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Coherence, Contradiction and the Development of School Science Identities

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Abstract

This study demonstrates the potential for collaborative research among participants in local settings to effect positive change in urban settings characterized by diversity. It describes an interpretive case study of a racially, ethnically, and socioeconomically diverse eighth grade science classroom in an urban magnet school in order to explore why some of the students did not achieve at high levels and identify with school science although they were both interested in and knowledgeable about science. The results of this study indicated that structural issues such as the school's selection process, the discourses perpetuated by teachers, administrators, and peers regarding ''who belongs'' at the school, and negative stereotype threat posed obstacles for students by highlighting rather than mitigating the inequalities in students' educational backgrounds. We explore how a methodology based on the use of cogenerative dialogues provided some guidance to teachers wishing to alter structures in their classrooms to be more conducive to all of their students developing identities associated with school science. Based on the data analysis, we also argue that a perspective on classrooms as communities of practice in which learning is socially situated rather than as forums for competitive displays, and a view of students as valued contributors rather than as recipients of knowledge, could address some of the obstacles. Recommendations include a reduced emphasis on standardized tasks and hierarchies, soliciting unique student contributions, and encouraging learning through peripheral participation, thereby enabling students to earn social capital in the classroom.

Keywords: urban education; equity; sociocultural issues; teacher change; teacher/student empowerment; general science

Coherence, Contradiction and the Development of School Science Identities

> On the first day of the eighth grade science class in City Magnet, Aileen, an African American girl from a working class family, said loudly to the teacher and to the students around her, ‘‘I failed science last year and I am going to fail it again.’’ Since that first day, in both interviews with me and discussions with the other students, she has said that she does not like science and is not good at it. During class, she often speaks with peers in the back of the room about topics that are unrelated to the science concepts that are being discussed. She rarely volunteers to participate in whole class discussion, and frequently says, ‘‘I don’t know’’ or makes jokes when the teacher, Ms. Loman, calls on her. Yet she voluntarily comes each week to a lunch group for reviewing the science topics discussed in class, where she often uses canonical science language to explain concepts to another student who attends. In these explanations, she demonstrates knowledge of many of the ideas and procedures taught in class. In interviews, she says that although she hates science, she likes both her teacher and the hands-on activities. What is particularly confusing is that the same science questions to which she will answer, ‘‘I don’t know’’ in whole class discussion, or will leave blank on a quiz, she seems to be able to answer when in a small group setting in class or in the science lunch group. Her science grades have been low at times, yet her standardized test scores in science are high. While being able to assess a student’s strengths and weaknesses in understanding the material is important for good teaching, it seems like it would be very difficult for a teacher to tell what Aileen knows about science, or her attitude towards the subject (Stacy’s City Magnet field notes, 2002).

Aileen’s enigmatic actions and attitudes toward science are not unique for this urban magnet school eighth grade classroom. There were other students from a variety of socioeconomic, ethnic and racial backgrounds who exhibited inconsistencies in their apparent knowledge of science throughout the year. At first glance, these widely varying performances of science knowledge appear perplexing, highlighting the complexity underlying what it means to know and be interested in a particular subject. Yet an understanding of this complexity is vital for teachers who wish to effectively teach Aileen and others like her who demonstrate discrepancies in what they seem to know about science depending on the setting.

One purpose of this study is to explore why some of the students in this urban magnet school did not achieve at high levels and identify with school science although they were both interested in and knowledgeable about science. The other is to investigate the impact of a

collaborative research approach between four students, a teacher and a university-based researcher aimed at jointly identifying classroom and school structures that pose obstacles to achievement and the development of school science identities and working together to resolve the contradictions. The university-researcher (Stacy Olitsky), the teacher (Linda Loman), and two of the students (Jessica Gardner and Markita Billups) are the co-authors of this article.

Based on our findings, we argue that while the interaction of classroom structures and individual student differences is complex, it is still possible to glean sufficient knowledge in order to implement positive changes that increase opportunities for student participation and learning. We discuss how the use of cogenerative dialogues (Roth & Tobin, 2004) can provide some guidance to teachers wishing to alter structures in their classrooms to be more conducive to more of their students developing identities associated with science.

Research questions included:

(1) Which structural factors, both in the classroom and in the magnet school as a whole, posed contradictions that impeded the development of school science identities?

(2) What types of changes can reduce these contradictions, thereby supporting school science identity development, learning and achievement?

Through conducting research with the students in this classroom, we began to see that what varied with Aileen and some of the other students between settings was not necessarily their knowledge of science, how much they liked science, or even how well they liked the teacher, but how they felt their demonstration of science knowledge would meet their social goals within particular contexts. For example, interviews, conversations and observations all suggested that Aileen would ‘‘talk science’’ in the science lunch group, which was a voluntary weekly science session, because she felt that another student who attended benefited from her

explanations. She was therefore able to achieve solidarity with her peers through engaging with science discourse. However, in the classroom, she sometimes faced negative feedback from peers for her science answers, yet obtained positive feedback for making funny, off-task comments. Rather than knowledge of science existing somewhere in Aileen's mind, ready to be released at the properly phrased question, we view her expression of such knowledge as tied to her performance of her social identity in various settings.

One might consider Aileen to be in a privileged position in the tiered school system (Kozol, 1991) of the large city in which this study takes place, as she attends a magnet school with a selective admission process rather than one of the neighborhood schools which admit students based on their residence rather than based on their achievement. Yet the variations in Aileen's and other students' performances, many of them from minority and/or low-SES backgrounds, suggest that at least this particular magnet school has some problems in howwell it functions as an environment that is supposed to promote learning and achievement among all of the students. It would be too easy for a teacher to observe some of Aileen's whole-class behaviors and decide that she was not interested and not good at science. Lowered expectations of teachers have been shown to have a negative impact on student achievement and often are correlated with student race, class and gender (e.g., Proctor, 1984) thereby contributing to societal inequalities. African American students' opportunities to develop identities associated with science may be further reduced if they are experiencing negative stereotype threat (Steele, 1997) or if the school norms are not congruent with their cultural practices (Parsons, 2008). Aileen may therefore already be in danger of being marginalized in her science classes, as she is an African American female, is from a working class background, and attended an elementary school in a low-income area of the city.

The variability in Aileen's science participation between settings may not draw the attention of some of her teachers. Yet in our society, how Aileen performs in whole class discussion and on her tests is likely to have more important consequences for her future than her explanations in small groups with peers. If she does not achieve in her science classes, her choices and potential for mobility in society may be limited, as science is required in many occupations and for entry into college. It is therefore especially important for teachers to make the extra effort to understand Aileen's varied ''performances'' and to try to set up classroom conditions so that the knowledge and interest that is clearly apparent in Aileen's small group interactions is able to flourish in other classroom activities.

The results of this study suggest that even students within the high tracks of a tiered urban system may face school-related obstacles to developing identities associated with science. We discuss how in this school, some of the discourses perpetuated by teachers, administrators, and peers regarding ''who belongs'' at the selective high school served to highlight rather than mitigate the inequalities in students' initial educational backgrounds. These inequalities generally corresponded with race and class, as the neighborhoods in the city are segregated and schools are unequally funded.We found that school discourses, procedures and rules that promoted the idea of a ''meritocracy'' often allocated advantages to the development of school science identities for the White, middle class students. They also interfered with the classroom functioning like a community of practice (Lave & Wenger, 1991) in which peripheral participants can become enculturated into and have an influence on collective activity.

Through cogenerative dialogues between the teacher, students and university researcher, we found that some of the ways in which the school procedures and discourses exacerbated inequalities were amenable to change, as they were influenced by particular classroom structures

and teacher practices. Over the course of the study, the teacher was able to modify aspects of the classroom in order to increase opportunities for student agency in expressing identities associated with school science and in achieving. Although school-wide changes were not actually undertaken in this classroom-based study, we also make suggestions for such changes based on the outcomes of these dialogues. We hope that this case study can provide a model for improving science learning that empowers students and teachers to work collaboratively to reflect and act with the goal of effecting positive change in science classrooms, particularly in urban settings characterized by diversity.

