The Qualitative Report

Volume 12 | Number 4 Article 10

12-1-2007

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Abstract

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Keywords

Secondary Students, Mexican American, Chemistry Attitudes, and Alternative Schools

Acknowledgements

I would like to thank Dr. Maria Lahman, Dr. Loretta Jones, Nicole Kunze, Nate Barrows, Rod Simpson, and John Dunkle for their assistance and suggestions. I would also like to thank Derek Lefebra, my research assistant. This research was supported by the Center of Teaching and Learning in the West (CLTW), a National Science Foundation project, ESIE Award #0119786.

The Qualitative Report Volume 12 Number 4 December 2007 705-728
http://www.nova.edu/ssss/QR/QR12-4/peterson-beeton .pdf

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Latinas/os form the largest minority group in the U.S. and they are growing more rapidly than any other ethnic group in this country. However, the number of Latinas/os in chemistry is not proportional to their population; they are noticeably absent from the physical science fields. Little research has explored the circumstances that Latino students encounter in high school chemistry. In this exploratory study, four Mexican American students and one Native American student were interviewed and observed in a physical science class at an alternative school that enrolled predominantly Latino students. Five underlying themes were found: negative perceptions of science, benefits and disadvantages of alternative school science, traditional teaching methods versus student-centered teaching, outreach possibilities, and changes in stereotypes of scientists. A further investigation and more in-depth contextual knowledge is needed in order to determine more precisely what caused the students to have their opinions on physical science. Key Words: Secondary Students, Mexican American, Chemistry Attitudes, and Alternative Schools

> [Learning science is important for students] because I think people need to understand the world and how we live and what we're doing to the Earth and stuff. I think they need to understand what's going on.
>
> I don't think [learning science is] a must. I don't know. Where are you going to use it at?

Introduction

With each passing year, the population in the United States is becoming increasingly multiethnic and multilingual. Minority groups make up approximately 30% of the total population (U.S. Census Bureau, 2006). The U.S. Census Bureau estimate for July 2005 has Latinas/os at 14.4% of the population, a greater percentage than African Americans, the previously largest group, at 13.4% (U.S. Census Bureau). Latinas/os are the fastest growing minority group due to high birth and immigration rates (Edmonston & Passel, 1992). There are over 15 million recent immigrants from Mexico, Central America, and South America (U. S. Census Bureau). The number of Latino school-age children has risen rapidly. In 2000, 16% of school-aged children in the U.S. were Latina/o. By the middle of the 21st century, Latinas/os are expected to make up nearly one-fourth of the population (National Center for Educational Statistics, 2003a).

While the number of Latinas/os in this country is rapidly increasing, they are the least educated ethnic group and are significantly underrepresented in higher education. Some educational gains have been made; however, they remain underrepresented in science careers and in post-secondary and secondary preparation for science careers. This is especially true in the physical sciences (The Education Trust, 2003). Table 1 gives a summary of the number of Latino students who earned science degrees in comparison to European American students.

Table 1

Percentage of Students Who Earned Degrees in Chemistry, by Ethnicity

	European American	Latina/o	Latinas (% of total Latina/o degrees earned)[1]
Total population[3]	67.8%	12.0%	
Bachelor's degrees[3]	67.6%	9.8%	
Bachelor's degrees in chemistry[2]	70.6%	4.0%	36%
Master's degrees in chemistry[2]	75.7%	4.6%	73%
Doctoral degrees in chemistry[2]	61.7%	4.1%	33%

Sources: [1]National Science Foundation, 1998
[2]Heylin, 2003
[3]National Center for Educational Statistics, 2003b

There is a large volume of literature on minorities in science, however few studies have looked specifically at Latino students. There have been a few reports of Latino students' viewpoints and feelings about school in general (Frau-Ramos & Nieto, 1993; Jennings, 1993; Zanger, 1993), and less than ten studies were found on Latino students in chemistry or even in science, in general (Black & Crawley, 1991; Crawley & Koballa, 1994; Flores-Feist, 1996; Fowler, 1992; Mason & Mittag, 2001; Stansbury, 1998). One reason for this lack of research is the heterogeneity of the Latino student population (Lucas, Henze, & Donato, 1990). These students come from Mexico, Central and South America, Cuba, and Puerto Rico. Some are first- generation immigrants knowing little English, while other students come from families that have lived in the United States for hundreds of years. The experiences of these first generation immigrants may be extremely different from those of the subsequent generations (Suarez-Orozco & Suarez-Orozco, 1993). The educational background and social economic status of the parents can vary greatly. Due to all of these factors, one localized group of Latino students may be different from another localized group, making this a very challenging and interesting group to research.

There are many barriers to science that Latino students face, making equity in science education a complex area to study. In an article by Rakow and Burmudez (1993), 21 factors were identified as variables on Latina/o achievement in science, while Barba and Reynolds (1998) listed 13 factors. Having access to few role models in science, low levels of awareness of science careers, having few relevant science experiences, lack of funding for higher education, the viewpoint of a scientist as a White, male profession, and low expectations from parents and teachers all contribute to a negative viewpoint of science as a career. A summary of the barriers that Latinos students encounter are listed in Table 2. There has been criticism of studies on equity in science because many group all minority students together (Artiles, 1998; Baker, Keller-Wolff, & Wolf-Wendel, 2000;

Landrine, 1995; Ramirez, 1998) or are conducted with large surveys with little contextual information (Baker, et al., 2000; Battle, 2002), so little is known about minority students' perspectives. There have been a few reports of Latino students' viewpoints and feelings about high school (Frau-Ramos & Nieto, 1993; Jennings, 1993; Zanger, 1993; Telese, 1999); however, few studies have specifically looked at their attitudes and perceptions towards chemistry and physical science. Student interest in science starts to deteriorate in the middle school and high school years (Clewell, Anderson, & Thorpe, 1992). Therefore, in order to better understand why the number of Hispanics in chemistry is low, it is important to determine the attitudes of younger Hispanic students.

