Strategies for Teaching Science to Culturally and Racially Diverse Students

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A Project Submitted to the Faculty of

The Evergreen State College

In Partial Fulfillment of the Requirements

for the degree

Master in Teaching

2007

This Project for the Master in Teaching Degree

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Has been approved for

The Evergreen State College

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ABSTRACT

Students of color in the United States often experience difficulties in reaching academic success, particularly in the sciences. This paper is a critical review of the research literature based on the question "what are effective strategies for teaching science to culturally and racially diverse students?" An introduction and educational history of the topic will precede a research analysis in which multiple issues faced by students of diverse racial and cultural backgrounds are examined. Students from cultures and races that differ from the dominant culture have historically struggled to receive an equitable education and continue to pursue careers in science in much lower numbers than their white, middle class counterparts. In another aspect of culture, Christianity is the dominant religion in the United States, but Christian students often find their beliefs incompatible with concepts in science. Though this research analysis covers a breadth of culture, including ethnicity, language, and religion, the primary focus is on marginalized groups. The research literature finds that incongruence between the cultures of home and school, language differences, and lack of access to culturally relevant materials often cause students from marginalized groups to reject academic and scientific identities. Classroom implications include the importance of building relationships with students' families and communities, having high expectations for all students, and using culturally relevant curriculum. Future research implications are also explored.

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ACKNOWLEDGEMENTS

This paper would not have been possible without tireless assistance from my faculty, Dr. Anita Lenges, PhD., Dr. Sonja Wiedenhaupt, PhD., and Dr. Sherry Walton, PhD. In addition, I wish to thank my entire cohort for their support throughout the writing of this paper. Finally, I wish to acknowledge Jonathan Hartman for love and understanding throughout my master's paper and graduate school experience.

CHAPTER ONE: INTRODUCTION

My schooling experiences were what I would consider "normal." I have come to realize, though, that my schooling felt normal because the culture of school matched my white, middle-class upbringing quite nicely. Most of my teachers represented my home culture in terms of race, religion, expectations of behavior, and learning preferences. My parents supported my education and were always lending a hand with my homework and projects. I learned quickly what I needed to do to succeed academically. The transition between my home culture and school culture was effortless.

This is not the case for many of the students of color and students of low socio-economic status in the United States. Often, school culture contrasts greatly with family and social structures. English language learners struggle to meet the demands of becoming fluent in Standard English. Students of color often do not see themselves represented in the curriculum or in the faces of their teachers. By the time they reach high school, many students are uninterested in taking classes like science or are uninterested in achieving academic success because of fear of having to reject their cultural identity for an identity of academic success.

What can a science teacher do to harness all students' innate creativity and imagination, to improve attitudes towards science, and to help all students achieve academic and personal growth? The following paper asks the question "what are effective strategies for teaching science to culturally and racially diverse students?" The paper is a review of the research literature surrounding these questions. The remainder of Chapter One will discuss my rationale for analyzing this question, definitions of terms, and limitations to the research. Chapter Two will examine the educational history of

diverse cultures and races in public schools in the United States. Chapter Three will be a critical review of the research literature in which I will focus on the following topics: movement between the worlds of home and school, family and community involvement in science education, formation or rejection of a scientific identity, challenges in learning the language of science, strategies for teaching science to all students, and the influence of religion on science education. Chapter Four will conclude the paper with a summary of findings and implications for future practice and research.

