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ABSTRACT

This study examined the practice of two science teachers who increased the participation of minority students who historically had not participated or succeeded in science. The two teachers were identified through a process of recommendation, personal interview, and observation. Researchers captured the practice of both teachers throughout one semester using in-depth teacher interviews, participant observations, classroom documents, and interviews with students and colleagues. The principles of constructivist analysis guided the data analysis. A cross-case comparison revealed patterns of similarities and differences between the two teachers. For example, both emphasized a few key topics in their classes, respected students and their cultures, were professionally active in and out of school, had in-depth knowledge of science, and had high expectations for their students. Differences included the nature of their teaching and the nature of the classroom environment. The study suggests that teachers who are working with diverse populations should be sensitive to their students' backgrounds, hold high expectations for them, and develop an understanding of science that informs their practice. (Contains 26 references.) (SM)

Increasing the Participation of Minority Students in Science: A Study of Two Teachers

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Abstract
The purpose of this study was to explore the practice of science teachers who have increased the participation of students who historically have not participated or succeeded in science. The two teachers in this study were identified through a process of recommendation, personal interview, and observation. The practice of both teachers was captured throughout a semester with in-depth interviews, participant observations, and the collection of classroom documents. In addition, students and colleagues associated with each teacher were interviewed. Using the principles of constructivist analysis and cross-case comparison, researchers and teachers revealed similarities and differences between the teachers. The similarities were in-depth instruction on few key topics, respect for students and their culture, professional activity in and outside of the school, in-depth knowledge of science, and high expectations for their students. The differences were the primary teaching style and the classroom environment. This study suggests that teachers who are working with diverse populations should be sensitive to their students' backgrounds, hold high expectations of students, and develop an understanding of science that informs their practice.

School demographic data reveal that many districts are ethnically and racially diverse and that this diversity will continue to increase (Atwater, 1995; National Center for Educational Statistics (NCES), 1994). The nation's largest school districts report a majority of students as African-American, Native-American, Mexican-American, or Puerto Rican. For example, the New York City Public School District reported 82.0% of students as ethnically and racially diverse; the Los Angeles Unified School District reported 87.0%; and the Dade County (Miami) Public School District reported 83.3% (NCES, 1994). This type of diversity continues to increase in the 25 largest districts in the United States, and in many other districts (NCES, 1994).

As classrooms become increasingly diverse, several researchers report that science instruction does not provide students with opportunities to do science, science instruction is not relevant to students' lives, science instruction does not result in equitable achievements for students on science assessments, and science instruction is not conducive to the on-going participation of all students in advanced science classes (Jones, Mullis, Raizen, Weiss, & Weston, 1992; Madigan, 1997; NCES, 1994; Stake & Easley, 1978; Tobin & Gallagher, 1987; Weiss, 1987; Yager & Penick, 1983). Although the relationship

between doing science, the relevancy of science, science achievement, and science participation to ethnicity is not clear, African-American, Hispanic-American, and Native-American students score lower on science literacy assessments and participate in fewer science classes than their Anglo and Asian counterparts. Results of the National Assessment of Educational Progress (NAEP) indicates that Hispanic-American, Native-American, and African-American students typically do not participate in elective science classes, such as Biology, Chemistry, or Physics at the level of their Anglo or Asian-American counterparts. When Hispanic-American, Native-American, and African-American students do participate in elective science classes, there is a substantial gap between their ability and their Anglo and Asian-American counterparts ability to understand simple scientific principles, apply general scientific information, analyze scientific procedures and data, and integrate specialized science information (Jones et al., 1992). Clearly, the picture is bleak for minority proficiency and participation in science.

Practice that increases that participation and proficiency of minority students is critical as our schools increase in ethnic and racial diversity. The purpose of this study was to examine the practice of two science teachers who have increased the participation and proficiency of students who historically have not participated or persisted in science. In-depth interviews, observations, classroom documents, and interviews with students and colleagues were used to capture the practice of two teachers throughout a semester. This study provides insight into working effectively with students who historically do not participate or persist in science.