Table 2

Barriers to Latino Student Advancement in Chemistry

- High school drop-out rates
- Negative attitudes
- Pressure from family
- Poverty
- Low expectations from teachers and parents
- Lack of counseling on prerequisites
- View of chemistry as a white male profession
- Lack of relevant science experiences
- Lack of science resources
- Low English proficiency
- Racism in schools
- Lack of science role models
- Tracking into lower classes
- Peer pressure

Sources: Rakow & Burmundez, 1993; Barba & Reynolds, 1998

Attitude is an important factor in chemistry achievement and is associated with both gender and ethnicity. Even if all other contributing factors were equal, interest and motivation are still needed for a student to learn chemistry effectively (Herron, 1996). Several large surveys of student attitudes towards science have been carried out over the past 20 years. Many of these surveys indicate a decline in physical science interest with increasing age regardless of gender or ethnicity. A survey of students at 11 years old and later at ages 13-14 years old, found that attitude towards physical science, along with opinions about science careers declined with age. This was especially true for females (Kelly, 1986). Patricia MacCorquodale (1984) found that females and Mexican Americans were the most likely to say that they would not be interested in taking science courses.

Several other studies have found that Latino students are generally interested in science, but would not be interested in pursuing a career in it (Fowler, 1992; Maholmes, 2001; Sorge, Newson, & Hagerty, 2000). This was also found to be the general consensus of all students. A study done in 1989 using survey data from 3,460 high school chemistry students, showed that overall these students had a positive attitude towards science and the importance of science in society (Menis, 1989). However, they were less positive about science in school and science careers. In contrast, surveys by the National Action Council for Minorities in Engineering (1995, 2001) found that high school students of

Color responded positively to scientific careers, but were not taking enough mathematics and science courses to be able to pursue them. Seventy-seven percent of students of Color thought being a scientist would be interesting. These students generally like their science and mathematics classes; still 60% of Latinas/os planned to drop mathematics and science classes as soon as possible (NACME, 1995).

This study focused on students in an alternative school. An alternative school is a school environment separate from mainstream schools and are "intended to provide supportive learning environments that address the needs of specific groups of students," (Coyl, Jones, & Dick, 2004, p. 39). There is not a set standard of what constitutes alternative schools and programs (Lange & Sletten, 2002); however many students who are not succeeding in regular public schools are placed in alternative school settings In general, students are referred to alternative schools and programs if they are at risk of education failure due to poor grades, disruptive behavior, truancy, pregnancy, suspension, or similar factors associated with early withdrawal from school (Foley & Pang, 2006; Grunbaum et al., 2000; Guerin & Denti, 1999; Wiest, Wong, Cervantes, Craik, & Kreil 2001). Due to the laid-back and caring structure of alternative schools, other studies have found that they increase the attendance of students (Dugger & Dugger, 1998, Lehr & Lange, 2000). Loutzenheiser (2002) interviewed nine young women at an alternative school about their experiences with schooling. While each of their stories were unique, Loutzenheiser found that "receiving little one-on-one attention" and lack of caring teachers were factors in why some of these young women did not make it in public schools.

An alternative school was chosen for this study because of the number of student attending alternative school is increasing and there is a high concentration of minority students that attend these types of schools. Estimates made in 2000 suggested that almost four million students in the United States attend alternative programs, and many of these are minority students (Lehr & Lange, 2000). Also, because of the small class size and nontraditional teaching formats often found in alternative schools (Olive, 2003), research in an alternative school may provide a unique setting in which to examine school's effect on Latino students' attitudes towards science.

The research question for this study was: How do Latino students at an alternative school perceive chemistry and science in general? The focus was to find out what these students thought about chemistry, what factors determined whether they would pursue it further, and what experiences they had in science. It is the hope that studies such as this will increase the understanding of this complex issue and help to find methods of promoting chemistry to Latino students. The advancement of minorities in the sciences is important to promote an equal and educated society. "Given the increasingly technological nature of our society disparities in science education participation will dramatically widen the gap between the have and the have nots, the elite and the excluded" (Muller, Stage, & Kinzie, 2001, p.182). With the increased amount of technology in our society, there is a need to increase the number of scientifically literate members, from all ethnic groups (Bybee, 1997).

Methodology

Research Design

Due to the exploratory nature of the research question, and the number and complexity of factors contributing to student attitudes in science, this study was done using a case study format (Merriam, 1998; Stake, 1997). The case study research design was selected to create boundaries and structure for the investigation, while still allowing for rich description and the inclusion of context. Qualitative methodologies are appropriate to use when there are large numbers of variables in an area where much is still unknown (Creswell, 1998). One of the strengths of a qualitative case study is its openness to generating new knowledge without having a predetermined hypothesis or theory; rather, understanding or meaning emerges from the data (Patton, 1990). The case in this study was comprised of students in an integrated physical science class at an alternative high school in the spring of 2004. The class was a one-semester course designed to introduce students to the physical science topics of geology, physics, and chemistry. Multiple sources of data are used in case study research to gain as much understanding about the research context, the participants, and the researchers as possible. In this study there were four sources of data: student interviews, artifacts, observations, and the researcher's reflective journal.

