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Constructing Scientific Literacy in Inquiry-Based Communities of Science Practice

Research Questions

1) What opportunities did the teacher provide students to engage in science? More specifically, what opportunities were provided to engage in scientific practices, and to communicate orally and in writing?

2) What opportunities did students take up during the ecology unit? How did they individually and collectively engage in scientific practices, scientific communications, and in experiences relating to science?

3) What did students learn about scientific practices and scientific communications as a result of their participation in this fresh water ecology unit?

Rationale: *Socioeconomically Disadvantaged Students*

Current research (Chudgar & Luschei, 2009; Denson & Chang, 2009; Jordan, 2010; Lee & Luykx, 2006) shows that socioeconomically disadvantaged students in the U.S., including English Language Learners, are underperforming in science. In particular, socioeconomically disadvantaged students are not keeping pace with socioeconomically advantaged students in standardized test scores of science content knowledge. Chudgar and Luschei (2009), in particular, made visible that where school resources were skewed toward wealthier children, socioeconomically disadvantaged students suffered academically. These researchers further found that when school resources were focused on socioeconomically disadvantaged students, the return for investment in school resources was higher for disadvantaged students than it would have been for privileged students.

The Seaside Charter aims to serve the needs of socioeconomically disadvantaged students and English Language Learners. The charter petition enables a focused stream of resources that are targeted at disadvantaged students. The Seaside Charter biology course and fresh water ecology unit that were the subject of this study filtered school resources into a science course for disadvantaged students who would not have realized this opportunity to participate in the inquiry-based study of local fresh water ecology within the traditional school programs in Seaside.

Overview of the Study

Context, Participants, and Researcher

School. The community of Seaside is situated along the Western slopes of the coastal Rocky Mountains. Approximately 45,000 people live in the town of Seaside where agriculture and aerospace employ many of the community's residents. Over the past 5 years, Seaside Unified School District has experienced declining enrollment (California Department of Education, CDE, 2009), not because the town's youth population is declining, but because Seaside families are opting out of traditional public school programs and sending their children to one of the charter schools in the area or, if they are able, homeschooling. In addition to declining enrollment, Seaside Unified School District continues to realize flat and declining standardized test scores among English Language Learners and socioeconomically disadvantaged students (CDE, 2006; 2007; 2008; 2009).

The natural environment surrounding Seaside is classified as Maritime Chaparral which hosts unique and fragile ecological communities. A major salmon river used to rage through Seaside on its way to the Pacific Ocean; the river was dammed to supply water for another, much larger, coastal city. Within the past 20 years, the natural area surrounding Seaside has been overtaken by vineyards and wineries. The Seaside groundwater basin continues to decline as local vineyards use more and more water while the area's natural river is kept from replenishing the local groundwater basin. Both the Seaside education community and the natural environment are threatened by diminishing resources: the school district is losing students and the natural environment is losing water.

Students. Current research in science education (Barton & Tusting, 2005; Lee & Luykx, 2006; Nieto, 1999; Roth & Barton, 2004) reveals how students' sociocultural identities place them at risk of educational failure without taking into account what individual abilities and talents these students possess. Nieto (1999) pointed to racism and institutional discrimination as primary sources of "policies, practices, attitudes and beliefs" (p. 23) that result in educational inequality and "explain by example what a society believes its young people are capable of achieving and what they deserve" (p. 23). Seaside Unified School District has been designated as a "Program Improvement School District" (CDE, 2008) according to the No Child Left Behind Act. This designation has been placed on Seaside Unified School District because two populations of students, English Language Learners and those who are socioeconomically disadvantaged, have not realized improved standardized test scores over the past 5 years. One traditional high school and one traditional middle school in Seaside were classified as Year 4 Program Improvement Schools at the time of this study; these schools will require restructuring during year 5 of Program Improvement status as mandated by the No Child Left Behind Act.