Methods

Identification of Science Teachers

During the fall of '96, a search was conducted to identify science teachers who were successful with Hispanic-American, Native-American, or African-American students. At this time successful was defined as science teachers whose students continued to participate in science, science teachers whose student enrollment had increased, and science teachers whose students typically earned a C or better in science class. Names of teachers were collected from university science educators, principals, district science

coordinators, and science teachers. Each science teacher identified was interviewed, observed, and information was collected pertaining to their student enrollments and proficiencies over time. From a list of ten names, three teachers were identified as being successful with minority students and these teachers did not self-nominate. Two science teachers agreed to participate in the study -- Ruth and Linda.

Data Collection

During the spring of '97, an extensive data collection period began. Ruth and Linda were observed weekly in their classes and interviewed throughout the semester. In addition, documents pertaining to classroom instruction were collected, and interviews with students and colleagues were conducted. Data were collected by two researchers; one with a monocultural background who is a university science educator, and one with a multicultural background who is a graduate student in science education. Data were collected from different sources and by two researchers to triangulate the sources and eliminate some of the inherent bias that occurs with qualitative data collection (Mathison, 1988; Marshall & Rossman, 1989).

Unstructured interviews were used throughout the study in order to understand the complexity of the situation without limiting the field of inquiry (Fontana & Frey, 1994). With this format, the teachers in this study, their colleagues, and their students were initially asked one or two general open-ended questions to begin the interview. Their ensuing responses defined the content and direction of the interview (Bogdan & Biklen, 1992). As teachers and students talked freely throughout each interview, they were also asked to provide details and examples that clarified stated perspectives. The interviews with the teachers in the study were conducted every three weeks, while interviews with colleagues and students were conducted towards the end of the semester. All interviews occurred at the respective schools of the teachers and students. The interviews lasted from one to two hours, and each was transcribed from an audiotape recording.

Bi-weekly participant observations of Ruth and Linda lasted an entire class period -- approximately fifty minutes. The observations were a gathering of data that consisted of written sketches of students, reconstructed dialogue, accounts of events, depictions of activities, and notations about the behaviors of Ruth and Linda (Bogdan & Biklen, 1992).

Class materials were also collected as documents that portrayed the practice of Ruth and Linda. These materials encompassed the entire semester and were collected following observations or interviews. Ultimately, they provided an unbiased account of the practice of both teachers.

Data Analysis

The principles of constructivist analysis guided the interpretation of the collected data (Denzin, 1994; Guba & Lincoln, 1989). A interim analysis of each teacher began as the data were first being gathered. The initial constructions were tentative and emerged through the periodic interactions between the two project researchers. These constructions helped to define how clearly the research topic was being captured, and indicated if necessary adjustments needed to be made within the design protocol (Miles & Huberman, 1994).

During the summer, the transcripts from Ruth and Linda's interviews, class materials, and transcribed participant observations were inductively analyzed (Bogdan & Biklen, 1992; Miles & Huberman, 1994) by two researchers and Ruth. Two thematic cases were developed that represented Ruth and Linda. A cross-case comparison was made to reinforce emergent constructs, while identifying case particularities (Miles & Huberman, 1994). The resulting cross-case comparison revealed patterns of similarities and differences between Ruth and Linda.

Ruth & Linda

The following descriptions about the teachers in this study were created by the researchers and the teachers.

Linda

I did not intend to pursue teaching as a career. In fact, my entire life I was discouraged by both of my parents, who were teachers, from pursuing education. I initially came from Puerto Rico to study chemical engineering, and I ended up in Pharmaceutical Science pursuing my Ph.D.. When my Ph.D. advisor did not get tenure, I had to find something to do. A friend suggested teaching and I was hired on an emergency certificate

to teach bilingual biology at South High School. I have been here ten years, and I teach bilingual biology and bilingual chemistry.

I enjoy teaching, I enjoy teaching science, and I enjoy the students. As a teacher, I am a "nerve striker." I challenge my students' beliefs about themselves and I set high standards for my students. This is how I strike a nerve.