Theoretical Framework

The research described here was based upon the theories of social constructivism and world view. Social constructivism states that knowledge is actively constructed by each individual and that this process is socially mediated (Tobin & Tippins, 1993). This means that every person creates his or her own personal reality. This reality is influenced by the life experiences of each person. Tobin and Tippins further described meaning as socially mediated, noting "the recognition that knowledge has both individual and social components that can not be meaningfully separated enables us to construct science learning environments where multiple ways of knowing are sought and valued" (p. 6). Different cultural groups can have different ways of knowing due to their collective backgrounds and beliefs.

World view theory "explains the how and why of things, and why things continue as they do," (Corbern, 1991, p. 19). The development of a world view is driven by the need to relate to the outside world. By the time children get to school they already have a clear idea about what is real, what is meaningful, and what is acceptable. Years of schooling add to the world view and "in turn, a world view provides a foundation upon which cognitive frameworks are built during the learning process" (Cobern, 1991, p. 19). Solomon (1987) has extended this to science education by noting that social influences, which are crucial to world view theory, are important in science education, and if the students are not reached in an everyday context, science cannot be learned well.

Both constructivism and world view theory emphasize the importance of culture in learning and understanding the world. Chemistry had traditionally been viewed and taught as a Western male approach to thinking (Collins & Matyas, 1985). Students who come from a different cultural background may need help to bridge the gap from their

way of knowing to that of chemistry. According to these theories, the Latino and Native American students I interviewed may have a unique way of approaching chemistry and a unique outlook that needs to be understood to help them develop and retain interest in chemistry.

Researcher's Role

Since the researcher was "the primary instrument for data collection and analysis," (Merriam, 1998, p. 7), it is important to include a description of myself and what role I had in this research. Differences in gender, class, ethnicity, and age all affect the type of information that participants give (Merriam). It was important to acknowledge these differences and keep them in mind throughout the project.

During this project, I was a doctoral student in chemical education and earned my bachelor's and master's degrees in chemistry. I had gone straight through school and had not taken any time off to work. I enjoy teaching and have taught general chemistry at the college level. Prior to this study, I had only a few small teaching roles involving high school students, since leaving high school. I have a feminist view of the world and so, in my research, I always am aware of differences between the experiences and attitudes of male and female students.

I presented myself to the students as a college student. I dressed causally and was able to blend in with the students. I was in my mid-twenties and was often mistaken as a high school student by the teachers that had not met me. I tried to be seen by the students as less of an authority figure than a teacher and more like an older student, so that they might feel more comfortable interacting with me. Many students at the school seemed intrigued that I was a college student and asked me questions about college.

Setting

This project took place in an integrated physical science class at an alternative school, which will be referred to as "Alternative". This school was an alternative high school for at-risk students in northern Colorado. The school was comprised of 87 students in grades 7 -12, 89% of whom are Latina/o, and 75% of whom qualified for free lunch; a strong indicator that these students came from low income families (SchoolTree, 2003). The school was located in an urban setting with a surrounding rural area. Many of the students' parents were employed as agricultural workers in the surrounding farming and ranching communities.

This school was selected for the study because it was easy to access, it enrolled a high percentage of Latino students, and little is known about the science experiences of students in alternative schools. The school was composed of five classrooms and a small computer lab. Three of the classrooms were in the main building, with the remaining two in a small building behind the school. There were nine teachers, creating an approximate 1:10 teacher to student ratio. The atmosphere at the school was open and relaxed; the teachers had no dress code and the students referred to them by their first names or as, "Hey mister." The teachers often joked and talked about topics not related to school with their students. The students, in turn, seemed at ease with the teachers and other students. Few disciplinary actions were observed.

The majority of the students were Latina/o; however none of the teachers were Latina/o or fluent in Spanish. The principal of the school was Latino and spoke Spanish fluently. He was concerned with the well-being of the students in his school and was often found walking around the classrooms talking with the students in Spanish or English.

There were inherent problems for the teachers since this alternative school served at-risk students. Many of the students had dropped out or been expelled from mainstream schools. Also, some of the students were sole providers for their families or had children. A few may have even been involved in illegal activity, including gang-related violence and drug abuse. Due to these circumstances, there were problems with excessive absences. In spite of the challenges students faced at home, they appeared to want to attend school. To attend the alternative school, each student is required to go through an application process and only students who are serious about completing are enrolled, a process that most likely eliminates students who are not interested in learning.

The class on which this research was focused was an integrated physical science class for high school students. It was a one-semester course designed to introduce students to the physical science topics of geology, physics, and chemistry. The school did not offer individual chemistry or physics courses. A block schedule was utilized, with 75-minute periods. All classes met every day. Although the physical science class was a high school level class, the students used an 8th grade textbook. The class took place in the art room, with the walls covered with masks and paintings. There was only one small, unused chemical storage unit located in another room. There were 17 students in the class. The teacher was a White middle-aged male, with a background in earth science. He had previous teaching experience, but this was his first year at "Alternative". Students spent the majority of the class time copying notes the teacher placed on the overhead projector, and filling out worksheets that came with the book. The teacher was aware that the students did not enjoy this, so he tried to incorporate art projects into the class.