Theoretical Background

Science is a social activity, requiring collective effort in designing and conducting experiments and developing evidence-based explanations and arguments. Lemke (1990) highlights the importance of discursive practice for science learning, as students need to develop the ability to recognize and communicate thematic patterns, or concepts, which are networks of relationships between terms. Further emphasizing the importance of discourse, Airey and Linder (2009) characterize learning as, ‘‘coming to experience disciplinary ways of knowing as they are represented by the disciplinary discourse through participation’’ (p. 28).

Lave and Wenger’s (1991) conception of ‘‘communities of practice’’ provides a useful model for classrooms designed to encourage such discursive practice among participants. They describe how such communities are characterized by interaction among peripheral participants as members provide scaffolding for each other to acquire the skills and knowledge for participation in collective, goal-oriented activity, rather than relying on a one-way dissemination of information from expert to novice, such as from a teacher to a student. Theoretically, learning

any particular subject or skill should be an opportunity for individuals not only to increase their knowledge, but also to expand the communities of practice in which they participate and therefore to add to their identities. While Lave and Wenger focused on professional communities in their research, Brickhouse, Lowery, and Schultz (2000) write that the communities of professional scientists are too distant from the textbook science in which students participate to be considered a relevant community for students. Instead, they refer to the social community in which students participate as ‘‘school science,’’ which has both similarities and differences from professional science in norms, procedures, and language. They write that whether a student will provide a scientific explanation is influenced by whether the student has developed a sense of identity as a member of a school science community.

Brown (2004) describes how students have ‘‘discursive identities,’’ in that they use particular language in order to signify the types of people that they are. In his study of an urban classroom, he found that some students acquired scientific ways of viewing the world yet resisted using science discourse because it involved a conflict between identities associated with science class and their cultural identities. He describes a typology of student behaviors: Opposition status, Maintenance status, Incorporation status, and Proficiency status. He writes:

> Those individuals who demonstrated the Opposition status Discursive Identity avoided use of science discourse as a rule. Generally these students employed several strategies to avoid using science discourse, including denying knowledge of answers, avoiding discourse opportunities, and yielding speech opportunities to fellow classmates. Students who demonstrated Maintenance status employed science-specific discourse, yet moved into nonscience specific genres in an effort to maintain cultural identity. . .Individuals who demonstrated Incorporation status demonstrated short-term mastery of science discourse practices. . .Lastly, students who demonstrated Proficiency status engaged in extensive use of science discourse, incorporating technical terminology as a product of their everyday classroom discursive practices (p. 824).

In City Magnet, rather than individual students generally falling into specific categories, more frequently a student's actions along this continuum would vary depending on the setting. While Aileen sometimes showed an ''oppositional'' discursive identity in class, in small group work she often displayed more of a ''maintenance'' status. In a lunch group in which students discussed science topics, she sometimes showed a ''proficiency'' status. Following Hsu, Roth, Marshall, and Guenette (2009) we do not take students' use of science discourse or self-descriptions as representative of identities ''in the head,'' but as self-presentations relative to context-dependent goals.

We found that a helpful way to understand Aileen's and other students' apparently changing discursive identities is to conceive of identity as continually constructed and as emerging from a dialectical relationship between agency and structure. Tobin (2005) draws on Sewell (1992) in describing structures as consisting of both schemas and resources. ''Schemas'' refers to norms, ideas, principles of action, and habits, which include the ideas communicated through discourses. Material resources include the physical setting, the nature of the relevant task, and the resources for learning available. Human resources refer to students' stores of cultural, social and symbolic capital (e.g., Bourdieu, 1986), which are exchangeable and have a powerful influence on people's social positions and ability to attain their goals. In this study, we use the term symbolic capital to refer to labels assigned to individuals, although we recognize that this is only one of the forms of symbolic capital as Bourdieu has described. Sewell (1992) describes how structures both constrain and enable action, but that such structures can be changed as a result of human agency.

A view of identity as emerging from a dialectical relationship between agency and structure suggests the strong role that classroom discourses, rules, procedures and norms play in

whether students adopt ‘‘proficiency’’ discursive science identities. It also suggests that the structures that pose obstacles to the expression of science-related identities are amenable to change by the actions of agents. In this study, we worked as co-researchers in order to identify classroom and school structures that posed contradictions for students’ science participation. We then used these insights to plan for changes that could reduce contradictions and support students’ science learning and identity development.

The Setting

The city in which this study takes place is one of the largest school districts in the country, serving over 200,000 students who are predominantly from non-dominant backgrounds. Eighty percent of the students are non-White and 71% receive free or reduced lunch (Orfield & Lee, 2005). The larger metropolitan area has a tiered school system (Kozol, 1991), with high-achieving suburban schools, urban magnet schools, and neighborhood schools. While students within the city limits do not have the choice of attending the better-funded suburban schools, within the district there is an extensive choice system that includes magnet schools, charter schools, and small learning communities within neighborhood schools. City Magnet is divided into a middle school, grades 5–8, and a high school, grades 9–12. Students are selected from elementary schools throughout the city to attend the middle school based on their third grade test scores and grades. In the eighth grade, City Magnet students submit applications for high schools and are chosen for admission based on their grades in seventh grade, behavior marks, attendance record, and scores on standardized tests. Only about 100 out of the 200 eighth-grade students will be selected to enter the more prestigious high school, housed in the same building. The remainder of the students either attends other magnet schools, private schools, or neighborhood

schools. By neighborhood school, we refer to a school in which students are placed due to their residential area. Some of these schools are very under-resourced. The middle school at City Magnet has a much larger population of African American children than the high school, and several of the teachers have expressed concern about the lack of diversity in the high school.

The eighth-grade classroom that is the focus of this study had 33 students. Of these, approximately 40% were White, 34% were African American, 10% were Asian American, 10% were Latino, and 6% were multiracial. Some of these students came to City Magnet from private schools, some from elementary schools in middle-class neighborhoods, and some from elementary schools in low-income, predominantly African American neighborhoods. While all of the students were high performing in their elementary schools, at City Magnet there were large variations in academic performance that tended to correspond with whether they attended elementary school in a high-poverty area of the city. For example, on the first science test of the year, eight students failed and eight students received As. Most of the students who failed had attended low resourced schools.

The eighth grade class was divided into physics, chemistry, and earth science trimesters. The eighth grade science teacher and co-author of this article, Ms. Loman, is also their advisory and guidance teacher and teaches high school physics. Her teacher education was based on her experiences teaching in Papua New Guinea in the Peace Corps. When this study began she had just finished her Master's in Education through a Returned Peace CorpsVolunteer program to bring science teachers to urban districts. She is White, in her late 20s, and came to this city from New Mexico. The university researcher (Stacy) is also White.

In the beginning of the research project, Ms. Loman discussed some of the difficulties she had teaching all of the students effectively, given the variety in students' backgrounds and

experiences with science, and her cultural differences from the students. She had a strong desire to alter her teaching and the conditions in the classroom to bridge the gap in achievement and enable a greater number of students to succeed.

City Magnet cannot be considered representative of the city's public schools. However, in many ways the selectivity of the school made it a good setting for studying how school and classroom structures can constrain and/or enable the development of identities associated with science. Since students had been selected for their high achievement, and since interviews indicated that they generally tended to value school success and class participation, it is unlikely that resistance to schooling or associating achievement with ''acting white'' (Fordham & Ogbu, 1986) was the predominant influence on some students' avoidance of science discourse. Therefore, students avoiding canonical science language in the classroom even though they used it competently in other settings could be more specifically related to the conditions of the science classroom, attitudes toward science, and social interactions surrounding science rather than students' dislike of school.