A charter high school, Seaside Charter, was co-founded by this researcher at the beginning of the 2008-2009 school year with the expressed goal of serving disenfranchised high school students. Before the founding of the Seaside Charter,

approximately 250 high school students dropped off the records of the community's traditional high schools each school year over the past six years. Seaside hosts two traditional high schools with populations of approximately 1,600 students each, and a continuation high school with a maximum capacity of 160. Students must be sixteen in order to apply to attend Seaside's continuation high school. The Seaside Charter intends to educate disenfranchised students whose needs are not being met by either the traditional or continuation high schools.

Local statistics (CDE, 1999) show that English Language Learners and socioeconomically disadvantaged students in the Seaside education community continue to perform poorly on standardized tests that require literacy across all academic content areas, including science. This study focused on one group of Seaside Charter biology students who are English Language Learners and socioeconomically disadvantaged. Local statistics support the inclusion of these biology students in this study of scientific practices and communications that are productive of knowledge and literacy development among the disenfranchised students of Seaside. All Seaside Charter students have opted out of traditional educational programs in Seaside.

Teacher/researcher. My unique position as both the teacher and the researcher in this study has been socially and historically constructed over time within the educational community of Seaside. I have been teaching in multiple states within the United States for the past eighteen years. I moved to Seaside in 2000 and accepted a teaching job at Seaside Middle School where the student population consisted primarily of English Language Learners and socioeconomically disadvantaged students. Over the past ten years, I have observed and personally experienced discriminatory and racist practices and policies that have been enacted by Seaside Unified School District.

In 2005, it was announced that Seaside Middle School, the school where I taught, would be closed due to declining enrollment; the students and staff at Seaside Middle School were told that the district could not afford to keep the school open any longer given the district's financial difficulties. As a Seaside Middle School teacher, it was devastating to see the only secondary academic program in Seaside that was successful with English Language Learners and socioeconomically disadvantaged students discarded without a second glance at our improving standardized test scores.

Seaside Middle School implemented a core teaching philosophy with its students. Seaside students stayed with one teacher for English, reading and social studies, and a second teacher for mathematics and science. I was a mathematics and science teacher. This core teaching philosophy opened up opportunities for teachers and students to develop rich relationships, while standardized test scores improved dramatically over time. Between 2000 and 2008, Seaside Middle School students realized dramatic standardized test score improvements (CDE, 2000; 2001; 2002; 2003; 2004; 2005; 2006; 2007; 2008). Even as the school was preparing for closure, Seaside Middle School noted substantial standardized test score improvements while the other secondary schools in Seaside were realizing declining standardized test scores most notably among English Language Learners and socioeconomically disadvantaged students. Despite these positive results among Seaside Middle School English Language Learners and socioeconomically disadvantaged students, Seaside Unified School District closed Seaside Middle School in 2008.

The relationships that were constructed between Seaside Middle School teachers and students have endured. I co-founded Seaside Charter High School with the expressed purpose of serving the educational needs and interests of the Seaside Middle School students and families who had moved on to traditional high school programs in Seaside and had failed to find success within these programs. Many of my former Seaside Middle School students enrolled in Seaside Charter High School. My aim in co-founding Seaside Charter High School was to provide educational opportunities and access to the students of the Seaside community who had been unsuccessful in traditional classrooms and programs. Many of these students were successful at Seaside Middle School. I make the assumption here that these successes at Seaside Middle School were positively affected by the teacher-student relationships that were enabled by the core teaching philosophy and scheduling constructs at Seaside Middle School. The families who enrolled their students at Seaside Charter said during multiple orientation interviews that they wanted to be involved in their children's education and that they wanted for their children to have close relationships with their teachers.

Seaside Charter adheres to a personalized teaching and learning philosophy. The following excerpt from the Seaside Charter petition (Lawrence, Lewis, & Lynch, 2008) explains this personalized learning philosophy:

> Each student has unique needs, abilities and goals. We understand that students learn best when they are motivated, involved, and appropriately challenged. Therefore we will individualize each student's educational program to his or her interests and ability levels to ensure that each student learns at his or her own optimal rate and level. A goal-oriented curriculum utilizing inquiry-based learning programs, cooperative school programs and classes, apprenticeships, community based educational programs, distance learning via current technology supplemental learning projects and current educational research will be established. All student curricula will be subject to Seaside Unified School District, SUSD, Board approval. (pp. 2-3)

This personalized learning philosophy was practiced with the students of Seaside Middle School before the school was closed in 2008, and with Seaside Charter students throughout the 2008-2009 school year.