Participants

Students were approached after class about participating in the study. In order to participate, they were required to sign an assent form and have a consent form signed by their legal guardians if the participant was under 18. Five students agreed to participate in this study. They included two Mexican American males, two Mexican American females, and one Native American male. The Native American male was selected because he was enthusiastic about the science class, whereas most of the other students were not. He was also often mistaken as being Latino, and I believed that he was Latino before I had a chance to discuss his background with him. The participants are described in more detail in the Results section.

Data Collection

Data was collected through a variety of methods that are outlined in the following sections. These methods included participant observations, individual interviews, journaling, and artifact collection. The individual interviews were the main source of data

used to address the research question, with the other methods used to provide contextual information for the study.

Observations

I spent ten hours in the classroom as a participant observer (Jorgensen, 1989) over a period of three weeks. Much of my time in the classroom was spent observing the students and their teacher. However, I also helped students who needed assistance with in-class assignments, talked with the teacher, or did chemistry demonstrations. The students were enthusiastic about the demonstrations, since there were few supplies at this school for doing hands-on laboratory experiments. In addition to providing me with a rich description and understanding of the environment, this role helped to introduce me to a new setting quickly and build a rapport with the students. Through my involvement in the classroom and interaction with the students, I was able to identify students that I wanted to interview.

Interviews

The five students selected to take part in this study were chosen by purposeful sampling (Merriam, 1998). Students were chosen who did not seem hesitant to speak, to maximize the verbal information that could be obtained (Creswell, 1998). Initial criteria were: Latino ethnicity, some experience with chemistry through their physical science class, and varying degrees of enthusiasm for the class. During observations, I became interested in Frank, who was not Latino, and decided to include him for reasons described previously. The students were contacted at the school during their lunch hour and interview times were scheduled.

The 20 to 30 minute interviews were tape-recorded and took place during 1st period (8:40am - 10:00am) in the teachers' lounge. The room had a door to the outside, which made it possible to bring in students from other classrooms without disrupting a class. Interviews were conducted in a semi-structured format (Merriam, 1998). Semi-structured interviews have a suggested set of interview questions, but the specific questions are flexible and can evolve with each interview if students bring up topics that are pertinent to the research question. This allows more freedom to explore an area without limiting the participants' responses to questions that the researcher thinks is important. Students were asked about their opinions and feelings about chemistry, and asked to describe their past experiences with science. Finally, students were asked what they thought would increase their interest in science and chemistry.

For the interviews, a senior Hispanic studies major at the local university helped to record thoughts and observations about the students as they were being interviewed. He was also available to help with potential language difficulties or cultural misinterpretations. The research assistant was fluent in Spanish and interested in science education. He was also 1/8 Latino and had a Latino appearance. His upbringing was that of a middle class White family.

Journal

A journal was kept through the duration of the study to record observations, thoughts about the project, preliminary analysis, and to encourage reflexivity (Janesick, 1999).

Artifacts

Documents, in the form of student handouts and assigned worksheets were collected. The worksheets contained activities and practice questions from the physical science textbook. These worksheets were new copies obtained from the teacher. The artifacts were used to remain actively involved in the class and in description of the context of the study.

Analysis

The tape-recorded interviews were transcribed in full using a transcriber and were the main source of data used in analysis. This information, along with journals kept by the researcher, observations, and artifacts collected in the classroom were used in the analysis. The data was analyzed using the constant comparative method outlined by Merriam (1998). Data was coded into meaningful pieces of information. Repeating ideas, or codes, for each participant were found and labeled. The repeating ideas for all the participants were reorganized into main themes.

When researching a different culture, there are some inherent difficulties encountered. Andersen (1993) addresses this concern in the statement, "Minority group members have insights about and interpretations of their experiences that are likely different from those generated by the white scholar" (p. 36). She suggests that a researcher looking at another culture must become aware of her own prejudices and realize how they shape her research, rather than assuming she is objective. She also suggests engaging oneself in their world and using multiple points of view. To make sure that my own biases were accounted for, I used personal journaling as a source of data (Janesick, 1999). By being a participant observer, I placed myself in the world of the subjects to some extent. Also, my research assistant assisted in the analysis of data and supplied a different perspective, thereby improving the credibility of the study.

Throughout the study, an audit trail was maintained. An audit trail (Guba & Lincoln, 1981) is a detailed description of the data collecting and analyzing process that allows others to know the exact protocol of the study and to increase dependability of the study. The research journal maintained a detailed description of the study and data collection process. Also, all of the interviews were recorded to ensure that a copy of the original source of data was accessible. (See Moschkovich and Brenner, 2000, for a discussion of trustworthiness criteria in qualitative research).

Results

Description of Participants

The following is a brief description of the five students who were interviewed in this study. To ensure anonymity, participants were asked to choose a pseudonym to be used in data collection and reports. A summary is shown in Table 3.