Methods

In conducting ethnographic research, we drew on some of the practices of critical ethnography (Anderson, 1989) in our efforts to avoid a traditional researcher/researched relationship that could exploit individuals (Barton, 2001). We evaluated the ongoing research project using Guba and Lincoln's (1989) criteria for validity and authenticity in ethnographic research, which require fairness, an emphasis on increasing understandings of others' perspectives, ontological authenticity which ''refers to the extent to which individual respondents own emic constructions are improved, matured, expanded and elaborated, in that

they now possess more information and have become more sophisticated in its use'' (p. 248), and catalytic authenticity, which requires working with participants toward positive change in local settings. We viewed change as requiring collectively identifying and eliminating the internal contradictions within classroom activity (Engeström, 1999) that prevented students from science identity development, learning, and achievement. The goal for research was not only to benefit a distant readership, but also to help participants develop a greater understanding of their social situation and to work toward freeing themselves from structures that limit them. We were influenced by other projects that have involved students as researchers, such as Elmesky and Tobin's (2005) study, where students made significant contributions by providing insider perspectives, conducting interviews of peers, and serving as teacher educators.

In selecting the four student researchers, Ms. Loman and Stacy asked students who were different from each other in terms of their academic achievement and their expressed interest in science. Involving students who differed in these ways would allow for some of the benefits of maximum variation sampling, facilitating ''detailed descriptions of each case'' and ''important shared patterns which cut across cases and derive their significance from having emerged out of heterogeneity'' (Patton, 1987, p. 53). The concern was not to provide a representative sample of the students to act as researchers, but to have a variety of perspectives.However, we also were interested in having a stronger representation of African American students among the researchers than in the student population of City Magnet, because the public school population in the city is predominantly African American.

Three of the student-researchers were African American girls who had come to City Magnet from neighborhood elementary schools. Aileen and Markita were failing science at the beginning of the semester. Jessica usually gets As or Bs in her classes but got a 65 on the first

science test. The fourth student researcher, Lisa, usually gets As in her classes. Her father is White and her mother is African American. The four students had very different experiences with the high school choice system, with two of them attending high schools that they chose (Jessica and Lisa), and two of them not attending their desired choices (Aileen and Markita).

Markita grew up in a single parent home with an older brother and a younger sister. She was the first person from her community to attend City Magnet. Her mother worked for the city but was injured during Markita's enrollment at City Magnet. This caused her family to fall deeper into poverty. During ninth grade, Markita's mother passed away and she became the rock of the family, managing the household by working, attending school and taking care of her younger sister. Despite this hardship, she continued to excel academically and completed high school with honors.

Jessica grewup in a two parent home along with an older brother and sister. Like Markita, Jessica was the first person from her community to attend City Magnet. Her mother was prompted by her fourth grade teacher to enroll her in City Magnet because she felt the curriculum being taught at the neighborhood school was not challenging enough. Jessica did not stay at City Magnet for high school but attended another magnet school. With the support of her family, Jessica graduated in the top 15% of her high school class and is pursuing a Bachelors degree in Biology.

Initial Year of the Study

During the 2001–2002 school year, the university-researcher (Stacy) acted as a participant observer in the classroom. She attended class two to three times each week, videotaping and taking field notes. She also interviewed students about science learning and

various other topics related to their schooling experiences, held meetings with just the student researchers, debriefed with the teacher after class sessions, conducted a weekly voluntary science lunch group designed to supplement the classroom learning, sat with the students during assemblies when high school representatives gave presentations about high schools, attended peer advisory sessions, sometimes co-taught with Ms. Loman, and facilitated research meetings with both teacher and student co-researchers.

The student researchers' roles included participating in research meetings and interviewing other students about science learning and high school selection. Having students interview other students was advantageous in that the students can better understand the experiences of other students, and would be able to elicit ideas in ways that the university-researcher could not. The students received training in conducting interviews by the university-researcher, and they benefited from developing new skills and taking a more active role in constructing and carrying out the research. The teacher researcher's role was to participate in research meetings with Stacy and the student researchers, to keep a journal of reflections on class sessions, and to discuss the classroom events with Stacy in separate meetings.

The research meetings were structured as cogenerative dialogues, in which participants review classroom events, discuss the structures that pose contradictions to both individual and collective goals, and generate solutions to problems. These dialogues promote collective responsibility for classroom events and lead to shifts in roles of teachers and students in order to increase all participants' agency in expanding practices and improving learning environments (Roth & Tobin, 2004). In these dialogues, we informally discussed issues that were of concern to both the students and Ms. Loman, reviewed videotapes of class, and identified and examined salient incidents involving teaching and learning. While we recognize that divisions in power

between teachers and students persist regardless of our use of cogenerative dialogue, this separate field allowed for criticism and disclosure, which do not often occur in classrooms. Students did not need to fear that their grades would be affected, and Ms. Loman had the freedom to ask questions that normally she would not ask because of the need to maintain authority in the classroom. The process of cogenerative dialogue as a whole empowered students to be reflective and critical of teaching and learning, and gave Ms. Loman information about student perceptions of the class and social constraints that would not have been obvious to her. A limitation is that only these four students participated in the dialogues, whereas there were other classroom participants who were not heard in this format.

Stacy held somewhat of a facilitator role during these dialogues. While all members of the research team raised issues and questions, she began most meetings with topics and video clips that could serve as initial foci for discussion. These topics were most often prepared either in collaboration with Ms. Loman or on the basis of conversations with the student researchers. During the dialogues, she sometimes posed questions and invited participants to clarify their statements to ensure that participants understood each other's ideas and that conflicting opinions on various issues were discussed rather than de-emphasized in favor of consensus.

During some of the weeks when Ms. Loman had other responsibilities, Stacy met with the students alone. In addition, Stacy often met with Ms. Loman after class. During these meetings, topics could be discussed that might not be appropriate for the cogenerative dialogues, yet were helpful in insuring that all of the participants' ideas could become part of the emerging research questions. For example, Ms. Loman could discuss issues regarding students' grades with Stacy, yet she would not have felt it appropriate for the student researchers to hear her talk about grades. As another example, the students could talk about high school choice with Stacy,

which was important to understanding the climate of the school and the impact on science learning. However, this topic did not often emerge in cogenerative dialogues, during which the students were more inclined to discuss potential improvements to the science class.

In addition to facilitating research meetings, Stacy conducted a voluntary science lunch session once a week where students who were having difficulty in the class could discuss topics that confused them. Usually, Aileen and Markita were the only students who attended, although others came occasionally. Ms. Loman often gave materials to Stacy to guide her in focusing the discussion on upcoming topics.

During this eighth grade year the goal was to have the students act as researchers rather than as informants, but it was a gradual process. In the first year, students' roles extended beyond informants in that they constructed rather than merely consented to research questions and assertions, and participated in data gathering and analysis. However, the 45-minute lunch periods did not provide enough time for students to be developing their own presentations and writing. In addition, the cogenerative dialogues mostly centered around participants' emic constructions, rather than including the emerging theoretical constructs.

The 3 Years Following the Study

During the summer following the eighth grade school year, the teacher and the four student researchers met for 4 hours, 5 days a week, for 6 weeks in order to work on data analysis. The sessions took place in an office that was equipped with computers, transcribers, and video editing equipment. The students spent their time learning and applying social theory, analyzing videotaped class sessions, transcribing, interviewing each other on various topics, creating home ethnographies, developing PowerPoint presentations on aspects of Ms. Loman's teaching and

student learning, and writing. For their home ethnographies, students borrowed a video camera for the weekend in order to gather data on their own lives. They brought these tapes into the office and using the I-Movie software, edited them into 5- to 9-minute videos. At the end of the summer, they presented their ethnographies and PowerPoint presentations to other university researchers, teacher researchers, and student researchers who were involved in the larger five-school study in the city. While during the eighth grade school year the research meetings were voluntary, during the summer students were paid for their work. It was over the summer that students moved from more of an informant role to a researcher role.

