth, Norris and Phillips (2003) draw a central distinction between fundamental and derived senses of literacy in science. They define the *derived* sense of scientific literacy as encompassed in being knowledgeable, learned, and educated in science and *fundamental* science literacy as coming from the ability to read and write on the subject of science (Norris & Phillips, 2003). These researchers make suggestions regarding fundamental scientific literacy and build the argument that reading and writing in and about science do not stand alone as mere devices for the recording and communication of science (Norris & Phillips, 2003). Rather, science literacy in the fundamental sense serves as a central component in building the conceptual, epistemic, and societal dimensions associated with a derived sense of literacy.

Across definitions, a collective view of scientific literacy defines learning to ''do science'' as more than simply being a receptor of factual scientific knowledge and concepts. Attaining scientific literacy additionally involves learning to talk and argue in the language of science (Lemke, 1990) given some particular set of purposes and goals. The social activity of learning science involves the cultural transmission of scientific practices among people within a particular social group (Kelly & Green, 1998; Toulmin, 1972). Nevertheless, these social practices do not occur in vacuo, and they can be more or less transparent for science learners. It is unwise to assume that science students are instinctively able to pick up the scientific thinking, speaking, reading, and writing skills necessary to succeed in science education without direct instruction of how to do so. The adroit abilities required within the disciplines of science and mathematics must be learned through participation in the discourse practices characteristic of the relevant community of practice. The nature of the relevant discourse community is a constant struggle in schools, where the ways knowledge are entered and excluded constitute a central legitimation issue (Apple, 1998). The thematic patterns that exist within the specialized language of science are not automatically acquired by students (Halliday & Martin, 1993) unless their prior experience has been such that they have been taught the vocabulary and technical terms as well as how to properly use the scientific grammar and apply it within a scientific context (i.e., an experiment, dissection, microcomputer lesson, observation, or science report).

This study widens the scope of vision of science as a co-constructed and meaningful collective activity (Roth & Lee, 2002). We, much like Roth and Lee, are concerned with the collective praxis of teaching and learning science from a situated perspective as it occurs in and for a particular community of practice. Our empirical study regarding the co-development of academic identity formulation and scientific literacy identifies how within this classroom community, the social interactions that took place during science investigations allowed students and teacher to co-construct identity roles for themselves and each other. We argue that the development of identity in this manner helped the students to participate in science from a particular frame of reference. The collective language and science activity of the classroom served as socially symbolic resources for communicating and understanding scientific concepts within the classroom culture.

Method

Data Selection

This study took place in an elementary classroom within a public school located in a small city off the Central Coast of California. The data source for this study is drawn from a 1-year study of science teaching within an elementary classroom and includes videotaped records of classroom interaction, student products, and interviews with teacher and students. The data set analyzed for this article takes place during the first half of the academic year, from September to December. To conduct an ethnographic study of a third-grade classroom in a public elementary school focusing on the co-development of science literacy and academic identity formulation, we needed to acquire access to a classroom that provided the range of membership needed for this type of study.

Although the first author had formerly been an elementary school teacher, and was familiar with public school settings, access to the research site was facilitated through the second author. The second author's mutual interest with the first author in co-researching his teaching practices allowed for a negotiated entry into this classroom. The second author introduced the first author to the co-teacher, the children, their families, the principal, and school faculty. For the entire academic school year, the first author collected video data, took ethnographic field notes, conducted science related interviews with the students and teacher, and served as a kind of teacher's aid/teacher within the class. During the first 2 weeks of school, he collected video data everyday and continued to do so for the duration of the school year whenever the participating teacher was teaching. The participating teacher was sharing a teaching contract with another teacher and worked one to two times per week, depending on his schedule. For analytical purposes, we refer to the first author as the ''ethnographer'' in this study. While all three authors contributed to the analysis, the first and third authors completed the initial analysis for review and comment by the researcher-teacher (second author).

By co-researching the teachers' instructional curricular decisions, and teaching practices, we were able to examine the opportunities for learning that the teacher provided for students to develop science literacy. This research approach can serve as a lens through which the relationship among science content, teacher pedagogical decisions, and student learning can be examined.

Participants

The class from which the data were selected contained 17 students throughout the time of data collection. However, at the beginning of the school year the class had 18 students, one of which was transferred to a sheltered English emersion classroom because she was new to the United States and spoke virtually no English. The student population was comprised of primarily of two ethnic groups, defined by the district as ''White'' (56%) and ''Hispanic'' (39%), with smaller percentage of one other ethnic group ''Asian American'' (5%). The students in this classroom ranged in age from eight to nine years of age with 8 females and 9 males. The students' cumulative records were not analyzed for the purposes of this article because the primary author did not wish to form preconceived notions, based on previous years' academic performance, regarding students' ability or inability to learn science content.

Teacher-Researcher

The teacher in this study, Ralph Cordova (second author), engaged in teaching and learning practices that draw upon an ethnographic perspective taking into account theory–method praxis and its role in co-constructing a community of learners. The participating teacher is a member of a teacher-researcher collaborative research group (Santa Barbara Classroom Discourse Group) that examines teaching practices across the content areas in monolingual and bilingual classrooms. Ralph is a leader in the South Coast Writing Project (SCWriP), National Writing Project (NWP), and the National Council of Teachers of English (NCTE). This teacher is an instructor within the University of California at Santa Barbara's Graduate School of Education, Teacher Education Program, has over 10 years of teaching experience, and has recently completed his doctorate in education with an emphasis on Teaching and Learning. Ralph's experience as a teacher, teacher educator, and educational researcher afforded the research team a unique perspective to investigate the ways in which literate practices and academic identities are discursively constructed in the day-to-day situated nature of classroom life.

Ralph was both a teacher educator and an elementary classroom teacher during the year of this study. As a teacher educator, and through his own program of research, Ralph drew from an interactional ethnographic perspective to reflect on, and make visible, the cultural practices of classrooms. In his own elementary classroom, he sought ways to communicate how disciplinary knowledge is framed, with and through the discursive choices of the teacher and students, to make visible connections across subject matter content (i.e., actions of mathematicians, ethnographers, scientists, readers, and writers). Ralph's goals included providing students ways of interacting with and learning from academic content. In doing so, students had opportunities to develop understandings of situated academic literate practices. In his teaching, Ralph mediated the ways in which he offered particular opportunities for learning to become third-grade scientists. Specifically, he mediated the ways in which students took up, represented, and sustained multiple academic identities and roles within the classroom community, as it was co-constructed across time through purposeful activity. Through participation in literate practices, Ralph sought to develop students' academic orientation as they interacted with each other and the academic content across the year. Thus, students expanded their repertoire of ways of acting and being in the world. As a bilingual teacher of Mexican American ethnicity, Ralph was sensitive to the interaction of academic and other student identities, such as their racial, ethnic, or linguistic identities as ongoing developing phenomena. Rather than viewing academic identities as fixed, or as adversely influencing students' ethnic identities, Ralph supported his students in becoming more cognizant of their own literacy development from specific frames of reference.

Studying what constitutes co-constructing literate practices in science and potential academic identities has been an ongoing professional interest of Ralph. He intentionally invited John M. Reveles into his classroom as a way to begin formally documenting the everyday work in which he and his students engage. Therefore, this research partnership comprised Ralph's perspective as the teacher-researcher, who acted as cultural guide for John. Ralph and John worked together across the school year. In and through their day-to-day observations, these two researchers had many conversations about what they were observing as well as ongoing discussions with students about the work they were accomplishing with one another. This allowed for developing a research relationship that made visible and privileged both the teacher-researcher's epistemological perspective as well as the researcher's perspective grounded in the theoretical orientation undergirding this study. Greg Kelly was invited to serve as an analyst and contributed to the ethnographic and discourse analysis. The researchers did not come to conduct research "on" Ralph. Rather, Ralph invited them to conduct research "with" him and with his students. In the current standards driven rhetoric of accountability and high-stakes testing, Ralph provided John and Greg with opportunities to learn what is possible when the teacher views what children are able to accomplish as opposed to what they cannot. In turn, through the ongoing discussions among Ralph, John, and Greg, Ralph had an opportunity to view his practice from a more distanced perspective of researcher as teacher, and not solely the teacher as researcher who was studying his classroom in the moment.