Table 3

Summary of Research Participant Characteristics

Participant	Age	Ethnicity	Gender	First Language	Time at Alternative	Future Aspirations
Anastasia	16	Mexican American	Female	English	4 mo.	college/nurse
Cecilio	15	Mexican American	Male	Spanish	7 mo.	undecided
Frank	16	White/Native American	Male	English	2 mo.	army
Jessie	18	Mexican American	Female	English	2 yrs	college/journalist
Samuel	18	Mexican American	Male	Spanish	3 yrs.	tech school/auto repair

Anastasia

Anastasia was a 16-year old Mexican American female. Her parents were originally from the southwestern United States and spoke English. Her first language was English and she could only speak a little Spanish. Anastasia was in 11th Grade and had been at "alternative" for about 4 months. She was 6-7 months pregnant and told me that she could not find out the sex of her unborn child because her insurance would not pay for another ultrasound. Her grandmother lived with her family and was the person who signed her consent form. Anastasia was the only female in the integrated science class who seemed interested in the course content and the chemistry demonstrations that I brought. She volunteered to assist with some of the demonstrations done in front of the class, such as mixing chemicals together to get warm or cold mixtures (endothermic and exothermic reactions), and was always talkative with other students, the teachers, and me. She wanted to be a nurse when she finished school, but was discouraged from this profession because she was not doing well enough in science.

Cecilio

At the age of 15, Cecilio was the youngest participant in this study. His ethnic background was Mexican American. His parents had moved to the United States from Chihauhau, a city in north central Mexico. The language spoken in his home was Spanish, and consequently, he did not learn English until he attended elementary school. He had been going to "Alternative" for about seven months. His parents enrolled him at "Alternative" because of his poor attendance record at the mainstream school. He emphasized that he did not like it at "Alternative" as much as his previous school because he missed his old friends. In class, he had perfect attendance for that quarter and completed his work quickly and efficiently. After he had finished his work in class, he would often sleep or talk with other students. While he did seem interested in the

demonstrations (often shouting at me to blow something up), he seemed to regard this class, and school in general, as something that he had to do and not something that he wanted to do.

Frank

Of all the students in the integrated science class, Frank was the most actively involved. He was also one of the few students at the school who ethnic background was not Latino. He was 16 and his ethnic background was half Native American (a mixture of several Nations) and half Irish/German. Both of his parents grew up locally. He said that although he was not Latino, because of his darker skin, he was often mistakenly identified as being Latino. He did not speak Spanish, but had learned some French at his former school. During the science class, he seemed curious, caught on to concepts quickly, answered the teacher's questions, and was usually the first one to complete tests and assignments. During the classes, in which I was doing demonstrations, he would ask me questions about what I was doing and always wanted to volunteer to help in the experiment. Frank had been at "Alternative" for only two months and was enrolled by his family because he had too many unexcused absences at his former school. His future career goal was to enlist in the army.

Jessie

Jessie was a Mexican American female who was about to graduate. She was 18 and wanted to go to college to study journalism. Her parents grew up in Colorado and her grandparents were from the southern United States. English was spoken in her home. Jessie could understand Spanish, but could not speak it herself. In class, she seemed completely disinterested in what was being taught. She was quiet and preferred to sit by herself and complete her work quickly. During videos, she would usually sit with her head down and sleep. I asked her to help with a demonstration, which she reluctantly did, not showing any excitement or interest in doing the experiment. She seemed to like the artistic projects that were done in class. Outside of class, she was much more talkative and outgoing. It did not seem that any of her close friends were in the science class. She had been at "Alternative" for two years and had chosen to attend because she was not doing well at her previous high school.

Samuel

Samuel was a Mexican American student who was going to graduate in a few months. He turned 18 during the study and planned to continue his schooling to become an auto mechanic. His parents were from Mexico and he did not learn English until he went to elementary school. He had been at "Alternative" for three years and stated that he chose to attend the school because of the smaller class size. Samuel showed little interest in science. He was often found talking to two females who sat behind him or passing notes. While the students were allowed time to work on worksheets, he did not use most of that time productively.

Themes

This section describes the five major themes that were found across all of the participants. These themes are: negative perceptions of science, benefits and disadvantages of alternative school science, traditional teaching methods versus student-centered teaching, outreach possibilities, and changes in stereotypes of scientists. Participant quotations were deliberately included to enrich the text with perceptions and understandings of their experiences.

Negative perceptions of science

The five students interviewed in this study had varied levels of interest in science. Although a few of the students did see the value in having to learn science, only Anastasia thought that taking science was going to be useful to her personally because she was interested in nursing. The participants also did not see how science related to the real world, as demonstrated in this comment by Cecilio. "I don't feel like we are going to use it." All of the students stated that the main reason they were taking the integrated science course was because it was part of the required curriculum, as Samuel succinctly stated, "I need it to graduate." When Samuel was asked if he thought it was important for society as a whole to have some science background he replied, "Yeah, 'cause some have an interest in science. Some just don't, like me…I really don't use any science."

All of the students mentioned a negative experience associated with science. For example, Anastasia was discouraged away from nursing because it was a science intensive major.

> I kind of wanted to do something with nursing, but then they…like, they told me that I had to do better at science. So, then I was kind of like, kind of forgot about it, but now that I passed my science class with a B, kind of makes me rethink it.

Other negative encounters with science that students mentioned are summarized in Table 4.