Ruth

I have been teaching for 12 years. I started out as an education major, but left after my first education course. I explored a couple other majors, but eventually ended up earning a degree in biology and chemistry. After working as a research assistant in the laboratory for a few years, I decided to get my teaching certificate. I wanted something that was more exciting than mixing chemicals and watching reactions, and education seemed to be an option that was worth revisiting.

Over the years, I have developed a deep appreciation for all aspects of this profession. I value the students; after all that is why I teach. I enjoy being professionally active; with my work on Project 2061 being some of the most important in my career. I like several disciplines in science, and I am always trying to remain current in my field. Indeed, there is no better profession than education, specifically -- science education.

Results

Themes

The following similarities existed between Linda and Ruth:

In-depth instruction on a few topics.

Both teachers emphasized a few key topics in their classes. For example, Linda spent two months on the concept of proportions. The students completed labs and they worked problems in order to understand the concept of proportion. Likewise, Ruth allocated two months to the topic of esters. Ruth provided week-long investigations in which students would explore the structure and function of esters. She emphasized the development of critical thinking skills through chemical investigations.

Respect for students and their culture.

Linda and Ruth respected their students individually and culturally. In their classrooms, Linda and Ruth encouraged and valued the ideas that their students put forth, and the students knew their ideas were valued. During classroom observations, students frequently asked questions. All students who were interviewed indicated that they felt comfortable asking questions. When asked why they felt comfortable asking questions, students responded with "our teacher listens," "she doesn't hassle us," and "she really wants to help us."

Both Ruth and Linda also valued the cultural background of their students. Both were familiar with the culture of their students and frequently asked students about their quincianeras, family gatherings, and family struggles (often related to immigration); and they both used examples from the students' culture during instruction. Linda, a native of Puerto Rico, often spoke in Spanish when describing concepts and when talking about personal issues. Her frequent use of Spanish was appreciated and valued by the students. Ruth did not speak Spanish, but she allowed students to use Spanish in her class. Ruth accepted the students' language as part of their culture and recognized that the Spanish language needed to be present in the class as students talked about chemistry and life.

Professionally active in and outside of the school.

Both Linda and Ruth were involved in several activities in and outside of their schools. In her school, Linda often organized educational trips that would broaden her students' horizons. For example, during the spring she took her students to the Inauguration of the President in Washington, DC. In her school, Ruth coordinated the NCA review team and she directed the committee for professional development. Outside of school, both were pursuing advanced degrees (Ed.D. & Ph.D.) and both participated in national and local projects (Project 2061 & problem solving in the classroom).

An in-depth knowledge of science.

Both Linda and Ruth had an understanding of their discipline that exceeded a typical bachelor's degree. This is primarily attributed to their research experience in different fields of science. Linda participated in several research programs during the period of time that she was pursing her Ph.D., while Ruth was hired as a research assistant

after she completed her bachelor's degree. In addition, both stayed current in the science areas that they taught. Linda frequently visited the local university to discuss the field of chemistry, and Ruth often took graduate courses or workshops that expanded upon her science knowledge.

High expectations for their students.

Linda and Ruth held high expectations for their students, although the reason for the expectations differed. Linda wanted her students to be prepared for college. She wanted her students to learn to work hard and she wanted her students learn the basics that would prepare them for college. Linda, in one interview, said "these students need to learn how hard you have to work to succeed, as they will always have to work twice as hard to achieve success." Ruth wanted her students prepared for life. While some of Ruth's students would go on to college, most would not. Ruth wanted her students to be scientifically literate which entailed knowing and learning how to think critically about natural phenomena.

The following differences existed between Ruth and Linda:

Nature of teaching.

Linda preferred an approach to teaching that used lecture and problems, while Ruth often implemented inquiry-based instruction. Linda often lectured and presented problems for students to work. While she frequently used this method, she also expressed a desire to learn other methods of science teaching. Ruth became an inquiry teacher because of her work on Project 2061. As an inquiry-based teacher, she constantly provided investigations for students in which they would construct their own explanations about natural phenomena.