Design and Procedure

Our methodological orientation is based on educational ethnography and informed by sociolinguistic discourse analysis (Crawford, Kelly, & Brown, 2000). This form of analysis examines ways cultural practices are interactionally constructed by the teacher, students, and texts through discourse processes (Erickson, 1992). Using a sociocultural research lens based on educational ethnographic methods afforded us a perspective from which to examine the appropriation of student scientific knowledge and attainment of specific literate skills related to the curricular content. By focusing on students' discourse processes within the classroom community, we examined how individuals' take up learning opportunities while formulating and maintaining identity roles as learners of science. Based on these ethnographic perspectives, we completed a set of methodological procedures initially developed in Reveles, Tuyay, and Kelly (2002):

1. We reviewed video and audio taped records, student science interviews, field notes, and artifacts of the classroom science activities for the entire year in this classroom. This provided us with an overview of the academic year. From this outline we identified several key science activities up on which to focus.
2. To make sense of this data set, we constructed timelines showing the sequences of events and time distributions for each day recorded. Figure 1 presents an index of various science investigations and experiments that took place during the first half of the academic school year. These timelines identified discursive events that linked science learning across the academic year. The timelines made visible the connection of scientific inquiry practices across the curriculum (in language arts, math, social science) and particular culminating activities (e.g., the watermelon investigation, important class discussions about science, and weather-related science experiments) that provided opportunities for student scientific learning.

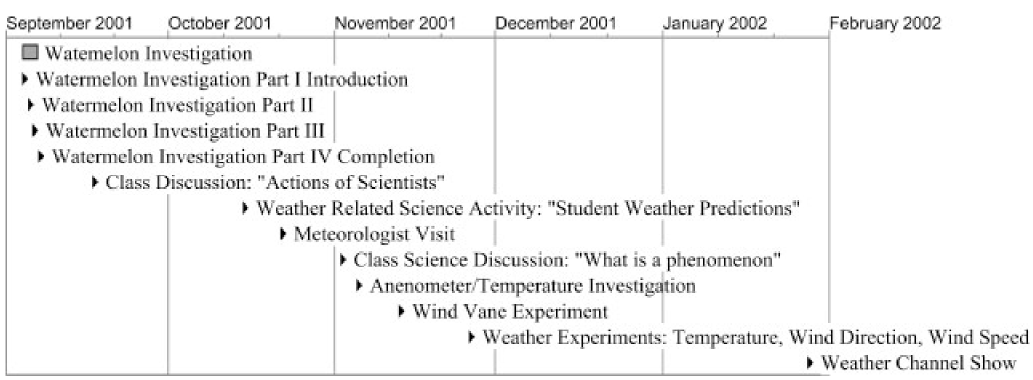

Figure 1. Example of a timeline of classroom science activities.

3. We used sociolinguistic features of the participants' conversations to identify the interactionally marked episodes in the classroom conversations. These procedures are consistent with microanalytic ethnographies (Erickson, 1992; Green & Wallat, 1981; Kelly, Chen, & Crawford 1998), and results in a set of event maps showing the type and nature of classroom events. Figure 2 provides an example of the event maps that were constructed from a direct examination of the video-taped science activity identified by the timelines. Event maps of the science activity and lessons taking place within this classroom context were created for the entire academic year. These event maps serve the analytic purpose of presenting a narrative record regarding the scope and nature of

Event Map I: Onset of Science Activities during 2001-2002 Academic School Year

Watermelon Investigation Project: Day 1

Phase unit I: Introduction to the Watermelon Investigation 00:12:34 to 00:14:04
9:35am – 10:55am
(9/04/01~Tape 2 of 3)
00:12:34 Teacher begins orientation to "what we're going to do today"
00:12:43 Potential divergence: Teacher requests students not to talk at same time as him to show respect for the speaker
00:13:07 Teacher begins talk about class project: watermelon investigation
00:13:10 Teacher notes "tradition."
00:13:21 Project will take the class four days to complete
00:13:30 Teacher explains that the class will be eating the watermelon on the last day
00:13:39 Teacher tells students that its going to be a math project
00:13:58 Teacher asks, "what do mathematicians do?"
00:14:04 code switch to Spanish:
Vamos a empecar sobre lo que es lo que hacen los matematicos. Personas que hacen matematicas, porque vamos a hacer un proyecto trabajando con sandias en un momenentito despues de recreo.
(We are going to begin to think about what mathematicians do. People who do mathematics, because we are going to do a project working with watermelons in a bit after recess.)

Phase unit II: What do Mathematicians do? 00:14:21 to 00:25:50
9:35am – 10:55am
(9/04/01~Tape 2 of 3)
00:14:21 Beginning of conversation about "what is a mathematician?"
00:14:23 Student asks "What is a mathematician" and teacher restates question to class in order to engage students in a conversation regarding what a mathematician is
00:14:43 Teacher uses the example of what is a reader and what do readers do to get students thinking about some of the practices of mathematicians
00:14:51 Teacher asks students if they think that readers imagine when they are reading, study, get confused, get frustrated sometimes, and succeed sometimes
00:15:10 Teacher tells students that, "Thinking along those lines what do mathematicians do?"
00:15:37 Teacher asks students to think about their own experiences doing math
00:15:51 Teacher begins writing student responses, they study math, they think hard, they make their own problems, they write
00:17:59 Teacher tells students that he wants them to start thinking about what it is mathematicians do because they are going to be thinking like different people throughout the year, thinking like mathematicians, thinking like historians, thinking like readers and writers, thinking like scientists like lots of different people
00:19:34 Teacher continues writing answers from students on the white board about what mathematicians do
00:21:53 Teacher reviews list of what mathematicians do with students: they study math, they think hard, they make their own problems, they write, they write down their problems, they solve problems, they think of new ways to solve problems, they sketch, they observe,
00:22:25 Teacher translates the list of what mathematicians do into Spanish
00:25:20 Teacher tells students that they are going to get started with the watermelon investigation but he wants them to understand the actions of mathematicians as it relates to what they physically do

Figure 2. Example of an event map describing classroom science activity.

science activity taking place within this classroom. Constructing these event maps offered an in-depth post hoc analysis of the discursive interactions that transpired during classroom science activity. The use of the event maps as a central analytic instrument permitted a detailed examination of particular classroom interaction representing theoretically significant episodes.

4. Verbatim transcripts of classroom discourse were created for theoretically salient events showing how the science of the classroom was interactionally constructed between teacher and students. We narrowed our analytic focus from the corpus of event maps by selecting dialogic interchanges representing precise illustrations of developing student scientific literacy and identity. For example, among the numerous event maps within the data set we had to choose certain conversationally bounded episodes to transcribe in detail. The chosen episodes represent ways science was framed by the teacher for students and ways the students chose to engage in scientific discourse. These episodes examine the interactional contexts where the students were seen to negotiate, display, and maintain identity roles within the classroom community. This process began from the onset of students' classroom experience with the teacher doing most of the talking to frame science as one of several disciplines with a particular point of view that students would later be asked to appropriate. Once science was framed and connected to the students' own lived experiences, the teacher provided opportunities for students to engage in science activities and articulate their understanding about the phenomena they were investigating. Analysis of these transcripts showed the ways science was communicated among participants. These episodes focused on the communication of science, allowing the researchers to examine students' acquisition of scientific literacy and the formulation of their academic identities. Student identity roles were co-constructed throughout the year during moment-to-moment interaction as students and teacher participated in inquiry-based science activity. For this reason, we had to select particular episodes that represented teacher framing of scientific literate practice as well as student take-up of identity roles and appropriation of scientific understanding. Thus, we transcribed many more classroom dialogic interchanges (i.e., student-student, small-group, student-ethnographer, and student-teacher) than are presented in this article. The transcription data that is embodied in this article are illustrative of specifically chosen representations within the overall cycle of science activity. The transcripts show: (a) how the teacher presented science to his students from a particular frame of reference; (b) how he connected the actions of scientists to students' own lives; and (c) how the teacher afforded students opportunities to engage in inquiry-based activities and appropriate their own scientific understanding regarding learned science content. The chosen transcripts exemplify the fact that the talk of and about science within this classroom formed links of activity that were constructed over time, and were therefore embedded in the discourse between students and teacher.
5. Analyses of the classroom interaction were completed to create summaries and taxonomies of teaching practices and to identify those practices supporting student access to science. Within this classroom context, science lessons were taught in an interconnected manner driven by student and teacher generated research questions and hypotheses. The patterned science activities were structured in such a way as to provide students with varied opportunities to learn about and construct their own meaning about particular phenomenon that they were researching.