After that summer ended, Ms. Loman moved to Colorado for a new teaching position. However, Stacy and Ms. Loman continued to collaborate on the research project through exchanging papers and short pieces of writing, having phone conversations surrounding research topics, and meeting twice a year for intensive writing and data analysis sessions. In addition, Stacy continued to meet with several of the student researchers once a week, depending on who was able to attend, during the following three school years. During Ms. Loman's visits to the city, all six participant researchers reconvened in the research office for 2 days for further data analysis. The students kept journals of their thoughts on the project, and at various points in time were interviewed by Stacy, Ms. Loman, and each other about their perceptions of research, the project, their role, and the impact that being a researcher had on their lives.

While in the beginning of the study, conversations took place around participants' emic constructions, over time etic constructions became a part of the discussions as well. The intention was that by having all researchers learn and apply aspects of social theories, the voices of the adult researchers would be less privileged than would otherwise be the case. The students had the opportunity to be critical of the theoretical lenses, apply them in creative ways, and dispute the

adult researchers' interpretations. While Stacy and Ms. Loman recognized that the students' understandings of the theory would differ substantially because of their age and experience, the students still were able to interpret ideas on the basis of their own experiences, develop their own claims using theoretical frameworks, and critique claims that the teacher and university researcher made (Olitsky, 2005; Olitsky & Weathers, 2005).

This phase of the research had some implications for relationships between participants and for the impact of the research. While during the school year the insights generated in cogenerative dialogues could be applied to making changes in the classroom, during the summer, any insights generated from the research process would have no impact on the eighth-grade science classroom that was the focus of the study. However, Ms. Loman has documented how the research has impacted her teaching in subsequent years. In addition, the students have described how their participation in the research has affected their perspectives on schooling and has given them knowledge and skills that they could apply in other settings.

Data Analysis

Studying the ways in which students develop and demonstrate identities associated with science is not a straightforward task, as identities are constructed through ongoing interaction. Carlone and Johnson (2007) conceptualize science identities as having three components: competence, performance, and recognition. In this paper, we focused primarily on the ''performance'' and ''competence'' aspects of students' science identities. Eighth grade students may not say directly that they identify with school science if they are asked. However, participation in science class activities, written work, use of canonical science discourse, body

language, facial expressions, gestures, and written work can serve as indicators of identities as science learners (e.g., Brickhouse et al., 2000; Brown, 2004).

To address the question about the structural aspects that impeded the development of identities associated with school science, we examined differences between identity performances across contexts, attending to location, topic, activity structure (e.g., whole class discussion, demonstration, small group work, science lunch group), rules, level of teacher expertise, teacher and student roles, time of the year, and preceding interactions. We compared student-generated documents with participation in class on the same topic, to investigate both coherences and discrepancies. We also compared the participation of students of different educational backgrounds, prior achievement, gender, and race.

To address the question regarding the possibilities for enacting changes in order to reduce obstacles to students' participation in science, we applied the insights generated in cogenerative dialogues to changing classroom rules, procedures, and activity structures. We then observed the impact they had on students' performances of science-related identities, and discussed the outcomes in subsequent cogenerative dialogues.

During an entire school year, much more data were collected than could be analyzed in detail, as we had approximately 1400 hours of video and audio tape in the data set. There were a variety of approaches that we used to select particular vignettes for examination at the micro level using video analysis or discourse analysis. For each class session, Stacy, Ms. Loman, or a student researcher created a video description, in which we recorded the sequence, topics, and participants in identifiable phases of activity and interactional events. We used the CVideo software to outline the sequence for the videotapes. After the events were recorded, we coded incidents for issues relevant to the emerging research questions and any topic of interest to the

researcher. At first we used open coding, but as the questions became refined we went back and recoded. Incidents included when students used canonical science language, participated in activities and experiments, taught others about science, used science argumentation, supported other students, denigrated other students' answers, or asked questions.We also had different participant researchers code the same video and compared the descriptions and counts.

These video descriptions allowed for the purposeful sampling (Strauss & Corbin, 1994) of short vignettes that were relevant to the research topics and were representative of other interactional events throughout the data set.We could then examine these smaller segments at the micro level. Discourse analytic techniques included examining double-voicing, indexicals, deictics (Wortham, 1996), semantics, grammar, subject choice, exclamatives, and appraisal (Eggins&Slade, 1997). Stacy conducted the discourse analyses. However, she showed her analyses to the other participant researchers to get feedback.

Discourse analysis helped illuminate how school discourses and associated schemas were reflected in students' talk and how identities were constructed through social interaction. Similar to Barton and Tan's (2009) study, in which they ''looked for what funds and Discourses were invoked, how and when they were invoked, what happened to the learning community and individual students after they were invoked'' (p. 55), we examined the impact of the invocation of dominant school discourses on students' presentations of science-related identities.

The longitudinal aspect of the study was beneficial for addressing research questions related to students' school science identities because we were able to compare the student researchers' eighth grade classroom participation with their long-term engagement with similar science content and activities. In addition, we could revisit the same question, issue, vignette, or text at different times during the students' high school experiences and during Ms. Loman's

subsequent teaching experiences, rather than relying on interviews that elicit participants' perspectives at only one particular point in time. As identities emerge through ongoing interaction, shift depending on the setting, and change over time (e.g., Carlone&Johnson, 2007) the ability to collect and collaboratively analyze data over a 3-year time period was invaluable.

We employed different approaches to triangulation that included having several researchers examine and code the same set of data, using a variety of data sources, and comparing different levels of analysis, such as investigating whether the observations and claims made on the meso level cohered or contradicted with those made on the micro level. An additional form of triangulation emerged from the participatory nature of the research process, since claims were reviewed by all participant researchers. The aim of such triangulation was not consensus, but an analysis that retained our different voices and accounted for different perspectives and interpretations.

In this article, the views of all co-authors entered the general text. However, we chose to sometimes keep authors' voices distinct in order to insure that the different voices did not become subsumed into the overall article. In the results section, block quotes represent those that the co-authors wrote into the text as they were reading drafts of this manuscript. We kept those exactly as the researcher-authors wrote them. Quotes within the paragraphs are data sources gleaned from classroom discourse, cogenerative dialogues, or interviews.

Results

Discourses Posing Contradictions With Science Learning: City Magnet Is for ''Smart'' Students

In choosing groups with which to identify, students are limited to those that are visible and accessible to them (Brickhouse et al., 2000). The student researchers have identified some of

the relevant groups as those who know hip–hop culture, those who watch sports, those who play sports, and extracurricular groups within the school, such as the National Academic League in which Aileen participates. In City Magnet, another influential group that students wish to be associated with is ‘‘smart students.’’ Structures such as the speeches of administrators in assemblies where high school selection is discussed, the comments of teachers in classrooms, and the school’s grading and sorting practices all contribute to the importance of being seen as ‘‘smart’’ for social acceptance at City Magnet.

Administrators and teachers speak about the high status accorded to ‘‘smart’’ students as a benefit of the school and as an incentive for learning. However, some of the school’s practices that are intended to promote excellence may actually perpetuate inequities. Cohen (2000) describes how inequities emerge in classrooms through an emphasis on standardized tasks, which ‘‘encourage a process of social comparison in which students evaluate how well they are doing in completing assignments rapidly and successfully. The net result of this process of social comparison is a rank order agreed upon by teachers and by students on the relative ‘‘smartness’’ of each member of the class’’ (p. 271). Based on analysis of the data in this study, we argue that the overemphasis on the ‘‘smart’’ label leads to social comparison which poses a barrier to socially situated learning in science. Such a label excludes potential newcomers and can interfere with opportunities for peripheral participation in science activities.

While students can join other groups through the acquisition of skills and knowledge, new knowledge acquired during students’ time at City Magnet does not necessarily make them ‘‘smart.’’ Several students have described how the labels of ‘‘smart’’ or ‘‘not smart’’ are a form of symbolic capital ascribed to students early in their career based on the initial grades and performance in the classroom. In City Magnet, these labels were difficult to change.