Nature of the classroom environment.

Linda was regimented and organized in her approach to instruction in the classroom. Linda expected her students to begin working the moment they came to class, even if the class had not started. There was a set procedure in Linda's class that was followed daily. Ruth's class was casual, but efficient. Ruth frequently began class with brief discussions that quickly turned into active investigations. Ruth would move from student group to student group to assist students as they participated in their

investigations. Students and teachers would frequently stop by Ruth's class to visit with Ruth or her students.

Discussion

In this study, we tried to understand how two science teachers increased the participation and persistence of students who historically do not participate in science. We attribute their success to four factors. First, these teachers demonstrated a cultural sensitivity towards students. These teachers allowed their students to bring their culture into the science class. Both allowed the language of the students to exist, and both allowed students to discuss events that were related to their culture. Furthermore, during discussions and investigations, both Linda and Ruth connected to their students' culture by providing culturally relevant examples and by using the Spanish language. Powell (1996) concluded that cultural sensitivity is intuitive, yet others suggest that cultural awareness is fostered (Grant & Tate, 1993; Noordhoff & Kleinfeld, 1993).

Second, these teachers utilized several practices that are consistent with the National Science Education Standards (National Research Council, 1996). Both Linda and Ruth provided extensive instruction in a few areas, both provided opportunities for students to participate in science investigations, and both emphasized rich science experiences. We are not sure of the relationship of their previous research experience to their instructional emphasis, but it has been suggested that a previous research background may positively influence the type of instruction that a teacher enacts (Salish Research Collaborative, 1997). Both Linda and Ruth valued their research experience, and both considered it important to their understanding of science and the key concepts in science. Ultimately, Linda and Ruth's understanding of science may have resulted in their teaching fewer concepts over a greater period of time.

Third, both Ruth and Linda held high expectations for their students. Both teachers wanted their students to succeed, and both continually set high standards for their students. Both teachers expected students to understand key concepts and they expected students to complete the work they assigned. Not surprisingly, their students met their expectations. When individual students encountered difficulties, Ruth and Linda worked

with the individual student and modified the curriculum, provided individual tutoring, or provided alternative activities in order to ensure student success. Holding high expectations is an important factor in working with diverse students (Atwater, 1996).

Finally, both were committed professional science educators. As professionals, they were continually reflecting upon their practice and revising their instruction. After an observation it was not uncommon for Linda and Ruth to discuss how they would enact the lesson next year or share where they had found the lesson. Both discussed finding lessons on the World Wide Web or through science education workshops or courses. As professionals, Linda and Ruth were also active in their respective schools. They took on positions of responsibility that allowed them to influence school policy and direct school activities. Both considered their professional involvement to be an important aspect of their job.

Implications

From this study, and the work of others, there are three recommendations that can be made for in-service programs of teachers who work with culturally diverse youth. First, philosophical discussions of science and historical accounts of science that represent different cultures should be presented throughout in-service science education programs (Martin, 1986; Matthews, 1989; National Research Council, 1996). Embedding the history and philosophy of science throughout a program can present science as an enterprise that all people experience and contribute to, and demonstrate the nature of science as well as the knowledge in science. Ideally, as in-service teachers learn that science has existed in several cultures and beyond the last four hundred years, they will modify their practice to be more inclusive of all students. Second, in-service science education programs should address issues related to teaching culturally diverse students. Atwater and Riley (1993) stress the need for teachers to be familiar with the cultures of students they instruct. In-service education programs should be created that directly addresses the needs of underserved and underrepresented youth in science. These programs should focus on effective multicultural teaching and learning (McDiarmid, 1990). Third, experiences related to multicultural science education should be long term, as short term experiences

regarding multicultural education have a limited effect in altering the attitudes, beliefs and practices of teachers (Aaronsohn, Carter, & Howell, 1995; McDiarmid, 1990). In-service programs should provide ample time for teachers to examine aspects of multicultural science education and implement practices associated with multicultural science education in their classrooms.

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