Course and curriculum. The ecology course that was studied here by this teacher/researcher was situated within this personalized learning context. I knew my student participants well; I had known many of my students and their families for several years. My students and I shared a history that colored and shaped both our relationships and our discourses within the biology course and fresh water ecology unit that was studied. The very specific and local problems that the fresh water ecology course at Seaside Charter High School aimed to address were: (a) a lack of equitable educational opportunities in science among English Language Learners and socioeconomically disadvantaged students, and (b) a lack of equal access to standards -based and literacy-rich educational experiences that hold the potential for enabling English Language

Learners and socioeconomically disadvantaged students to realize educational and academic success.

The biology class that was the subject of this study met throughout the 2008-2009 school year. As the teacher of this course, I spent the entire school year leading up to the ecology unit under study, working with the students who became my research subjects. When I began the fresh water ecology unit, my students and I had already established a teaching and learning culture that continued to shape and color the discourse and learning in my classroom and with my students throughout my research project.

Throughout my teaching career, I have worked to provide learning contexts that require literate interactions among my students. I base my conceptions of literacy on Street's (1984) writing about ideological literacy. According to Street, "A lot of time has, then, to be devoted to establishing what particular literacy practice individuals are interested in or 'need', and this inevitably involves some analysis of their social position and of the social context within which that practice has relevance" (p. 219). Ideological literacy, in my view, is represented in locally relevant scientific communications and practices. My personal experiences with English Language Learners and socioeconomically disadvantaged students in mathematics and science classrooms have taught me that my students need ample opportunities for literate expression within a learning environment that enables knowledge and meaning constructions. My response to my students' literacy needs has been to construct curriculum that requires students to read, write, talk, practice and think within academic experiences that are context-bound and locally relevant. My fresh water ecology unit was fashioned with my students' literacy needs in mind.

The students who were studied here were made aware through their experiences with me as their teacher prior to this study that they would be required to read about fresh water ecology, write about fresh water ecology, talk about fresh water ecology, and think about fresh water ecology. This reading, writing, talking, and thinking characterizes the data I have collected in curriculum, lesson plans and fieldnotes; in audio recordings; in still photographs; in illustrated guides to macroinvertebrates; in macroinvertebrate indices; in transcribed interviews with students; and in students' power point presentations. These data revealed my own classroom culture as this culture was continuously reconstructed by both me and my students. This ethnographic perspective enabled me to see aspects of my students' learning culture that were invisible to me before I undertook this research project. Through this research of my own teaching practices, I have now come to recognize my students' individual and collective learning cultures, how these learning cultures affect my students' constructions of scientific practices and scientific communications, and how these practices and communications enable and constrain learning.

Methods

Participants and Researcher

Students. At Seaside Charter, thirteen students between the ages of 11 and 18 enrolled in my biology course and participated in this study. All 13 participating students were socioeconomically disadvantaged according to the Seaside Unified School District

student database (2009). Seven of the students were female and six were male. Eleven of the students were Latino; one was European American and a recent immigrant from Bulgaria; and one student, Jennifer, considered herself to be both European American and Latina. Eleven fresh water ecology students spoke English as a second language, and two spoke English only. Hector, who was eleven, was an eastern European immigrant who was classified as an English Language Learner. Hector was designated as gifted and talented and took courses at Seaside Charter and at the local community college. Hector's academic gifts and talents were most obvious within the academic domains of mathematics and science. Two students, Maribel and Fernando, joined the class by choice during two class meetings. These students were not enrolled in the course, but they are depicted in the transcribed discourse during the two class meetings that they voluntarily attended.