> Jessica (10th grade): The saying ‘‘your first impression is a lasting impression,’’ was true at City Magnet. Once you were labeled it was hard to remove that label. For example, I had Mrs. Peters for science in 7th grade. I used to talk a lot in her class and my name was always on the board, but then I started being quiet and I started doing my work but because I was known to talk in her class, every time someone in my section or the section around me would talk I got in trouble.

> Ms Loman: By the time I met them as 8th graders they had 3 years of these labels and often used these labels to describe themselves to me before I had a chance to see how ‘‘smart’’ or ‘‘hard working’’ they were.

The emphasis on the importance of ‘‘smartness’’ is connected to the school’s practice of only admitting approximately one half of the City Magnet middle school students to the high school, which helps send a message that some of the students do not really belong there. During assemblies when the principal discussed high schools, she often emphasized that ‘‘City Magnet is for the brightest students.’’ While it is understandable that administrators will promote school pride, the phrase has a different meaning when considering that half of these eighth grade students will not get to continue, yet still did consider themselves to be academically inclined.

> Jessica (10th grade): Many of the people that went to City Magnet would have excelled in their neighborhood school, so in all reality everyone at City Magnet was smart.

The principal’s statements often seemed to be directed at the students who will get accepted to all the schools to which they apply, in the interest of convincing them to choose City Magnet. She rarely addressed comments to students who were unlikely to be accepted, other than occasionally saying that she hoped that they would find a place that is also suitable for them. Aileen described in a cogenerative dialogue, ‘‘You get kind of tired of hearing them say ‘‘for the rest of you. . .’’ Not all of us can get straight As here. They don’t care about all of the students.’’

> Jessica (10th grade): I think comments like the principal made caused her to lose the little bit of capital she had with a lot of students because she never tried to help the students that would not get into City Magnet.

Many of the students were still struggling with the material because they came to City Magnet without adequate preparation from their elementary schools. For example, Markita described how in her elementary classroom, ‘‘Science was the hamster in the back of the room.’’ Jessica also discussed how they did not really teach much science in her school.

> Jessica (10th grade): At my neighborhood school, science consisted of watching movies and building models of the ocean or playing with blocks. Although I succeeded at City Magnet the change was hard. The first year at City Magnet I actually had to take books home. . . at my neighborhood school I would finish all of my homework in school so that I never had to bring any books home. In fact I do not even remember having textbooks.

The way that some teachers ‘‘encourage’’ students to achieve can reinforce students’ sense of not belonging. Several students reported teachers having said to them as early as the fifth grade, ‘‘How can you not know this if you are at City Magnet?’’ Markita explained in an eighth-grade interview: ‘‘My fifth grade teacher would say (changing to a lower voice) ‘‘This is City Magnet. You should have learned this in elementary school.’’ (Changing back to her own voice.) Only they did not teach me that at my elementary school. I was the only one from my elementary school ever to get into City Magnet. They even had a special assembly for me.’’ While certainly there are benefits for schools having high expectations of students, messages such as those Markita had been hearing did not make her think the school expected great things from her; rather, she got the message that maybe she did not belong.

Some of the school’s efforts to reward hard work send confusing messages to students. For example, parents are invited to one assembly each year where students who received straight As sit in the front of the auditorium and receive certificates for ‘‘distinction.’’ Students who

received As and Bs have their names read aloud as ‘‘meritorious’’ students, but sit in the back with the remainder of the class. Students who have one or more Cs also sit in the back, and their names are not called. In anticipation of the assembly, which none of the student researchers seemed to want to go to, Markita told Stacy howits ‘‘not right’’ to have an assembly where they invite parents and give awards to the students with ‘‘distinction,’’ who have all As and sit in the front row, while students like herself sit in back with their class. She explained, ‘‘Other people work hard too. They give special parties for the A students. It’s not right. This is a hard school.’’ Stacy sat near her in the assembly, and while the principal was speaking about the honor that the ‘‘distinction’’ students deserved, Markita whispered to her, ‘‘See what I mean!’’

> Jessica (10th grade): I feel that honoring students who achieve well is a good thing. However I think there is a right way and a wrong way to do it. . . The problem with City Magnet is that they did separate those who excelled from those who did not. Also City Magnet from what I remember never offered any encouragement to those students that were not honored. . . Another thing that my neighborhood school did was to honor the most improved student. I think doing something like this lets the students know that even though they are not making all A’s or B’s you still recognize their effort and progress.

While in theory the competition could stimulate achievement, based on interviews and discussions, the students do not seem to view the system as rewarding hard workers or even talent, but instead as rewarding people who are ‘‘smart,’’ which they describe as a label that is equated with one’s status relative to others. In dialogues, the student researchers described how the appearance of exerting effort paradoxically makes students look less smart, since if they were actually smart they would already know how to do the task. This idea of smartness can be considered a type of schema communicated by teachers and administrators, which became a structure influencing students’ perceptions, communication, and actions.

Research studies (e.g., Dar & Resh, 1986) suggest that students learn more when in a class with higherachieving peers, so City Magnet should, in theory, be a good environment for students from lower-performing schools. Yet based on interviews, some of the students did not feel that they learned enough from their education at City Magnet to justify the disadvantage they received from negative labels.

> Jessica (10th grade): I think students did not get as much out of City Magnet as they could have for two reasons. One reason is that the change in pace from their neighborhood school to City Magnet was too much, causing them to throw in the towel way too early. The second reason is the negative or boastful talk of the staff and the students who had high academic marks.

Certainly a school where being smart is ‘‘cool’’ and smart students are less frequently threatened with ridicule can have strong benefits for creating a supportive learning environment. However, not all of the students have the same opportunity to succeed, as they arrive with very different types of academic backgrounds because of inequalities within the school district. In the context of these inequalities, the ‘‘boastful talk’’ that the students describe can have racial undertones, as many of the African American students faced more of a struggle because of the differences between City Magnet and their neighborhood schools. They also can face negative stereotype threat (Steele, 1997), and therefore may experience more pressure than the White students to prove they belong at City Magnet. Given that students in eighth grade are often at an early stage of their racial socialization (Stevenson, 1995), and therefore are not as aware of race privilege, their experiences in the classroom where they need to compete in standardized tasks with those who came from higher-performing elementary schools may become tied to a general sense of inferiority rather than a sense of injustice. The emphasis on smartness and standardized tasks leads to students being assigned labels that become increasingly difficult to change and that impact their emergent identities as science learners.

Impact of Emphasis on ‘‘Smartness’’ on Student Learning

In these next sections, we describe how the discourses that promote the importance of smartness can obstruct student learning and interfere with the classroom functioning as a ‘‘community of practice.’’ Such discourses have contributed to students avoiding verbal participation in class, privileging others’ incorrect scientific explanations, not trusting their own problem-solving abilities, and avoiding seeking resources that could foster learning.

Students Avoid Participation to Look Smart. In order to bridge students’ worlds and the methods of description and argumentation of school science, students need to be able to ask questions of the teacher and of each other and have discussions where ideas are exchanged and built upon. Ideally, all students would be able to put their ideas and questions forward in class to help them reconcile their own understandings with school science. However, because of time constraints, not all ideas are shared in whole-class discussion. Students who participate more frequently and in more substantial ways than other students can receive more feedback from their teacher and peers, have more opportunities to negotiate meaning, and gain more experience as peripheral participants in school science.

In this classroom, all students spoke when the teacher called on them to answer. However in the first half of the year only a few of the students regularly volunteered to ask questions or make assertions regarding science content. As we counted interactional events in the classroom videos, we noted that most of the students who voluntarily participated came from higher-performing elementary schools and had the ‘‘smart’’ label.