Analysis of Classroom Discourse: Science Literacy and Academic Identities

In the following section we present the analysis of several dialogic interchanges relating to the introduction of scientific activity. These dialogues were purposefully sampled to examine opportunities for students to co-construct the scientific knowledge of the classroom and actively formulate their academic identities as ''scientists.'' Therefore, in analyzing the dialogic interchanges presented in this article, our focus was on both ways the teacher framed science, mathematics, and language arts from particular perspectives (thus framing the potential for academic identity development), as well as ways students engaged in scientific literate skills (that is, ways students' identities were constituted through discourse). These episodes were chosen for three reasons: (a) they typify the ways that students within this context learned scientific concepts, and ideas surrounding the investigative study of interconnected phenomena; (b) they indicate typical ways students participated in and contributed to the formulation of their own as well as others academic identities; and (c) the transcript episodes exhibit the use of meta-discourse by the teacher to facilitate students' understanding and meaning about the science content they were studying.

Talking About Inquiry Across Disciplines: Introduction of Meta-Discourse

The first episode occurred during the onset of science activity (see Figure 2, Phase unit II, labeled ''What do mathematicians do?''). At this time, the teacher was introducing the students to ''the watermelon investigation'' science project and speaking about ''actions of mathematicians'' as related to the investigation at hand. Using meta-discourse to lay a strong foundation for science learning and to project into the future certain ideas concerning the actions of mathematicians, historians, readers, writers, and scientists, the teacher initiates a conversation regarding what they will be doing throughout the school year. The term *meta-discourse* is introduced and explained in the following section, referring to the teacher's initiation and continuance of a type of talk taken up with his students that facilitated the co-development of students' science literacy and academic identities.

Mr. C = Teacher (Ralph Cordova), R = Rosa, L = Luke, A = Amelia:

1. Mr. C: thinking along those lines of what readers do, what do mathematicians do?
2. Mr. C: so I'm going to start writing down what it is you tell me.
3. Mr. C: what is it that mathematicians do?
4. Mr. C: think about your own experience in doing math.
5. Mr. C: what do you do?
6. R: they study math.
7. Mr. C: what else to mathematicians do?
8. L: they think hard.
9. Mr. C: they think hard.
10. Mr. C: what else?
11. L: they make their own problems.
12. Mr. C: so they make their own problems.
13. Mr. C: what else to mathematicians do?
14. Mr. C: what does a mathematician do?
15. Mr. C: do they write?
16. Mr. C: sometimes.
17. Mr. C: they not only write word problems they may write stories.
18. Mr. C: they also may write reports.
19. Mr. C: because if a mathematician is going to communicate with other people.
20. Mr. C: they have to be able to express their ideas.
21. Mr. C: what else do mathematicians do?
22. R: they do mathematics.
23. Mr. C: okay they do mathematics, think a little bit more.
24. Mr. C: what does that doing look like when you say ''do'' mathematics?

25. R: they write problems down on paper.
26. Mr. C: okay so they write problems down on paper.
27. Mr. C: boys and girls the reason.
28. Mr. C: I'm wanting us to talk about what these actions are that mathematicians do.
29. Mr. C: so I want us to think about what it is that mathematicians do.
30. Mr. C: because I want you to start thinking like mathematicians.

In this interchange, we see that the teacher engaged the students in helping them come up with a list of the ''actions of mathematicians.'' The teacher drew upon students' existing knowledge base to introduce the idea of taking an interdisciplinary point of view. The students and teacher introducing and taking up multiple ways of knowing and acting as mathematicians, scientists, historians, etc., would be a common set of practices throughout the school year. By providing students with the opportunity understand disciplinary knowledge from the point of view of practitioners, the teacher was creating a context that aided students in thinking of themselves in new ways associated with their actions taken during investigative activity. In lines 1–14, the teacher allowed students to articulate their current level of understanding about what they think mathematicians do. In lines 4 and 30 specifically, the teacher relates students' own experiences in doing math to those of mathematicians and tells them explicitly that he wants them to start thinking like mathematicians. In lines 31 and 32, the conversation proceeded with the teacher signaling to the students a social studies project that they would be engaging in during the immediate future. As in the case with mathematics, the students were asked to think about the specific actions that constitute a disciplinary approach to inquiry.

31. Mr. C: we are going to start another project next week sometime.
32. Mr. C: in social studies where you are going to do interviews with your families.
33. Mr. C: I'm going to ask you to think like historians.
34. Mr. C: people who do and write history.
35. Mr. C: so we're going to be thinking like different people in this classroom this year.
36. Mr. C: we're going to be thinking like mathematicians.
37. Mr. C: like readers and writers.
38. Mr. C: we're also going to think like scientist.
39. Mr. C: we're going to do a lot of science in this classroom.
40. Mr. C: we're also going to think like historians.
41. Mr. C: we're also going to think like responsible people.
42. Mr. C: we will think like lots of different people.
43. Mr. C: but today we can think like mathematicians.
44. Mr. C: so far we have.
45. Mr. C: they study math, they think hard, they make their own problems, they write.
46. Mr. C: they can write down problems on paper.
47. Mr. C: what else?
48. R: they solve problems.
49. Mr. C: they solve problems.
50. Mr. C: what else do mathematicians do?
51. R: they think of better problems.
52. Mr. C: they think of better problems.
53. R: yeah.
54. Mr. C: say more about that.
55. R: they just like.
56. R: they have problems and then make an answer.
57. R: and then they think of another answer of the same thing.
58. Mr. C: okay so they think of more difficult problems.

59. Mr. C: or so if they have an answer.
60. Mr. C: then you're saying that a mathematician may come up with another problem.
61. Mr. C: okay.
62. Mr. C: oh so they come up with different ways to solve problems.
63. Mr. C: is that what you're saying?
64. Mr. C: okay.
65. Mr. C: so there is more than one way of solving a problem.
66. Mr. C: so they think of a new ways to solve problems.

In lines 35–43, the teacher told students that they would be thinking of themselves as many different people throughout the year as they participated in the classroom activity. The teacher let the students know that they would be thinking like mathematicians, readers, writers, scientists, and historians during their work together. In lines 47, 49, and 54, the teacher probed one student's understanding about how mathematicians solve problems and think of new ways to solve problems. Lines 48, 51, 56, and 57 illustrate the student's gradual increase in understanding of how mathematicians think of new ways to solve problems as she interacted with the teacher.

This interchange eventually led to an important understanding of various ways that mathematicians solve problems (lines 60, 62, and 66) as well other things that they do within their community of practice. These ''actions of mathematicians'' were then recorded on a list, revisited, and drawn upon by students during the upcoming science project. This example demonstrated student learning as a co-construction of knowledge by teacher and student. As community members engaged in a classroom conversation about what mathematicians do, students began to realize their ability to think of themselves as mathematicians, readers, writers, scientists, and historians throughout the school year. The understanding of students' knowledge of what mathematicians do was explicitly linked to students' lives by the teacher and was expanded and built upon during the interchange.

This episode marked the first instance of a pattern in the teacher's approach to inquiry across the disciplines. Throughout the school year, Ralph continually oriented students to thinking about actions of inquirers, and connected these points of view to the past, present, and future classroom events. This talk about learning is referred to by us as ''meta-discourse,'' the discourse used by the teacher to orient community participants to the talk about their own inquiry. In this way, Ralph encouraged students to think about how they could learn to see themselves as scientists, historians, ethnographers, mathematicians, etc. This meta-discourse transcended time in the sense that the teacher was continually reminding students of interconnected science concepts and knowledge already covered; while orienting them to the science activity they were participating in, and at the same time fixing their eyes and minds toward future classroom science activity.

Introducing Potential Scientific and Literate Practices

The process of engaging students during the onset of the watermelon project introduced a set of potential scientific and literate practices. These practices are ''*potential*'' in that each instance may become a practice through use over time. For example, a number of the scientific and literate practices are noted in Table 1. These scientific and literate practices introduced students to important ways of engaging with disciplinary knowledge through specific actions and an orientation as inquirers. These potential practices served as initial ways of being students and, we will show, would be reexamined and drawn upon in the future during subsequent investigations. As will be evidenced throughout this article, science in this classroom was presented in meaningful ways and was also woven across the curriculum. Common literate practices were connected to actions taken by members of other disciplines as well as by the students themselves.