Table 4

Negative Experiences Encountered in Science

Classroom experiences were not stimulating	"I've kind of had a hard time with science. I don't like doing it….it's boring in there." - Cecilio
Past teachers students did not like	"There's one science class I didn't like. That's 'cause I had a mean teacher…we weren't allowed to look at the clocks; we weren't allowed to smile; we had to look at the boards" – Frank
Difficulty with the subject	"[My past experiences with science have been] awful. I didn't pass my science classes, like, I like science, I like figuring out the clues and all that, but I just, like I always had a hard time with it" –Anastasia "I didn't really like science…I didn't understand it." - Jessie

Discouragement from others	"…they told me that I had to do better at science." -Anastisia

Benefits and disadvantages of alternative school science: Is less really more?

There were advantages and disadvantages found to taking science at "Alternative". The small class size and informal atmosphere of "Alternative" had helped these students to stay in school, and they had positive remarks about the school atmosphere. However, limited resources and lower expectations resulted in a lower quality of science education.

The students mentioned many advantages to attending "Alternative". Connection with the teachers was important to the students. Jessie stressed in several instances that having a connection with her teachers was important to her success in school. Samuel decided to attend "Alternative" because of "the help that they give you, smaller classes so they can help you better." Jesse also said that having a smaller class size helped her to understand science concepts better. She explained,

> I really didn't like science 'til I came here. I didn't understand it. Over here they help you a lot more. It's more one-on-one. It was, like, bigger classes, so I didn't understand. I didn't really like it. I didn't go.

Similarly to Jesse, four of the participants stated that the main reason that they were going to "Alternative" was because they were skipping too many classes at their other schools. Missing classes had a negative impact on all of their subjects, including science. When describing why science was hard for her, Anastasia made the following comment about skipping school.

> I was just, like, really bad about ditching, like, I would never go to school. So I think that's what made it hard on me. 'Cause now I'm going to school everyday and it comes a lot easier…this is, like, the first class I've passed in that…the first science class.

On the other hand, due to the small size of the school and the resulting lack of funding, "Alternative" had few resources for doing science experiments. Chemicals, equipment, and facilities for labs were virtually non-existent. While there was one small chemical cabinet, it was empty. Also, due to the small number of rooms available for classes, there was no designated science classroom. The rooms in which these classes were held varied from quarter to quarter, making it difficult to have any permanent set-up for experiments. The students noted the lack of resources. Cecilio compared "Alternative" to the public high school he had attended previously. "…at [Public High] they did, like, a bunch of demos…and when we were doing minerals and stuff, they would take all the rocks and stuff and we don't have anything [at Alternative] except worksheets." Jessis also made a similar observation and commented that, "I like to do labs and stuff. It's fun…at [Public High] we did them. They had a bit more."

Along with lack of resources, the students were not learning topics as advanced as they would have in the public school. Although the integrated science class was a substitute for high school earth science, physics, and chemistry, the textbook from which they were learning was an 8th grade level book. All of the students seemed to feel that attending "Alternative" greatly improved their achievement in school (in general), but they did seem to be missing science opportunities that might have been interesting to them, as Frank said, "there wasn't much hands-on stuff [at "Alternative"], but you know, I like it though."

Traditional teaching method versus student-centered teaching

The students all mentioned that the way their science classes had been presented to them in the past was not the way they wanted to learn science. For many this discrepancy was a large reason why they did not like science. When I asked them what a perfect chemistry class would be like, Samuel replied,

> Something where the teacher didn't talk so much, where there was more doing than writing. More doing experiments, 'cause that's why most people take science classes – to do experiments. Like I said, more experiments and more hands-on things than just paperwork and reading and taking notes.

Frank described a past teacher at a public school that he did not like. "We pretty much just listened to him and did paper work." In contrast, he described a teacher he liked as "more focused on stuff than, you know, hitting the books." Finally his description of a perfect chemistry classroom was, "Go in. Sit down. Take roll. Do a lot of hands on stuff…do work so we don't have to read, no homework." All five students mentioned experiments as something that they would like to do more often. Some of the specific experiments they remembered doing or seeing demonstrated by a teacher in a science class were dissecting bullfrogs, seeing hydrogen balloons ignited, and making volcanoes.

In this study, a variety of activities were observed in the classroom, such as taking notes, watching videos, and doing worksheets. The students also completed an art project related to a chemistry concept they had just learned. As mentioned in the previous section, only a few hands-on experiments were done in that quarter and the expectations of the students for hands-on work seemed to be low. The students and the teacher seemed to greatly appreciate the demonstrations that I brought to class.

Outreach possibilities

The participants in this study were asked what they thought would be effective methods to increase the interest of younger students in chemistry and science. All of their answers correlated back to their ideas of effective science teaching. The responses were similar to Jessie's, "Show them labs or something. Something they could do that's fun. I didn't like science, but if you do labs and stuff it's more fun. Something that's more fun. Labs are more fun for them than just sitting."

All of the students recommended including labs in the classroom. If they had more time to think about the question, they might have been able to come up with other suggestions. None of them thought of out-of-school activities until it I mentioned it. However, when asked if he thought younger students would be interested in participating in an after-school program with hands-on activities, Samual responded, "yeah, they probably would. I would." Cecilio agreed, "probably. It would be fun."

Some of the public schools nearby "Alternative" had after-school science programs. Frank described a program at his old school and said that it was fairly well received by the students. Also, students at the local university conduct chemistry demonstration programs at schools. However, none of these programs were available to "Alternative" students.

A stereotype revisited

In an attempt to determine if the students held any stereotypes of chemists, they were asked what kind of person they thought a chemist was and if this person would have any specific characteristics. The two female participants did not think that there were any defining characteristics of a chemist. All of the students had different ideas of what a chemist would be like. The students' comments are shown in Table 5.