It is possible that someone observing the eighth-grade class could think that the students who are not participating lack interest in the material, have not been listening enough to be able

to ask questions, or do not care about achieving. While Ms. Loman is aware of the complexity of the environmental factors and the nonconscious dispositions that could account for a student's silence or apparent distraction, during the time that she is teaching she explains howshe needs to act based on her immediate interpretations. She described in one of the post-class debriefings, ''Like what strategy would they use to show me they are interested? Okay well most of them would show they are interested by raising their hand if I asked a question. Kids who don't raise their hand I would say either don't know or don't care. So for whatever reason they are tuned out that day or they are tuned in but they don't have it.''

This particular conversation was held while the researchers were discussing one student's behavior in class, who often doodles on a blank paper and seems to talk to himself as he flips through the book during lecture. During one class, Ms. Loman took his behavior as a sign of lack of interest and tried to pull him into the class by catching him off guard with a question. The student looked up and answered correctly. Ms. Loman realized she had misinterpreted his actions and had to make a conscious change about the way she perceived his behavior in class. The student researchers also confirmed that just because they do not volunteer to participate does not mean that they are not following the discussions or are not interested.

> Jessica (10th grade): Everyone learns differently. Teachers sometimes think that just because you are not looking at them you are not paying attention, but someone could be looking straight at you and tune you out. Doodling on a paper or tapping a pencil or resting their head on their hand is what keeps the students focused sometimes. When I feel myself getting bored in class I often tap on something to wake myself up and give me new energy but that does not mean that I am uninterested in the lesson.

Another possible assumption is that some students do not participate because they do not identify with school. Fordham and Ogbu (1986) describe how African American students may not engage with school because they equate school success with ''acting white.'' However,

during cogenerative dialogues all four of the student researchers described how class participation was a desirable activity and did not make a student seem ‘‘nerdy,’’ ‘‘acting white’’ or any other kind of characteristic with negative connotations.

The students’ comments in various cogenerative dialogues, as well as interviews with other students in the class, suggest that the students without the ‘‘smart’’ label avoid participation because of the potential for negative feedback from the teacher and peers. In an interviewduring the summer following the study, Markita stated: ‘‘If you would answer the question wrong then either you would get looked upon as a class clown or you would lose social capital. Some people would look at you like ‘‘I can’t believe that she didn’t know that’’ or ‘‘that’s easy. How come you didn’t know that one?’’’ This pressure also restrains them from asking questions that would help them to clarify the material. In an eighth grade cogenerative dialogue, Jessica elaborated on why students avoid asking questions, ‘‘I do this sometimes because it is embarrassing to get help. So I try to fix it myself and figure out what is going on but it makes you feel dumb when you don’t know something and you are always used to knowing stuff.’’ Rather than perceiving the classroom as a community of learners centered on school science, the students portray whole class discussions as a competitive display in front of the teacher, who can act as a judge of who is ‘‘smart,’’ which in turn influences howthey are treated by peers.

To be an actively participating science learner involves a level of risk, since acquiring understanding in science entails proposing ideas that may be rejected later based on new evidence. Yet these students experienced a contradiction between the goal of participating, which would give them access to the collective knowledge, and the goal of avoiding negative feedback and losing social capital. The students labeled ‘‘smart’’ did not usually face this contradiction.

They were often able to participate without negative comments, even when they provided incorrect answers or had difficulty understanding newmaterial (Olitsky, 2007).

Certainly these students' fears are not unusual. Yet just because these fears are common does not mean that schools and teachers are absolved from responsibility from doing something about them in order to improve students' learning. It is problematic that the students with the symbolic capital (the ''smart'' label) exercised considerably more agency in accessing science knowledge in the classroom. Given that many of the students who did not get bestowed the ''smart'' label came from low-income, predominantly African American neighborhoods, the division in science talk reinforces a division in educational outcomes based on race and class. Inequality therefore exists not only in prior science background, but also in how the labels perpetuated by the dominant discourses of the school affect students' current agency in meeting their goals of participation.

Students Privilege Others' Incorrect Explanations. The hierarchy in ''smartness'' not only constrains some students from speaking, but can also contribute to students not trusting their own abilities in relation to other students. As one example, Ms. Loman and Stacy both noticed that when James, an African American student, spoke, some other students made mocking or otherwise insulting comments. While in the beginning of the year, James would continue with his explanation, over time he stopped protesting their criticism, as demonstrated by the following example in which Ms. Loman recounted an exchange between James and another student, ''How about today? When you (Stacy) said, 'What does density depend on?' And he said shape. And Mike said, no that's wrong. And I said its right. Because we haven't discussed its volume. But shape does affect volume. But Mike told James it's not right. James said 'Fine.

You define it then.' He was actually. . . he was a little upset about it. I said 'James, you're right' and Mike said 'what do you mean.' I said 'he said it depends on shape which is true. Because shape and volume are related.' ''

Based on Ms. Loman's account, James was willing to concede to Mike, a high-achieving, White student. This is an example of a pattern where some students are more likely to privilege the responses of other students rather than allow the teacher to sort out the conflict or use their own knowledge and reasoning to figure out why their answers differ.Too much willingness to concede to others can truncate a conversation that would provide a context for building deep understandings about concepts. Also denied are opportunities to participate in peer review and fully exploring the merits and shortcomings of stated positions.

A similar event happened during a ''Lego lab'' in which the goal was for students to experimentally discover the relationship between the weight of the load and the distance from the fulcrum by using Legos that attached to a lever. The students worked to establish equilibrium by having the counterclockwise torque equal to the clockwise torque. Markita insisted that in order to get the number of Legos that were needed for balance, she needed to multiply the distance by 2. Ms. Loman asked her why she thought that, and she said it was because Jorgi, a high-performing student, said so. Markita was following Jorgi's instruction in such a way that she would most likely obtain incorrect answers, rather than making sure she understood the rationale for the procedure so that she could avoid mistakes.

As another example, Aileen was once very confused (and seemed to be almost angry) because Rona, a high-performing White female student, said that oil is denser than water, yet in a lab, Aileen had observed the oil floating on top of the water. During the lab, she did not offer her own observations, or ask the teacher to explain. In the science lunch group, after Stacy had

asked, ‘‘What do you guys want to talk about today,’’ Aileen said, ‘‘I don’t understand ANYTHING about this density stuff. WHYis oil denser than water?’’ She did not even consider that perhaps the other student made an incorrect statement, and that her own thought that oil was less dense than water was correct. When Ms. Loman was teaching this particular class, she did describe in a debriefing meeting that many students were saying incorrect things about density as they experimented with the liquids. From her perspective, this did not seem to be a problem, since she thought the students’ conceptions would change based on their observations, their discussion with peers, and the review of density at the end of the class. However, this process did not sort out the issue for Aileen, who conceded to the student who had the ‘‘smart’’ label. The ‘‘negotiation of meaning’’ in science is restricted in an environment where students are not freely weighing ideas, but decide whether or not to speak, and whose responses to privilege, based on a hierarchy. This privileging of ideas also has a negative impact on the higherperforming students, who do not obtain the benefit of having to formulate cogent arguments for their ideas. These incidents suggest the strength of that label of ‘‘smart,’’ as students will accept the ideas of ‘‘smart kids’’ even if they are incorrect (like Rona’s) or not explained fully (like Jorji’s).

We do not want to imply that it is not good for students to listen to each other. In the limited time that students have to learn the material, it is understandable that they often rely on students who are considered ‘‘smart’’ for help. In this class, a great deal of productive peer interaction takes place, particularly between Jorgi and several of the girls. However, we think that misunderstandings can result when students privilege other students’ statements and criticisms, to the point where they do not trust their own observations, ask questions, or believe that they can understand the purposes of the procedures they are told to follow. Following Lave

and Wenger's (1991) description of communities of practice, such a classroom would be ineffective since many students are not acting as legitimate peripheral participants, they are not able to see the overall goals and purposes of the activity, they are not able to enact changes, they do not receive appropriate scaffolding, and they do not have opportunities to develop a science-related identity within their community.