Table 1
Introduction of scientific and literate practices during watermelon investigation

Day	Event	Potential Scientific Practices	Potential Literate Practices	Relevant Artifacts/Tools
1	Introduction Watermelon investigation: Part I	What do mathematicians Do:	Common record of actions of mathematicians generated by students	Watermelon
		They study math	Copied into inquiry journal	Scale
		They think hard	Teacher discusses concept of estimation w/students	Chart paper
		They make their own problems	Teacher tells students that he wants them to keep thinking like different professionals:	White board
		They write	Think like Writers	Dry erase markers
		They write down problems on paper	Think like Historians	
		They sketch	Think like Scientists	
		They observe	Restatement by teacher of student response that:	
		They estimate/predict	"Mathematicians come up with different and new ways to solve problems"	
		They practice and do problems over and over	Teacher discusses estimation related to evidence	
		They share	Teacher shows students how the scale works	
		They explore	Teacher puts watermelon on scale	
		They investigate	Teacher affords students an opportunity to try out the scale	
		They argue		
2	Watermelon investigation: Part II	Teacher conducts exercise w/students to exemplify different ways to measure and record results	Student groups begin working on watermelon worksheets	Watermelon
		Student groups cut and measure watermelon in various ways:	Creating a community of learners through job sharing and group work	Scales
		Some cut and weigh the rind and fruit	Access to knowledge through community participation	Tape measures
		Some measure watermelon circumference	Sharing responsibilities in collaborative groups	Knives
		Some weigh whole watermelon		Spoons, rulers, worksheets

3	Watermelon investigation: Part III	Student groups continue working on watermelon worksheets	Teacher asks students to act as observers	Worksheets
		Recording data collected	Introduction to Insider/Outsider information	Inquiry journals
		Measuring	Important Self-assessment rules:	Pencils, pens
		Observing	Sharing	White board
		Estimating	Listening	Dry erase markers
		Analyzing results	Observing	
		Discussing findings	Turn-taking	
			Figuring out how to share	
			Recording/writing information	
			Helping each other	
4	Watermelon investigation: Part IV			Worksheets
		Student groups finish working on watermelon worksheets	Teacher explains and teaches concepts of:	
		Complete recording of data collected during investigation	Deductive reasoning	Inquiry journals
		Measuring	Presenting your perspective	Pencils, pens
		Observing	Arguing your perspective	White board
		Estimating	Teacher discusses investigations and students abilities to argue their points	Dry erase markers

The next transcript presented came from a classroom conversation in which the teacher was speaking with his students regarding ‘‘actions of scientists.’’ In this episode, the students were required to consider how an observation of an everyday event (from an ethnographic perspective) was similar to scientific observations. The dialogue included the teacher, students, and ethnographer and primarily dealt with the teacher speaking to the students about why he wanted them to develop their observation skills. The teacher highlighted the importance of such observation skills as being closely tied to preparing their minds to think like different people (e.g., mathematicians, ethnographers, scientists). This episode occurred in Event Map II, ‘‘Action of scientists,’’ approximately two weeks after the watermelon project. Consider how the classroom conversation ensued in the next excerpt.

Mr. C = Teacher (Ralph Cordova), Mr. R = Ethnographer (John M. Reveles), R = Rosa, L = Luke:

67. Mr. C: I’m going to ask you a very hard question.
68. Mr. C: my hard question is this.
69. Mr. C: why do you think I am asking you to go home?
70. Mr. C: why do you think I asked you to go home and observe?
71. Mr. C: why do you think I did that?
72. Mr. C: why do you think that I as teacher would think that that’s important?
73. Mr. C: it’s a hard question I told you.
74. Mr. C: there is not a right answer.
75. Mr. C: there is no right answer to it.
76. Mr. C: so why do you think I asked to you to go home and observe?
77. Mr. C: Luke?
78. L: (inaudible).
79. Mr. C: right.
80. Mr. C: you were learning in class that day what the actions of mathematician were right.
81. Mr. C: and you also learned what it is that the ethnographer does back there.

In this example (lines 67–81), we see that the teacher was questioning his students as to the rationale for asking them to do a homework assignment in which they were to go home and carefully observe an everyday event and write down some interesting aspects of what happened. The teacher told students up front that this is a hard question and that there was not necessarily a right answer. In line 78, a student answered and the teacher validated his response and repeated the answer for the rest of the class to hear in line 80. In the very next line (81), the teacher connected the actions of mathematicians to the actions of ethnographers. By using the language arts homework assignment, and the classroom ethnographer, the teacher helped the students tie their own observations of the everyday events to other sorts of observations across disciplines. The dialogue continued:

82. Mr. C: Mr. R let me ask you this question.
83. Mr. C: when you are back there Mr. R do you do a lot of watching and looking?
84. Mr. R: I do Mr. C.
85. Mr. C: and seeing and remembering?
86. Mr. R: I certainly do.
87. Mr. R: I remember a lot of what’s happened in the class.
88. Mr. R: at the beginning of the year.
89. Mr. R: at the very first few days.
90. Mr. R: and then I remember.

91. Mr. R: and then I look at what's going on now.
92. Mr. R: and I observe.
93. Mr. R: I think about how you're learning some of the things that Mr. C is teaching you.
94. Mr. R: some of the concepts and interesting relationships.
95. Mr. R: between what mathematicians do.
96. Mr. R: between what ethnographers do.
97. Mr. R: between what scientists do.
98. Mr. R: it's very interesting to me.
99. Mr. C: also observing.
100. Mr. C: students today you are going to be asked today to do an even harder thing.
101. Mr. C: and I know you're going to do it.
102. Mr. C: it's harder because it's going to be new.
103. Mr. C: and I know you'll be able to figure it out.
104. Mr. C: if we're going to start science on Monday.
105. Mr. C: we need to have a mind that's prepared.
106. Mr. C: remember a little while ago I said we're preparing our minds.
107. Mr. C: we're preparing our minds by thinking like mathematicians.
108. Mr. C: we're preparing our minds by thinking like ethnographers.
109. Mr. C: and ethnographers observe everyday things.
110. Mr. C: let me ask you a hard question.

In lines 82–85, the teacher asked the ethnographer what he observed from the back of the classroom. The ethnographer responded (lines 86–98) and articulated the relationship that his observations have to the ways they were learning to think from differing perspectives. In lines 100–108, the teacher continued to explain to the students that they were preparing their minds to begin doing science (line 104) and that these ''habits of mind'' would require that they think like different people (i.e., mathematicians, ethnographers, and scientists).

111. Mr. C: do you think that event that happened last week on Tuesday (9/11/01)
112. Mr. C: when the twin towers were attacked by that plane.
113. Mr. C: are those everyday events?
114. R: no.
115. Mr. C: that never happens does it?
116. Mr. C: but it happened.
117. Mr. C: and now it's part of our history.
118. Mr. C: now an ethnographer.
119. Mr. C: like you guys are.
120. Mr. C: who study that way.
121. Mr. C: and think that way.
122. Mr. C: are thinking.
123. Mr. C: oh, that never happens.
124. Mr. C: I wonder what's going to happen next?
125. Mr. C: so an ethnographer.
126. Mr. C: what they do is they study everyday events.
127. Mr. C: you guys do it all the time.

In lines 111–117, the teacher linked the conversation to an historic national event, the 9–11 tragedy, which had taken place during the previous week. This was done to connect the importance of observing everyday events to the work that students and teacher would soon be doing together. Ralph elaborated on the relationship between students as ethnographers in lines 118–127.

This type of teaching and learning was essential to the formulation of students' academic identities as scientists, mathematicians, ethnographers, historians, etc., and afforded students opportunities to think and learn science in particular ways. Students in this classroom community learned to take on disciplinary perspectives that most third-graders would not have had occasion to do. They were, therefore, presented opportunities to think from different disciplinary frames of reference as they participated in the activity of the classroom. The teacher showed students that they were capable of observing from a particular frame of reference depending on the context. Students were afforded the opportunity to learn that science is one of many frames of reference, which has a particular way of observing phenomena that can take place everyday, or once in a lifetime.

Understanding Actions of Scientists

The third segment was taken from a conversation the teacher had with his students concerning "the actions of scientists." This episode occurred in Event Map II during Phase unit II in which the students and teacher were developing a list of "actions of scientists" that would serve as a valuable resource for students to use during their participation in science activity all through the year:

Mr. C = Teacher (Ralph Cordova), Mr. R = Ethnographer (John M. Reveles), R = Rosa, L = Luke, C = Cameron:

128. Mr. C: I'm making this list here.
129. Mr. C: we're going to make lots of lists.
130. Mr. C: remember I told you?
131. Mr. C: this year.
132. Mr. C: at the beginning of the school year.
133. Mr. C: we're going to be making a lot of lists.
134. Mr. C: when we study a project.
135. Mr. C: make a lot of lists of the things that we do.
136. Mr. C: when Mr. R told us what he did as an ethnographer.
137. Mr. C: we made a list of the things that he does.
138. Mr. C: you went home and you practiced ethnography by observing.
139. Mr. C: what I want you to do now is help me.
140. Mr. C: to list of actions of scientists.
141. Mr. C: tonight for homework you're going to have a special homework assignment.
142. Mr. C: you're going to interview your parents.
143. R: oh.
144. Mr. C: yeah.
145. Mr. C: so you have to get.
146. Mr. C: you have to help me get ready here.