Table 5

Student Views on Chemists

Student	What kind of person is a chemist?	What characteristics would scientists have?
Anastasia	"I don't know. Like a doctor sort of person could be."	"I think they'd be nice and they'd be patient."
Cecilio	"A pyro"	"Kind of strange, kinda freaked out'
Samuel	"My science teacher."	None
Jessie	"I don't know if there is a stereotype, just a scientist."	"Probably just be smart about science"
Frank	"Chefs, um, people who make bombs, stuff like that."	"I don't know. There are different ones, nothing specific, nothing in general."

Limitations

Due to the in-depth nature of qualitative research, with small samples sizes, the results have limited generalizability. It is unknown whether these results can be applied to other groups of students in different settings. The results may not even be applicable to all Latinas/os, due to the acculturative, socioeconomic, and other variability found within the Latina/o culture. Also, because of the small number of participants and the non-random selection process, no statistical data were produced from this study.

Since I was the primary instrument of data analysis, the results may be subject to my biases. This is especially important since I am studying a culture that is not my own. I am not Mexican American and had limited familiarity with the culture before this study. The data are also limited to the information the participants gave. They may not have revealed some of their thoughts because of embarrassment or feeling uncomfortable with me, due to the cultural difference or the unusual role of being a participant in a research study. Also, some student information may have been lost due to language differences. I had limited experience with the Spanish language; therefore outside assistance was needed to communicate effectively with parents and students in Spanish. While precautions were taken, there is still the possibility that the basic theoretical framework for this study was culturally biased, or in other words, that epistemological racism (Scheurich & Young, 1997) is built into the study and that the research methodologies are not congruent with Mestizo research methods (Ramirez, 1998).

Discussion and Conclusions

The students who participated in this study had, in general, negative views about science and chemistry, and a lack of understanding about how science relates to their lives and the world around them. They generally thought that science is useful to people who want to have a science career, but they did not think that science was personally useful to them. The exception was Anastasia, who wanted to be a nurse and therefore knew that she would need science to pursue that career. These findings are somewhat different from findings in other studies (Menis, 1989; NACME 1995; 2001), where these students did not have positive views of their science classroom experiences nor how science is useful in society. However, they, along with the other students who will follow, are not beyond hope. Nothing that was said made me believe that they were completely turned off by science and could not be reached by an interesting activity. All of them mentioned that more classroom activities that could interest them.

What these students seemed to want in their science classroom is exactly what researchers are realizing is better for the learning of all students. Traditional teaching methods view the students as passive acceptors of knowledge and often include strategies such as extended lectures, worksheet assignments, and tests, with little teacher-student interaction (Driscoll, 2000). Student-centered classrooms are gaining more attention with the growing acceptance of the constructivist approach to teaching and learning. It has been reported that students learn better when they put personal investment into the activity, when learning is socially-mediated, and when students are given the time to reflect on their own thoughts (Alexander & Murphy, 1998). Working in cooperative groups rather than in a competitive classroom also has benefits for all students. Herron (1996) pointed out that putting students in cooperative groups can enhance learning in the chemistry classroom because students are actively engaged in the project, use metacognitive strategies more frequently, and spend more time on the task. Positive reinforcement is also important. “When learners perceive that the academic climate is supportive and encouraging, they are more likely to perform well within the academic environment,” (Lambert & McCombs). Students also perform better when the teacher has higher expectations of them (Weinstein, 1998).

Teaching style also seemed to have an impact on these participants' views of science. They did not seem to separate their views of science in general from their views of school science. They also mentioned that by making their science classes more relevant to their daily lives and more interesting that they might have a more positive view of science. Some common strategies used to increase minority student involvement in the science classroom include having high expectations for all students (Rolon, 2003), making sure to call on all students equally (Bell, 2003), making science more learner-centered and socially-oriented (Hodson, 1993), and assessing prior knowledge (Rolon). Looking at issues from a global, current-events point of view, such as metal-extraction, recycling, and pollution give chemistry more of a socially oriented focus.

Providing quality science classes can be a challenge in alternative schools that lack the resources and space of larger, better-funded schools. That was the case at this school, where there was limited availability of physical science laboratory equipment and hands-on science activities. This is not an isolated problem. Over thirty years ago a commentary spoke about the difficulties of conducting biology classes in an art classroom (Sutcliffe, 1973). This paper described how a teacher has to be more creative, but claimed that quality science can be done at an alternative school even with limited resources. Sutcliffe suggests taking advantage of the community and independent projects to provide students with opportunities to do science. For chemistry, there are a growing number of resources providing experiments that can be done with household chemicals and cooking supplies (Ernst, 2002). Also micro-scale chemistry, or doing solution experiments with drop-size amount of chemicals, is gaining popularity in schools because small amounts of chemicals are used and little to no laboratory setting is needed (National Microscale Chemistry Center, 2002). These types of activities would expose the students to applications of chemistry, but keep supplies needed to a minimum.