The consistent privileging of some students' science explanations over others that occurred in the classroom can also be viewed as reinforcing race privilege. Because of the initial inequalities in educational background, White students were less likely to have their ideas questioned by other students than Black students. Also, being labeled as wrong could have more negative consequences for a Black student, who not only has to worry about their own reputation but also about views of their race. Even if White students answered incorrectly, they did not have to contend with negative stereotype threat, so they may have been more likely to continue participating than Black students.

> Jessica (11th grade): I agree because I feel like that sometimes in my Physics class. This white guy named Dave calls out wrong answers sometimes but he knows what he is talking about sometimes and besides he is one of the many whites in the class. On the other hand I am one of the three black people in my class and I am the only one who really acts urban so when I answer the question wrong I get all these looks and everyone seems to tell me that was wrong in their own way. So since I know the effects of answering a question wrong and since I know that 9 times out of 10 I don't know what's going on anyway I might as well not answer any questions.

We argue that in City Magnet, a classroom environment where some students are much more likely to concede to others is not only problematic because it reduces some students' agency as science learners and contributors, but also because it reduces student agency unequally along lines of class and race.

Students Do Not Access Resources for Learning. While the students may perceive a ‘‘sink or swim’’ attitude on the part of the school, the school actually does offer some supports for students who are struggling with the material or who do not have adequate material resources to fulfill class assignments. Students who cannot afford the cost of supplies for creating projects can stay after school and use the school’s supplies. There is a computer lab open during lunch that many of the students use to write their papers. There is also a peer tutoring program and a government-assisted program that paid for a teacher to stay after school and help students, which was mandatory for failing students to attend. However, just as discourse can signify identities that students may not want to adopt (Brown, 2004), the use of the tutoring program also connotes an identity that students in this school find unpalatable.

For example, in the Monday lunch group, Markita once asked the university researcher, ‘‘Is it bad to get a peer tutor?’’ Stacy asked, ‘‘Why would it be bad? Sounds like a good idea to me.’’ She said, ‘‘Tim kept saying that if you were smart, you wouldn’t need a tutor. But I need help in history and I don’t knowwhat to do.’’ Such a view of ‘‘smart’’ can be seen as antithetical to a model of socially situated learning where participants are involved in providing scaffolding for each other. In an effective community of practice, it should be acceptable for students to seek knowledge from more central participants, such as other students in the school. Tim’s comments, which were not unusual for City Magnet, actually serve to discourage students from seeking the assistance that might help them to succeed.

> Jessica (10th grade): Comments like the one Tim made can put a student’s self esteem down and intimidate them from going to get help especially if they never needed help before. Then this causes their situation to go beyond the means of help.

Most of the students at City Magnet did not need help before coming there, as all of the students were high achieving in their elementary schools. In the current structure, not only are students expected to admit to their teacher and peers that they need a tutor, but they need to change their identities (both in the sense of how they view themselves and how others view them) from a student who was smart and never needed help to one who is not smart and therefore needs help. Understandably, that is a hard move for any City Magnet student to make.

Students such as Markita had a goal of doing well in their classes, yet faced contradictions due to aspects of the structure, including schemas regarding smartness and tutoring, that restricted their agency to access this potentially useful resource. In eighth grade Markita never did get a peer tutor, though she was willing to come to the science lunch group. While one can partially blame Tim and other students for their hurtful comments, these students were only reinforcing the boundaries established by the school choice system, by teachers and administrators in their discursive practices in assemblies and classrooms, by the school's reputation in the surrounding community and by the emphasis on standardized tasks.

One relevant question is why the science lunch group did not have a stigma for students in the way that tutoring did. Markita and Aileen came, while they would not have gone to peer tutoring. Other students reported that nobody said anything negative toward students who came to the science lunch group or research meetings. It is possible that the science lunch group was associated with research and enrichment, rather than with just needing help. In addition, the students were aware that Stacy benefited from students coming to the group, so by attending they were helping with her research as well as receiving help with science. While participation in the research provided another group to which they could belong and within which they could provide valued, substantial contributions, tutoring was associated with not belonging.

> Ms. Loman: There were also two adults and I think finding help from adults was different than from kids. Also I think they enjoyed getting to giving me direct feedback which was a privilege that only four of them were given.

It would be possible for a teacher and administrator to observe that the tutoring system is underused, and to assume that this is because students are ‘‘unmotivated’’ or have ‘‘other priorities.’’ However, this would be a misrepresentation of what is actually taking place when some students avoid using this structure. Markita is very motivated. She described how she usually starts out the semester with low grades, but by working hard and seeking help from teachers, she had been able to earn Bs, although she had limited study space at home. If even a student as diligent and active as Markita does not feel comfortable using the resource of a student tutor, this suggests that one cannot blame the students, but that instead one needs to examine how school structures related to tutoring need to be changed.

Currently, Markita attends Temple University’s School of Social Work. She will graduate in May with honors from Temple University. She is President of the National SocialWork Honor Society, Alpha DeltaMu and she is also Vice-President of Golden Key International Honour Society. She has been able to succeed academically as is demonstrated by her acceptance to several graduate schools in social work. She is striving to change the perception of ‘‘needing help’’ by encouraging others to reach out and obtain support. She readily makes herself available to everyone she encounters and is now a valuable asset for her peers excelling in all areas including science. She attributes her success to her life experiences and thanks her mother for guiding her down the road to success.

Approaches to Reducing Contradictions

Changing Dominant Discourses Around ‘‘Who Belongs’’. One obvious structure that could be changed is the dominant discourse referenced by some teachers and administrators at City Magnet that emphasizes the importance of knowing who is ‘‘City Magnet material’’ (smart) and does not sufficiently emphasize the importance of accessing resources in order to learn. While teachers may wish to support all of their students and may not intend to emphasize the boundaries regarding who belongs at City Magnet, they play particular roles within the school choice system and therefore may unintentionally perpetuate the schema regarding ‘‘smartness.’’

Changing Structures Aimed at Providing Students With Extra Help. Another approach is changing the format of peer tutoring. Perhaps City Magnet students such as Markita should not be conceived of as needing tutoring in order to ‘‘catch up’’ to the other students. Instead, these students need an additional learning environment in which they would receive enrichment and have more opportunities to act as peripheral participants in communities centered on science learning. While the afterschool tutoring program was called ‘‘Enrichment,’’ students’ comments suggest that they did not view it that way, but saw it as remediation or even a form of punishment. Extra time spent learning science may be more appealing if students can gain knowledge that their peers do not have, so that in whole class settings they would have resources to provide unique contributions that their peers would value. Another beneficial feature would be if students were not just being ‘‘given’’ extra assistance in one-on-one sessions, but had roles as contributors, such as by helping their peers to understand the material within small learning communities. Similarly, it may also be possible to model tutoring sessions based on cogenerative dialogues, in which the objective is not remedial help but improvements in teaching and learning environments. Just as students were willing to come to research meetings with Stacy and Ms.

Loman, they might be willing to come to extra science lessons to help their teacher learn how to teach more effectively.

Soliciting Unique Contributions Rather Than Emphasizing Standardized Tasks. During one of the science lunch sessions, Aileen told Stacy that she ‘‘did not understand solutions at all’’, and asked whether the ‘‘concentration of a solution,’’ and ‘‘saturated solution,’’ were like the words ‘‘orange juice made from concentrate’’ and ‘‘saturated fats’’ on food labels. Stacy discussed with the students how the term concentration applied both to foods like orange juice and the solutions that they were working with in class. The day after that session, Ms. Loman was explaining the concept of concentration to the students. Aileen raised her hand and explained to the class how concentration was similar to the ‘‘from concentrate’’ label on orange juice. Apparently Aileen was willing to use an example that she obtained from a source outside the classroom (Stacy), display competence in science, and provide an analogy that she thought her peers might find useful, but was generally not willing to seek that type of knowledge by asking questions in class nor did she regularly choose to volunteer by answering questions unless it was about her home experiences.