In this transcript, the teacher used meta-discourse to situate students' to the task at hand (lines 129–140) and to remind them that making lists before, during, and after projects would be a regular practice that they would be engaging in together. In lines 130, 132, 133, and 135, the teacher reminds the students that he told them they would be making many lists of the things they do. These lists of actions taken by the students as well as actions of scientists, mathematicians, and ethnographers, etc., served as valuable learning resources for the students to link up the actions they took while participating in science activities to those taken by experts within their own disciplines. The discussion continued with the teacher, ethnographer, and students co-constructing a list of "actions of scientists" to serve as a classroom community resource.

147. Mr. C: what are some things that scientists do?
148. Mr. C: think about that for about 5 seconds.
149. Mr. C: and then we're going to get started.
150. Mr. C: Mr. R do you have a comment?
151. Mr. R: well I was just going to say.
152. Mr. R: I've been thinking.
153. Mr. R: about doing the things that you were talking about.
154. Mr. R: that some students' parents may be scientists.
155. Mr. R: or you know they may have these kinds of things that they do in their jobs.
156. Mr. C: yeah.
157. Mr. C: in fact.
158. Mr. C T: I'm waiting to hear from Nicholas's dad.
159. Mr. C: to invite him to our classroom sometime soon.
160. Mr. C: so he could help us add more to our list.
161. Mr. C: so he could learn what we do as scientists.
162. Mr. C: and he can tells us what he and his community does as scientists.
163. Mr. C: and see what happens.
164. Mr. C: so you're right.
165. Mr. C: lots of different scientists do lots of different things.
166. Mr. R: very exciting.
167. Mr. C: so help me make a list.

Lines 151–155 and 166 illustrate how the ethnographer was often included into the classroom community of practice by the teacher to assist student understanding. In this case the teacher immediately followed the line of reasoning presented by the ethnographer and continued to add to it by stating that he has invited one of the student's father, who is a practicing scientist, to come to the classroom and speak about what he does within his own scientific community of practice. The discussion continued in a fruitful manner with students adding their existent knowledge to the pool of classroom information to build a more complete understanding of the actions of scientists. The shifts in dialogue initiated by the teacher and participated in by the ethnographer provided students with additional explanations of the actions of scientists within scientific communities of practice by making possible connections to students' lives.

The teacher continued to move the conversation forward:

168. Mr. C: and we'll add more to it.
169. Mr. C: what are actions of scientists?
170. Mr. C: what do they do?
171. Mr. C: think about that.
172. Mr. C: what do scientists do?
173. Mr. C: who are they?
174. Mr. C: what do they do?
175. L: I have a question and an answer.
176. Mr. C: ok what's your question and what's the answer.
177. L: uh.
178. L: it depends on what science.
179. L: (inaudible).
180. L: are you talking about a certain scientist?
181. L: a certain kind of one?
182. Mr. C: no.
183. Mr. C: I'm.
184. Mr. C: I'm just saying scientist.
185. Mr. C: so you seem to know that maybe there are maybe different kinds of scientists.

In lines 169–174, we observe that the teacher had brought the discussion back to the matter at hand and was pressing the students to think about what they may already have understood to be actions of scientists. The teacher told students to think about scientists as a group of people and to consider what it is that they do. A student then chimed in with his perspective on the issue (lines 175–181), and the teacher rephrased the student comment for all other community members to hear. The student's question and answer evinced the fact that he already had some understanding that scientists practice their expertise in a variety of different fields and that while they may specialize in a precise scientific knowledge base, they are often collectively referred to by others as scientists. Finally, the teacher reified what the student was trying to express and made the information public so that the rest of the students could benefit from the conversation at hand. The discourse continued:

186. Mr. C: right.
187. L: they study brains.
188. Mr. C: ok.
189. Mr. C: so scientists study brains.
190. Mr. C: hold on.
191. Mr. C: I'm going to write this.
192. Mr. C: hold on.
193. R: they study dinosaurs.
194. Mr. C: wait a second.
195. Mr. C: so then.
196. Mr. C: Luke.
197. Mr. C: can we say?
198. Mr. C: listen to another one.
199. Mr. C: can we say?
200. Mr. C: that there are more than one kind of scientist?
201. Mr. C: ok.
202. Mr. C: so some study brains.
203. Mr. C: who said study dinosaurs.
204. R: me.
205. Mr. C: some of them study dinosaurs.
206. Mr. C: they study.
207. Mr. C: and it has a particular name.
208. Mr. C: right.
209. Mr. C: ok.
210. Mr. C: listen carefully.
211. Mr. C: do you think that those scientists study live dinosaurs?
212. R: no.
213. Mr. C: no.
214. Mr. C: so they study something.
215. R: fossils.
216. Mr. C: bones right?
217. Mr. C: and they make up what they imagine that may have looked like.
218. Mr. C: right?
219. Mr. C: they use their imaginations.
220. Mr. C: and they use a lot of arguments.
221. Mr. C: so they study dinosaurs.
222. Mr. C: and this kind of scientist is called a paleontologist.
223. Mr. C: paleontologist.

In this instance, the student was drawing on his own personal knowledge (line 187) of what his father, a research scientist at the university, does and proceeded to publicly make available this knowledge to the classroom collective. This discursive interaction served as an opportunity for another student to enter the developing discussion and make public her perspective on the matter in line 193. The teacher validated the first student's comment in line 189, 191, 200, and 202 and held on to the second student's remark (line 203–223). He then went on to elicit a clearer understanding, along with the student, of what a paleontologist (lines 219 and 220: *they use their imaginations and they use a lot of arguments*) does. In the last portion of this episode it should be seen that the teacher was connecting the various strands of the conversation into a corpus of classroom knowledge that would be recorded on a list to be drawn upon during future scientific investigations and experiments.

224. Mr. C: what else do scientists do?
225. Mr. C: we know there's different kinds.
226. Mr. C: but what else do they do?
227. Mr. C: Eduardo?
228. E: they learn.
229. Mr. C: they learn.
230. Mr. C: Luke?
231. Mr. C: what else do they do?
232. L: they discover.
233. Mr. C: they discover.
234. Mr. C: what else do scientists do?
235. Mr. C: ok.
236. L: my dad is a computer scientist.
237. Mr. C: so he's a computer scientist?
238. Mr. C: and what does he do?
239. L: he uses instruments.
240. Mr. C: so he uses instruments like microscopes.
241. Mr. C: ok.
242. Mr. C: they use instruments.
243. Mr. C: what else do scientists do?
244. R: they (inaudible).
245. Mr. C: so they predict.
246. Mr. C: and the example you gave us, like volcanoes.
247. Mr. C: in your table.
248. Mr. C: what are some of the things that scientists do?
249. Mr. C: anything Luke?
250. Mr. C: I'll get back to you.
251. Mr. C: Cameron?
252. C: they study things.
253. Mr. C: do we have study already?
254. Mr. C: no not yet.
255. Mr. C: they study.
256. Mr. C: I'm going to ask you to do something.
257. Mr. C: but it's not cheating.
258. Mr. C: it's being smart.
259. Mr. C: is there anything that you saw?
260. Mr. C: that mathematicians do?
261. Mr. C: or that ethnographers do?
262. Mr. C: that we could say that scientists do?

Lines 224, 237, 240, 242, and 248 indicate that the teacher brought back the discussion to the actions of scientists and built upon a student's existent knowledge by making public the information that the student was giving regarding what his father (a practicing scientist) does in order to add the knowledge to the class list. In lines 228, 232, 236, 239, 244, and 252, the student was responding to the teacher's questioning. Although some of the comments were inaudible, the teacher continually repeated the student comments clarifying them and requesting more information associated with things that scientists do. In the last few lines of this transcript (256, 259, 260, 261, and 262), the teacher made an explicit connection for students to draw upon in order to complete their list of actions of scientists. He indicated to students that they could refer to earlier lists of actions of mathematicians and ethnographers to add similar information to the list of actions of scientists. This episode began with the teacher and students coming up with a list of ''actions of scientists'' and continued with contributions by the classroom ethnographer as well as individual students who drew on their own experiences to add to the class list of actions of scientists. In this way, the teacher helped students make connections across the disciplines by showing some multidisciplinary actions.

Constructing Meaning: What is a Phenomenon?