It is interesting to note that neither of the two females mentioned any of the stereotypical features of scientists and one even stated that there were no stereotypes. They all had different answers and did not seem to have a common idea about what a scientist was. Since these students were just asked about scientists, and not told to draw them, it was not possible to determine if they had a particular gender or ethnicity in mind. It is also important to note that because I did demonstrations in the class, these students knew that I was a chemist. Therefore, they may not have wanted to offend me with negative descriptions of chemists and may have modified their answers. Many literature articles that address the issue of low retention of Latino and other minority students in science state that common stereotypes of scientists may play a role in making science less attractive (Barba & Reynolds, 1998; Rakow & Bermudez, 1993; Shakeshaft, 1995). Boys and girls, in as early as second grade, imagine scientists as "white men who have unusual hair, wear glasses and lab coats," (Koch, 1992). These stereotypes are encountered early in life from movies, television, magazines, and the lack of female and minority science role models (Samuels, 1999).

Studies have examined students' images of scientists since the 1950's using a variety of methods, such as questionnaires and Likert-scale surveys (Fung, 2002). The current preferred method of determining how students view scientists is the Draw-A-Scientist Test (DAST) developed by Chamber in 1983 (Chamber, 1983). In this test, students are given a blank sheet of paper and asked to draw a scientist. Chamber gave this test to 4800 children in grades K-5 and found several stereotypes present by second

grade, such as the wearing of lab coats and glasses and having facial hair. Fung lists 10 such studies done since that time and reports that they have all had similar results. He also comments that although there have been studies done with Taiwanese and Thailand students, few studies of this type have been conducted on minorities in particular. He also found that as the students got older, they were less likely to draw female scientists, with only 8% of the drawings female by the time children reached high school. All of the female students drew female scientists. The students were not asked to draw scientists for this study. Since drawing forces a person to define what a chemist would like, it is likely that these would have been different if the participants had been asked to draw a chemist instead of just verbally describing one.

There have been many suggestions for combating stereotypes in the science classroom, such as including examples of minority scientists and culturally specific scientific practices in the classroom (Hodson, 1993). Also, inviting guest speakers, from various ethnic backgrounds, into the classroom can help students see that many types of people are scientists (Harris, 1995). I saw no evidence of any of these practices in this classroom.

Finally, the participants in this study all thought that providing more hands-on activities, even in the form of outreach programs, would help younger Latino students stay interested in science. In the last 30 years, a considerable amount of funding has gone into promoting intervention programs in the sciences for minority students and females in a variety of settings; elementary school, junior high, high school, college, and the community (Jayaratne, Thomas, & Trautmann, 2003). Many of these programs try to involve the parents as well as the students. The first programs targeted science students at the college and graduate school level. The problem with these programs is that interest in physical science and chemistry starts to dissipate in the middle school years (Clewell, et al., 1992; Seymour & Hewitt, 1997), which was the case in this study. Later programs took this into account. A review done by Matyas and Malcolm found over 300 programs targeted at science (Matyas & Malcolm, 1991). Two problems emerged from this data. One problem was that little evaluation is carried out on any of these programs and it is not clear how effective they are (Davis & Rosser, 1996), and another is while the achievement gap has decreased substantially for white females, and somewhat for African American students, the achievement of Latino students in physical science or chemistry has not shown any increase (Rawis, 1991). In a recent study of a summer science program for girls, it was found that while the program encouraged increased interest and staying power for majority females, it actually decreased interest and staying power among minority females (Jayaratne et al.). This was true even though the emphasis in the programs was to encourage the minority girls and expose them to role models of similar backgrounds. The researcher was unsure why this result occurred, and concluded that there is still a lot of research needed to find effective ways to reach all minority groups.

Factors that caused the students in this study to lose interest in science were lack of hands-on activities in the classroom, the perception that science was difficult and boring, and too many absences from school to keep up with the material. One finding that deviated from previous studies was that these students did not seem to have the stereotype that scientists are all white males wearing lab coats and glasses. A more in-depth study needs to be carried out in order to determine what exactly turned these

students off from science. Longer involvement with the students and the school might give a deeper understanding of the issues. Also, in-depth interviews that focus on the students past experiences with education and science would help to frame their current experiences within the context of their lives. The students did not talk much about how their interactions with past and current science teachers shaped their views of science. It would be interesting to determine how much the Latino students' attitudes towards science are based on past science class and how much on outside factors, such as stereotypes of scientists and little knowledge about science careers. Also, did the science attitudes of these students change while going to "Alternative"? They mentioned getting better grades and understanding science better at the alternative school, but most contributed that to more regular school attendance.

Providing students in alternative schools, regardless of their ethnic background, with quality science education is important because more and more students are choosing to go to these schools. The number of students in alternative schools is nearly 4 million and rising. This is especially true for the Latino population. In 2000, the drop-out rates for Latino students was four times that of white students and double that of black students (Rolon, 2003). An increase in numbers of Latinas/os in science cannot be expected if the students do not stay in school. If advances are to be made in increasing the number of Latino students involved in chemistry, the quality of alternative school science needs to be addressed.

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I would like to thank Dr. Maria Lahman, Dr. Loretta Jones, Nicole Kunze, Nate Barrows, Rod Simpson, and John Dunkle for their assistance and suggestions. I would also like to thank Derek Lefebra, my research assistant. This research was supported by the Center of Teaching and Learning in the West (CLTW), a National Science Foundation project, ESIE Award #0119786.

Article Citation

Peterson-Beeton, R. (2007). Minority Students' Perspectives on Chemistry in an Alternative High School. *The Qualitative Report*, *12*(4), 705-728. Retrieved from http://www.nova.edu/ssss/QR/QR12-4/peterson-beeton.pdf