While this is only one example, overall Aileen was more likely to volunteer in whole-class if the task involved telling about a science experiment that she did at home, if she could use humor, or if she could bring in knowledge from outside the classroom. Further, patterns in class participation showed that this applied not only to Aileen. Overall a greater variety of students participated when they had opportunities to bring in experiences and outside knowledge, rather than answering questions that presumably everyone else in the class should be able to answer. It is understandable that students, particularly those with less symbolic or social capital, were more motivated to contribute when their statements could be applied to increasing collective

understanding rather than just being evaluated as right or wrong. This observed increase in participation during such types of questions is in accordance with Lave and Wenger's ideas on socially situated learning; it is not enough for participants to learn the relevant skills, such as the ''right answers,'' but they need to acquire roles as valued contributors in order for a group to be effective as a community of practice.

Such roles also reduce the reliance on standardized tasks and the hierarchical evaluation of students, as all students regardless of their grades can bring outside information to the discussion. Increasing emphasis on these types of participation could be one way teachers could avoid reinforcing the class and race inequalities due to students' prior educational experiences.

Changing Classroom Rules and Procedures. Ms. Loman was aware that students faced contradictions between being viewed as smart and participating in science. However, like any teacher, Ms. Loman did not have full knowledge of student perspectives on specific classroom structures or events. Some of the classroom structures exacerbated these contradictions in ways that she was not aware. In this section, we provide an example of how cogenerative dialogue resulted in Ms. Loman changing the classroom rules to lessen one of the effects of the contradiction between looking smart and learning science.

During one meeting between Stacy and Ms. Loman, Ms. Loman described howmost of the students who were doing poorly in her class handed in their tests early. Many of the tests were not even finished. She said to Stacy, ''Did they think they knew the material? Are they that unable to figure out what they know and don't know? And why hand in a half-finished test?'' She saw their failure to turn in complete tests as evidence of either a lack of science knowledge or a lack of self-awareness.

A few weeks later, during cogenerative dialogue in the research group, the four girls spoke about how they get nervous while taking tests. Jessica expressed how when Jorgi finishes first, she thinks there is something wrong with her that she is not even near finishing, and she just turns it in. The other girls joined in, interrupting Jessica, ‘‘Oh it makes me feel stupid.’’ ‘‘Yeah, I can’t stand when people get up during the test.’’ ‘‘Yeah, I go turn mine in too.’’ Aileen explained that she wanted other students to think that she ‘‘was smart and a fast test taker’’ so she handed in her test when the ‘‘first students had turned their tests in’’ to the box.

> Jessica (11th grade): I believe this is true for most students. No one wants to be the last one done because it makes them appear to be confused over the test material and it also puts preconceived ideas about a person in the minds of others. I still find myself looking around during a test to see who is finished. Every time I hear someone get up to turn in their test paper, a since of urgency rushes over me. I think this happens because if everyone is finishing up but you are nowhere near done, you start to doubt yourself and whether or not you know what you are doing.

Ms. Loman had not realized the extent of the pressure to appear smart even if it meant sacrificing their grades on exams, which could jeopardize their applications to high schools. About a week later, Ms. Loman said to Stacy, ‘‘after the conversation with those kids, next time I give a test, no one will be able to hand it in early. . . then it doesn’t put any pressure on kids that I have to finish fast that means I’m smart. Wherever that idea comes from.’’ The students had become accustomed over their years at City Magnet to turning in their work as soon as they are finished (or as soon as the fastest person finished), and had continued to do so in Ms. Loman’s class.

Based on the cogenerative dialogues, Ms. Loman changed the test-taking rules in the classroom so that students could no longer get up from their seats. When it was time for the next exam she instructed the class to keep their tests at their desks when they were finished and to

turn them over and doodle on the back. She kept watch over the class and when she saw everyone was finished she collected the exams. While we did not ask all of the students in the class, we can surmise that Jessica was correct in her assessment that most students felt as she did about test taking, as the problem of the blank tests was apparently resolved by this small change in rules. After this event, only a few of the tests that the teacher gave were not fully completed.

Ms. Loman did not have the ability to change the overall schemas regarding who belongs at City Magnet or the meaning of smart. Nor could she change the negative stereotype threat which likely enhanced some students' anxiety. However, the small structural change in the procedures for turning in exams reduced the contradiction and increased student agency by allowing them to showthe teacher their knowledge of science. During a test, the importance of demonstrating a proficient school science identity had been muted in importance, since only the teacher would actually view the students' answers. Grades were a somewhat private affair, whereas whether one was still working on a test while others had already finished was a public display. With the change, the lower-achieving students could now work toward developing identities as science learners by turning in complete tests and earning better grades. In addition, Ms. Loman had a better idea of what they did or did not know.

The process by which the teacher changed these rules demonstrates how the changed division of labor resulting from the collaborative research process was able to facilitate positive change in the classroom. While this is only one example, it illustrates the process of teacher and students working together in order to reduce contradictions that adversely impact science-related identity development, learning, and achievement.

Conclusions

In this classroom, many of the students had abilities, desire to participate, and motivation to achieve in science that were not always apparent in their classroom behaviors. The students who demonstrated the most discrepancies in their performance of school science identities were mainly from low-income, predominantly African American neighborhoods, which is particularly troubling given that this was a magnet school that supposedly supports the learning of talented students throughout the city.

In this study, we used cogenerative dialogues to investigate how classroom structures both constrained and enabled students in demonstrating proficient school science identities. We hoped that the insights from this process could guide classroom changes that would increase students' agency to meet their goals for achievement and participation, thereby increasing patterns of coherence in the classroom as a site for science learning. In this study, students seemed more likely to engage in science-related activity when such a course of action was beneficial to meeting their goals of gaining social and symbolic capital. This occurred when students felt their science talk was connected to a viable social role, such as helping their peers to understand a concept, providing information that other students may not know, or helping the teacher improve her practice. In contrast, the task of supplying an answer to a question or even achieving a higher grade was not sufficient motivation for students to overcome the risks of participating. The common practice of comparing students along a range of standardized tasks was particularly detrimental to participation. An implication is that the relevant factors in whether students demonstrate proficient discursive identities include not only what students know, but also how students appear to others, whether they have valued roles in collective activity, and whether they are acting in accordance with their desired identities.

The results of this study suggest that a perspective on classrooms as communities of practice in which learning is socially situated, rather than as forums for competitive displays, and a view of students as valued contributors rather than just as recipients of knowledge, may be an important step in addressing some of the contradictions that can interfere with students demonstrating proficient discursive identities in school science. The recommendations for change discussed in the paper, such as reduced emphasis on standardized tasks and hierarchies, enabling students to earn social capital through class participation, soliciting unique student contributions, and encouraging learning through peripheral participation, certainly do not solve the problem of the racial and socioeconomic inequalities impacting City Magnet students' experiences. However they do not reinforce the inequalities quite as much as other teacher practices can.

Implications

This study demonstrates an approach to the problem of limited teacher knowledge of students' experiences that shape their science participation, by showing how collaborative research can facilitate the joint identification of contradictions and lead to transformation. While we recognize that the time commitment required for research is not generally feasible in most classrooms, some of the methods could be adapted, such as the establishment of a forum for teacher and students to reflect on classroom events. We recognize that it would be a fallacy, and would conflict with a local view of change, to make general statements about conditions in other classrooms based on the specific results from this one setting. However, this research has implications for the role of the teacher in any setting as extending beyond communicating knowledge and fostering the development of skills to establishing an environment that is both

socially and academically conducive to learning. Also, a view of the activity of teaching and learning as collective and mediated by classroom discourse, rules and procedures can help teachers to alter conditions that can interfere with student achievement. Further, methods such as cogenerative dialogues can be used by other teachers in implementing classroom environments that better resemble communities of practice, allowing participants to appropriate science discourse and access resources for learning.

Notes

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