This next episode took place during a class discussion concerning student understanding of the word phenomenon in relation to the science activities that they had previously completed together. Compiled ethnographic field notes and event maps indicate that students were provided a variety of investigative opportunities to understand and appropriate the scientific knowledge of the classroom from a specific frame of reference. In these events, the teacher reviewed and facilitated an improved student understanding regarding the complexities of what the concept of ''phenomenon'' means (see Figure 1, November 13). In this instance, the teacher was orienting his students to understand the concept from a scientific frame of reference. He did this by reminding students of past ways they had studied different phenomena in order that they might draw on their understanding during future investigations.

Mr. C = Teacher (Ralph Cordova), O = Osvaldo, A = Amelia, K = Kathy, R = Rosa:

314. Mr. C: what again does the word phenomenon mean?
315. Mr. C: we studied the phenomenon of ourselves as scientists.
316. Mr. C: which we're doing all the time.
317. Mr. C: we've studied the phenomenon of the wind's speed.
318. Mr. C: we've studied the phenomenon of the sun's heat.
319. Mr. C: on the earth's surfaces.
320. Mr. C: today we're going to study the phenomenon of the wind's direction.
321. Mr. C: what does that word phenomenon mean?
322. Mr. C: so only one, two, three, four?
323. Mr. C: only four, five, six people know.
324. Mr. C: seven people know.
325. Mr. C: that means that.
326. Mr. C: now eight people know.
327. Mr. C: nine people.
328. Mr. C: half of you only know.
329. Mr. C: so that means that half of you only know.
330. Mr. C: the other half that forgot or don't know.
331. Mr. C: try and remember this.
332. Mr. C: I'm going to keep on asking you all the time.

333. Mr. C: what does phenomenon mean?
334. Mr. C: what does it mean?
335. Mr. C: Osvaldo?
336. O: something big.
337. Mr. C: something big.
338. Mr. C: ok.

In line 314–320 the teacher asked the students what the word phenomenon means. He also reminded them of the numerous ways they have studied the meaning of the concept (lines 315, 317, and 318) in the course of their science investigations and told them how they will be studying it on this day. The teacher then repeated the question in lines 321–328 and assessed who does and does not appear to firmly understand the concept. The teacher continued to remind students (332, 333, and 334) that he would repetitively be asking them what the word means. In the following interactions he specified the meaning of the word to its bearing on their classroom definition and use.

339. Mr. C: but how do we define it in the classroom?
340. Mr. C: how are we using that word?
341. Mr. C: Amelia?
342. A: something you could observe with your senses.
343. Mr. C: something you could observe with your senses.
344. Mr. C: and also you do something.
345. Mr. C: right.
346. Mr. C: who remembers the other part to it?
347. Mr. C: Kathy?
348. K: like something that happens.
349. Mr. C: it's something that happens.
350. Mr. C: that you can observe with your senses.
351. Mr. C: what else?
352. Mr. C: do you remember?
353. R: something that doesn't happen every day.
354. Mr. C: and something that sometimes doesn't happen every day.
355. Mr. C: but, for example, the weather that we have.
356. Mr. C: it happens every day.
357. Mr. C: doesn't it?
358. Mr. C: different kinds of weather.
359. Mr. C: but so many times you never stop to study it.
360. Mr. C: what's that?
361. R: rain doesn't happen every day.
362. Mr. C: rain doesn't happen every day.
363. Mr. C: but we have weather every day.
364. Mr. C: we have different kinds of weather.
365. Mr. C: phenomenon.
366. Mr. C: is something that you could study with your senses.
367. Mr. C: right?
368. Mr. C: sometimes some phenomenon is really strange.

In lines 339, 340, 346, 351, and 352, the teacher continued to pursue students' understanding of the word with a specific emphasis on how they have used and defined it in the past. Lines 350, 354, 355, and 356 indicate that the teacher was reminding the students that they have understood a phenomenon to be something that can be observed with the senses and that may or may not occur everyday. Finally (lines 365, 366, and 367), the teacher reinforced the fact that a phenomenon is something that can be observed and studied with the senses.

Applying Scientific Actions to the Investigation of the Weather

This excerpt comes from Event Map V: "The Wind Vane Experiment" (Phase unit III: Checking and Recording the Wind's Direction). In this discussion the teacher was discussing students' findings associated with a wind vane experiment that they conducted. During this experiment the students made their own wind vanes, collected and recorded data on their worksheets, and returned to the classroom to share their findings while the teacher recorded the students' readings from three different locations on a table that he had drawn on the white board.

Mr. C = Teacher (Ralph Cordova), A = Amelia:

263. Mr. C: if it was coming from the south?
264. Mr. C: most of all.
265. Mr. C: half the time.
266. Mr. C: would you say?
267. Mr. C: it was coming from where?
268. Mr. C: north or northeast?
269. Mr. C: so half the time.
270. Mr. C: the wind was coming from over there.
271. Mr. C: I mean most of the time it was coming from that way.
272. Mr. C: half the time it was coming from this way.
273. Mr. C: right?
274. Mr. C: is that right?
275. A: no.
276. Mr. C: north?
277. A: east is over there.
278. Mr. C: east to northeast.
279. Mr. C: half of the time it was coming.
280. A: no.
281. A: northeast.
282. A: northeast would be.
283. Mr. C: oh.
284. Mr. C: northeast?
285. Mr. C: half of the time it was coming from this way.
286. Mr. C: right?
287. A: northeast would be there.
288. Mr. C: yeah.
289. Mr. C: so, northeast.
290. Mr. C: half of the time it was coming from over there.
291. Mr. C: and heading that way.
292. Mr. C: most of the time it was coming from over there.
293. Mr. C: and going that way.
294. Mr. C: you think that could have happened when the wind shifted?
295. Mr. C: it changed.
296. Mr. C: I don't know.
297. Mr. C: we have to figure that out again.
298. Mr. C: if your parents said to you.
299. Mr. C: well
300. Mr. C: where wasn't the wind coming from?

301. Mr. C: what could you say to them?
302. Mr. C: it was never coming from.
303. Mr. C: or mostly never coming from where?
304. A: southwest.
305. Mr. C: you think southwest?
306. Mr. C: that is fascinating.
307. Mr. C: you know what?
308. Mr. C: this is really interesting.
309. Mr. C: I've never had a group of third-graders.
310. Mr. C: able to do something like this.
311. Mr. C: this is pretty amazing.
312. Mr. C: the way that you can just read that.
313. Mr. C: and know what it means.

In lines 263–273, the teacher was clarifying what he was asking the students regarding which direction the wind was coming from before he wrote down their readings. The teacher was physically orienting himself as he spoke to the students about the wind's direction and points toward the direction that he was asking the students about. The teacher then engaged in an interchange with one student (lines 274–289), who began assisting him in clarifying which direction the wind was coming from. In lines 275, 277, 280, 282, and 287, the student was responding to the teacher and was helping him make clear which direction the students found the wind to be coming from. Once this was determined the information was validated by the teacher and made public for the other students to use to report their own weather vane readings. Within this classroom context, the type of science teaching and learning conducted afforded students a range of opportunities to construct meaningful scientific experiences facilitating students' co-development of scientific literacy and academic identity formulation.

Student Articulation of Weather Instrument Research Questions

The final exchange presented here took place midway through the academic year after Ralph provided his students instructions on designing their research questions pertaining to the weather instruments they were investigating. The classroom conversation comes from Event Map VI: ''Weather Experiments'' (Phase Unit VI: Completing Weather Instrument Investigations) after the teacher had given students instructions concerning the investigative questions they had developed two weeks prior. At this point in time, the teacher had each group read their questions related to their planned experiments using weather instruments.

Mr. C = Teacher (Ralph Cordova), A = Amelia, C = Cameron, ED = Eduardo, E = Emily, J = Jade:

314. Mr. C: this is what I want to find out.
315. Mr. C: for the thermometer group.
316. Mr. C: what is or are your questions?
317. C: ''Is the temperature different if you have two thermometers in the same place, but one is under a cup, does it measure the same temperature?''
318. Mr. C: OK.
319. Mr. C: how about your group number.
320. Mr. C: wait I'm sorry.
321. Mr. C: what is or are your questions?
322. Mr. C: no number.
323. Mr. C: but the um anemometer people.