Instruments

1. Curriculum, lesson plans, and fieldnotes were used to detail my contributions to the academic context.
2. Students' classroom discourse was recorded and transcribed. Photographs were taken as students enacted community practices and communications.
3. Students' socially constructed illustrated guides to macroinvertebrates were analyzed.
4. Macroinvertebrate indices were prepared by students for Mission Pond and for Seaside Canyon Lake.
5. Power point presentations of water quality findings were constructed by four students.
6. Structured interviews were conducted with three focus students.

Findings

Key findings showed that opportunities were provided for students to identify questions and concepts that guide fresh water ecology research, formulate and revise scientific explanations using logic and evidence, and communicate a scientific argument. However, I did not find evidence that students defended scientific claims. I adjusted my lesson plans after reviewing my fieldnotes from the previous week. I noticed that students struggled with scientific language. Because of this, I limited my language use to discussions about macroinvertebrates and macroinvertebrate indices; I did not include language about pollution or geology. Findings indicated that students were able to use scientific language only when they were engaged in scientific practices. Students did not use scientific language when they were interviewed.

Policy Implications

What did I learn about my teaching and my students' learning? In conducting the Seaside research study, I learned a tremendous amount about my own teaching practice, about the culture of my own classroom, and about the learning cultures of my students. My transcripts revealed an interaction between the culture I created in my classroom with

my curriculum, my lessons, and my relationships with my students, and the various learning cultures that my students brought to school.

In analyzing my students' transcribed discourse over and over, I came to realize that my students acted and interacted from perspectives that are colored by their own histories and cultural foundations. I also noticed that the cultural influences of my curriculum, lessons, and relationships were filtered by students through their own cultures. It is my intention to attend to my students' cultural influences very closely when planning and implementing curriculum in the future. I learned in conducting this study that the cultural influences that I bring to the classroom are secondary to my students' cultural influences. Focus student, Marta, exemplified a cultural influence that I was not aware of before the Seaside study. Transcripts revealed Marta supporting learning as the informal teacher. I noticed that students relied on Marta's support in referencing the reading material as they constructed illustrated guides; while at Mission Pond, students watched Marta and did what she did.

In attending to my students' cultural influences when designing and implementing curriculum, I intended to provide learning contexts that enabled students to articulate their own cultural influences with the cultural influences that were derived by me, the teacher. I accomplished this goal by allowing students to work collaboratively without imposing group or cultural boundaries. Seaside students worked as a class rather than in prescribed groups. In the future, I will intentionally observe and advantage my students' collaborative learning cultures in the same way that Seaside students' learning cultures were observed, then allowed to flourish. In validating my students' own cultures and learning styles by enabling cultural expression, my teaching will continue to improve as my students' learning will be equally enhanced.

My students' meaning constructions were made visible in the data I collected. The constituents of these meaning constructions were made available to my students in the practices and communications of fresh water ecology that I imparted in my curriculum, lessons, and resulting classroom culture. Seaside students socially constructed meanings in and through their productions of illustrated guides, macroinvertebrate indices, and power point presentations. This meaning construction process was revealed in students' transcribed discourse and photographs. In observing and analyzing my students' discourse, I validated my own assumption that meaning construction and learning are enhanced and solidified through applied and locally relevant experience. Without this applied and locally relevant experience, practices and communications are left void without a context-bound purpose for constructing meaning. Transcripts and photographs during the first two weeks of the fresh water ecology unit revealed that students were reluctant to engage with written text; only Marta and Hector were observed reading the white board and reference material. During the beginning of the ecology unit, most students relied on Marta to access the information they needed to construct illustrated guides. During weeks three and four, and after students had visited Mission Pond and constructed a macroinvertebrate index, students were observed reading and referencing the white board and reference material. I drew the conclusion, after observing students' reading, that locally relevant experiences in constructing a macroinvertebrate index for Mission Pond had grounded students' meaning construction and learning. I conclude that most of my students needed reasons for reading; the construction of water quality indices provided these reasons.