324. Mr. C: your group first.
325. E: ''Can we see the wind speed change at different times of the day in the same spot?''
326. Mr. C: OK guys, listen.
327. Mr. C: they listened to your question.
328. Mr. C: you did not listen to theirs.
329. Mr. C: listen to their question again.
330. A: ''Can we see the wind speed change at different times of the day in the same spot?''
331. Mr. C: how about the other group investigating the anemometer?
332. K: ''Can the wind speed change in the exact same spot?''
333. Mr. C: so you're only gonna measure in one spot to see if it changes?
334. Mr. C: what did the barometer group do?
335. Mr. C: loud voice.
336. ED: ''How strong can the air pressure get in one day? How strong can the air pressure get in one week?''
337. Mr. C: now the last group over here.
338. Mr. C: wind vane what's your question?
339. J: ''How many directions can the wind vane switch to in one minute?''
''Which direction is the wind blowing if it is between north and west?''
''We would like to know how long it would take it to move in one minute?''
340. Mr. C: those are good questions.

In this transcript, we see that the teacher afforded students' the opportunity to voice their own views regarding researchable questions. Students' articulations represent their bids to negotiate participation in the social practice of posing questions. The teacher began the episode by requesting what each student group had constructed as their common question for their respective investigations (lines 314–316). Later, he had students articulate their questions to each other and the rest of the class (lines 317, 325, 330, 332, 336, and 339). Eventually, students would use these research questions to begin their weather experiments in which they would need to collect, record, and report data. This transcript demonstrates how these third-graders were able to articulate viable research questions regarding weather instruments. However, it is important to note that student ability to pose scientific questions within this context was not something that simply happened automatically. Rather, during the beginning of the school year the teacher articulated a vision of inquiry beginning with posing researchable questions. Nevertheless, he ultimately supported his students' scientific literacy development by affording them opportunities to develop and articulate their own unique understanding about weather related phenomena they were investigating.

Student scientific literacy development was supported through participation in the classroom culture. As the teacher was helping to develop students' ability to articulate their own researchable questions within this classroom, he was simultaneously creating opportunities for students' construction of scientific identities. Thus, in order for students to appropriate the necessary scientific language, they needed to make certain discourse choices that would sustain (over time) their academic identities within this classroom context. By participating as they did, students identified themselves as scientifically literate members of this classroom community.

In this and other examples, the teacher can be seen as framing science in reference to disciplinary literate practices, connecting science to students' lived experience, and providing opportunities for students to take-up, display, and maintain academic identity roles. In this way, Ralph contributed to students' scientific literacy development. This approach supported student academic identity development without subjecting his students into choosing identities with academic orientations over other aspects of their cultural and ethnic identity affiliations. Learning to pose questions represents one example of the disciplinary practices that contributed to development of scientific literacy.

We now turn attention to, and focus on, various ways the teacher within this community of practice introduced and recursively revisited other disciplinary practices concerning dimensions of scientific literacy. We also focus our analytic lens on distinctive ways students expressed their self-perceptions in and through their writing.

Table 2 represents a taxonomy of several disciplinary practices introduced during the onset of the school year in the watermelon investigation and later recursively drawn upon during future weather experiments. This taxonomy provides evidence to support the notion that this teacher provided multiple opportunities for his students to engage in meaningful science activity through particular disciplinary practices addressing fundamental dimensions of scientific literacy (Kelly & Duschl, 2002). Table 2 exemplifies the fact that investigative, communicative, and epistemic dimensions involved in the achievement of science literacy were a common feature within the classroom disciplinary practices. Case in point, students were taught how to compare prediction with measurement, conduct experiments and investigations, make predictions, and record observations on a table (investigative dimension) during the watermelon investigation and were later reminded how to used these skills when conducting various weather related experiments. Students were also introduced to, and recursively taught, the disciplinary practice of making ideas public; sharing predictions and results; using schematic diagrams, and recording data in teacher generated science worksheets/journals (communicative). Lastly, students were taught and repeatedly retaught how to argue their scientific perspective, formulate viable research questions, show their evidence, and use that evidence to make claims about their results (epistemic).

Table 3 exhibits student writing regarding ways that they began to see themselves as scientists within this classroom. The information came from student's inquiry journals, which were kept throughout the school year. These journal entries provide a snapshot of the ways students' thought and point to actions marking them as scientists within this community of practice. As an illustration of the self-reflective writing indicating students' self-perceptions as scientists, let us review several examples. Eduardo wrote, ''I'm a scientist because I study a lot of plants or living things; I predicted how the watermelon weighed, height, and width in an investigation.'' Emily indicated, ''I'm a scientist because I did some experiments; I ask questions and get answers; I learn about new things everyday, I do lots of experiments.'' Luke said, ''I do math, I measure, I learn.'' And Samuel wrote, ''I'm a scientist because I read like a scientist.'' These illustrations indicate various ways that students came to view themselves as scientists throughout their participation in the science activity of the classroom. Students' self-perceptions as scientists serve as one of the many indicators that evince ways that students' academic identities were formulated as they engaged in and co-constructed the science knowledge of this community of practice. Framed from a sociohistorical point of view, the development of a critical consciousness and displays of students' academic identities was visible as a manifestation of discursive practices (i.e., speaking, reading, and writing) within this context.

Connecting Science Disciplinary Practices to Academic Identity

The positive outcomes of making learning salient and meaningful for students cannot be overstated. However, it is not enough to teach students science without including certain scientific conventions that will afford them sufficient opportunities to attain increasing levels of science literacy. The transcripts selected for examination in this study epitomize ways that scientific activity was presented. The teacher in this study afforded students frequent opportunities to discursively co-construct scientific knowledge and actively formulate their own as well as each other's academic identities as ''scientists.'' These episodes were chosen because they illustrate

Table 2
Taxonomy of disciplinary practices

Dimensions of Scientific Literacy	Disciplinary Practices:	Introduced During Watermelon Investigation	Re-visited or Introduced During Weather Experiments
	Answering research questions with analysis		{✓}
	Comparing prediction with measurement	{✓}	{✓}
	Conducting experiments	{✓}	{✓}
	Conducting Investigations	{✓}	{✓}
	Creating procedures for taking measurements	{✓}	
	Double-checking findings		{✓}
	Estimating	{✓}	
	Figuring out	{✓}	
	Finding range/average		{✓}
	Generating research hypotheses		{✓}
	Generating research questions		{✓}
	Identifying phenomenon		{✓}
	Making comparative analysis		{✓}
	Making instruments		{✓}
	Making mistakes	{✓}	
Investigative processes/inquiry	Making predictions	{✓}	{✓}
	Making proofs	{✓}	
	Measuring phenomenon		{✓}
	Observing	{✓}	
	Recording (accurate measurements)	{✓}	
	Recording findings		{✓}
	Recording information on a table	{✓}	{✓}
	Recording procedure of investigation	{✓}	
	Sketching	{✓}	
	Taking measurements	{✓}	{✓}
	Understanding ideas		{✓}
	Using instruments	{✓}	{✓}
	Using tools	{✓}	
	Using units	{✓}	
	Verifying predictions		{✓}
	Displaying data	{✓}	{✓}
	Displaying information	{✓}	{✓}
	Keeping science worksheets/journals	{✓}	{✓}
	Making ideas public	{✓}	{✓}
Communicative	Note-making (recording interpretation notes)	{✓}	
	Note-taking (recording observational notes)	{✓}	
	Sharing predictions and results	{✓}	{✓}
	Using schematic diagrams	{✓}	{✓}
	Using visual representations	{✓}	
	Arguing	{✓}	{✓}
	Making claims		{✓}
Epistemic	Showing evidence	{✓}	{✓}
	Using evidence	{✓}	{✓}

how each transcript brought to light a portion of the larger portrait of science learning that took place within this context. The scientific concepts and ideas surrounding the investigative study of interrelated phenomena allowed students to participate in and contribute to the collective science knowledge of the classroom.

Table 3
Student writing about themselves as scientists

Student	Student's Written Comments
Yzabel	I predict and read.
Cody	In the watermelon investigation we used instruments.
Eduardo	I'm a scientist because I study a lot of plants and living things. I predicted how much the watermelon weighed, height, and width in an investigation.
Amelia	I'm a scientist because I learn. I did the watermelon investigation and I measured a watermelon.
Leslie	I ask a lot of questions every day. I learn things from my culture.
Osvaldo	This year my class did a watermelon investigation, and I observed.
Samuel	I'm a scientist because I read like a scientist.
Luke	I do math, I measure, I learn.
Jacob	I predict lots of things. We did the watermelon investigation. We measured things. I read lots of books.
Juan	I do experiments. I did the watermelon investigation.
Kathy	I think I'm a scientist because I record and read. I did the watermelon investigation. I did earth sciences.
Cameron	I like science. I did a science project.
Emily	I'm a scientist because I did some experiments. I ask questions and get answers. I learn about new things everyday. I do lots of experiments.
Rodrigo	I did the watermelon investigation with a partner. We measured the fruit it weighed 6 1/2 lbs.
Alexa	I'm a scientist because when I was in second grade, we learned about magnets.
Rosa	I'm a scientist because my cousin tells me a question.
Nicholas	I'm a scientist because in New Jersey I predicted that there were dinosaur bones in Montana. I ask at least 5 questions a day.

Contemporary views of science literacy are incorporating an array of differentiating perspectives to help explain the extremely interactive process of learning that comprises students' school experience. Several of these approaches adhere to traditional scientific methods of observing, analyzing, thinking, experimenting, and conjecturing while at the same time recognizing the fact that becoming scientifically literate is a co-constructed collective process. Teachers have the difficult task of synthesizing science teaching and learning in ways that aid students in acquiring habits of mind that enable them to grasp what the enterprises of science, mathematics, and technology are up to, in order to deal sensibly with problems that involve evidence, numbers, patterns, logical arguments, and uncertainties (AAAS, 1993). We argue that the teacher in this study achieved this end by providing his students with opportunities to communicate their ideas about science in an academically challenging yet emotionally secure classroom context. As a result, the possibility of examining students' academic identities as scientists was available at this research site. Moreover, students' access to science through social interaction, discourse processes, and participation in self-motivated science activities helped them learn the structure of the disciplinary knowledge being taught.

Discussion

The analyses of the classroom interactions in this classroom community identified a number of teaching practices that provided students ways to participate in and understand science. Student learning was supported by specific teaching practices. The teacher allowed students to communicate their ideas about science in their own unique ways and thus provided ways for the participants to focus on meaning making. As the teacher in this context provided his students with opportunities to develop their own distinctive and relevant understandings of scientific concepts, phenomena, and instruments, students engaged in the construction of scientific knowledge of the classroom. The situated perspective of what constituted learning science as well as accompanying opportunities for student learning were synchronized with recommendations for the restructuring of science. Such recommendations within science education call for students to construct meaning using theories and evidence to build conceptual understanding (Duschl, 1990).

Developing An Academic Identity

There is widespread acknowledgment that children's cognitive language structures result in part from the linguistic interactions that they experience within their environments (Gumperz, 1982; Hymes, 1972; Slobin, 1979; Vygotsky, 1978, 1986). Furthermore, the use of particular discourse processes are not neutral in terms of students identity (Gee, 2002; Gumperz, 1982). Therefore, analysis of the cognitive dimensions of classroom discourse needs to coexist with considerations of the identity formulation among student and teacher participants. Within this classroom context, students' academic identity formulation was constructed through the moment-to-moment formulation and reformulation of norms, values, and expectations. In the examples provided from this classroom, analysis of the discourse processes visibly indicated that as students began to engage with the substantive content of science (e.g., lines 333 Mr. C: what does phenomenon mean? 335 Mr. C: Osvaldo? 336 O: something big 339 Mr. C: but how do we define it in the classroom? 341 Mr. C: Amelia? 342 A: something you could observe with your senses) they also began to perceive themselves as more capable learners. Through learning about the learning processes and examining common academic practices, the students were provided opportunities to transfer their understandings about the disciplines and themselves as learners into other areas (i.e., mathematics, language arts, and social studies). The focus on learning about the common disciplinary practices and talk about the learning, set the science teaching in this classroom in contrast to conventional definitions of scientific literacy. Rather than viewing literacy as a set of attributes to be acquired by the students, the teacher situated literacy in the collective actions of the community of learners and made connections to the disciplinary practices of science, mathematics, ethnography, etc. The students within this context invested time and effort into the science activities to help define their identities as members of this particular community of practice (Wenger, 1998). For these students, identification as members of their classroom community was a process that was at once, both relational and experiential, subjective and collective (p. 191).

The teacher in this study served to enhance students' identity formulation as science learners by conducting particular science lessons in a co-constructive manner. This was achieved by validating the students' identities that they brought to the classroom and by developing students' scientific conceptual knowledge base through an integration of science lessons across the curriculum. Furthermore, the language of the classroom became a resource for not only enhancing students' conceptual knowledge base about science, it also served as the catalyst in the formulation of their academic identities by encouraging students to view themselves as viable members of classroom community of practice. Students in this context began the watermelon investigation with little or no knowledge about conducting a scientific investigation. By the end of the weather investigations, students were speaking, explaining, arguing, and personifying the actions of scientists who were capable and literate regarding knowledge and understanding about science.

Science Literacy within a Classroom Community of Practice

Scientific literacy is often set as an essential goal for students to achieve throughout their academic experience. While it is important for citizens to have certain understandings of and about science, the collective nature of knowing should not be omitted (Roth & Lee, 2002). Science impacts the lives of all people in all nations in diverse ways, therefore, it is critical for students to acquire progressive degrees of scientific literacy in order for them to learn how scientific knowledge is generated, interpreted, and reinterpreted. However, all people will not and cannot know all the scientific theories and facts needed to disentangle the vagaries of socioscientific issues. Rather, individuals within a society need to learn about the strengths and limitations of scientific inquiry and to learn to use scientific expertise appropriately (Norris, 1997).

If all students in our rapidly evolving society are to have equitable access to science knowledge, it also becomes necessary to create scientific learning opportunities that are in congruence with the unique knowledge and understanding that these students bring to the classroom instead of expecting them to bend their ways to those of the majority. In Halliday and Martin's (1993) study of science literacy related to writing, the researchers applied functional linguistics to written discourse relevant to educational settings (e.g., textbooks, scientific texts). Halliday and Martin demonstrated how the application of systemic functional linguistics can identify important structural features of written science. They argue that learning science can pose certain difficulties for students because of specific characteristics of scientific English, including interlocking definitions, technical taxonomies, lexical density, syntactic ambiguity, and semantic discontinuity. Still other researchers have conducted studies focusing closely on the moment-to-moment interactions in various discursive settings (e.g., lab work, group meetings, student presentations). In a series of studies, Kelly, Crawford, and Chen applied sociolinguistic perspectives to the analysis of classroom discourse across research sites (Crawford et al., 1997; Kelly & Chen, 1999; Kelly et al., 1998). These researchers demonstrated how teachers in science classroom contexts diligently worked to create discursive space over time through the encouragement of student articulation of their own scientific ideas. The perspective brought by these researchers has been influenced by educational ethnography and incorporate a common conceptual and theoretical framework that draws on interactional sociolinguistics (Gumperz & Hymes 1972; Green & Wallat, 1981).

The importance of structuring scientific activity as a way of cultural induction is not a new conception. Science educators have long had the goal of developing students' thinking abilities to mirror those of real-world scientists (DeBoer, 1991). Developing student thinking skills that are often associated with scientific practices (i.e., critical thinking skills, problem solving ability, and reflective thinking) requires the presentation of science activities to students in ways that allow them to not only learn how to carry out investigations in science but also affords them the opportunity to learn the discursive practices of science. The data collected for this research endeavor indicates just such an occurrence. The students in this study were afforded a range of opportunities to construct their own understanding of science during ongoing investigations and experiments that allowed them to make sense of the scientific content knowledge through inquiry-based activities.

Concluding Comments

In this article, we have argued that the co-development of scientific literacy and academic identity formulation were interconnected in the sense that each was dependent on the other, with students' academic identities being formulated and reformulated in and through specific science investigations. As students engaged in the collaborative science activity of the classroom during the academic year, they became more proficient at ‘‘doing science’’ in similar ways that scientists participate within scientific communities of practice. Therefore, students simultaneously gained additional competence in their academic articulations, which contributed to the formulation of their academic identities as ‘‘scientists.’’ They were in a real sense, children formulating their identities as students, acting as scientists.

This study provides findings of how a third-grade elementary school teacher taught multiple ways of communicating scientific knowledge while supporting the achievement of scientific literacy in his students. The teacher in this study presented students with manifold opportunities to read, write, speak, think, and understand science and its applications (DeBoer, 2000; Eisenhart et al.,1996; Norris & Phillips, 2003; Wellington & Osborne, 2001). Furthermore, the teacher taught science content to his students in a manner that provided them with opportunities to learn science by doing science. If teachers, researchers, and science educators are to provide students with variant opportunities to learn and contribute to the construction of their own scientific literacy, it then becomes imperative for these habits of mind to be developed at the onset of students' academic experience. Moreover, these thinking skills should be increased incrementally throughout their lives, in order for their facility with the language and activity of science to become a natural part of their cognitive repertoires.

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