Rationale

To teach well requires attending to the prior knowledge and experiences of all students. This is a growing challenge in a country where the population, and consequently the schools, is supporting an increased diversity of races and cultures. According to Spring (2006), the U.S. Census bureau projects that by the year 2020 the Latino school-age population will increase by 60% and White school age children will constitute just over half (56%) of school populations. These statistics, viewed under a positive light, provide a rich tapestry upon which the educational system in the United States could thrive. However, the teaching force remains dominantly white and middle class. Data in 2001 showed that 90% of public school teachers were white (Spring, 2006). For teachers to succeed in facilitating students' learning processes, they must be keenly aware of the backgrounds of their students. Historically, the public school structure in the United States has been geared toward educating the dominant culture—white, protestant, middle-class peoples. For marginalized groups to receive equitable educations, teachers must be aware of not only curriculum and teaching strategies that are primarily geared toward students of the dominant cultural group, but also the diverse

backgrounds and lifestyles that each student brings with them to the classroom. This is particularly relevant for science teachers. Science tends to be a subject that many students of color and some Christian students see as incongruent to their culture. Science also requires learning a new vocabulary which can be an added challenge to students who are not yet adept in English.

Many students of varied racial and cultural backgrounds struggle in finding correlations between their life experiences and the material taught in school. Several researchers have addressed this issue, using language such as "cultural interface zones," "boundary crossings" and "multiple worlds" (Norman et al., 2001; Phelan et al., 1991). In addition, this topic has been researched in a nature specific to science (Costa, 1995; Gilbert, 2001). By the time many marginalized students reach high school, they tend to have either been tracked into a curriculum wherein science classes are not an option or they have been turned off to science and are not interested in pursuing the subject further. The latter claim is supported by research that examines how students visualize the identities science and scientists as incompatible with the way they self-identify (Brickhouse & Potter, 2001; Charron, 1991; Parsons, 1997). In examining culturally relevant teaching, one of the first steps is in recognizing that many marginalized students simply see school, and especially science, as incongruent to their lives.

The purpose of this paper is not about finding a teaching strategy that works particularly well for African American students, or a strategy that works well for Latino students, because every student does not fit the stereotype of what "African American" or "Latino" means. Delpit, according to Levine et al. (1995) asserted that teachers cannot design specific instruction that supports each different racial or cultural group in their

classrooms. It is too difficult to accomplish and a teacher can make a mistake in assuming characteristics in a student that may not exist. This paper is about gaining a broader understanding of the teaching and learning styles that will best support students of color and students whose religious beliefs conflict with concepts in science. It is too difficult to accomplish and a teacher can make a mistake in assuming characteristics in a student that may not exist. This paper is about gaining a broader understanding of the teaching and learning styles that will best support students of color and students whose religious beliefs conflict with some concepts in science. This question is particularly important for a white teacher, like me, who will be interacting with students from a variety of backgrounds.

Teachers, and schools for that matter, should not expect students of color to bend their cultural norms and learning styles to meet the learning styles of the dominant cultural group in the country. Instead of relying on a particular style of teaching and learning that might only serve one group of students, a teacher needs to develop strategies that support the learning of all students. Although one strategy certainly will not work for every student, a teacher who is well versed in different learning styles and different teaching strategies that support those styles will be able to assess what teaching strategy is most effective for a student at a particular time.

Definitions of Terms

The term "culture" has many broad definitions. Vygotsky defined culture as "shared beliefs, values, knowledge, skills, structured relationships, ways of doing things, socialization practices, and symbol systems (such as spoken word and written language)" (in Miller, 2002, p. 374). In addition, culture can influence what skills are important to

acquire and how skills are acquired. Culture can include physical terrain, social and economic status, political climate, and schools. For the purposes of this paper, my explorations of culture will at times include geographic location (urban or rural), socio-economic status, race, ethnicity, religious beliefs, and language.

Race can be controversial and difficult to define. It is usually a label assigned to a person or group of people and as a self-descriptor. According to Campbell (2004) "race is the term used to describe a large group of people with a somewhat similar genetic history…we learn culture but we inherit race" (p. 70). Because the color of a person's skin is visible, the way a teacher views a student of a particular race, or the way a student views a teacher has implications for the teacher-student relationship. Biologically speaking, all humans are very closely related and distinctions of race are largely superficial descriptions of skin color or facial features. Currently, though not historically, race tends to be viewed as a social category rather a biological classification (Campbell, 2004). A person who is 'black" in one country may not be in another.

I will use the term "white" to describe Americans of European decent. The terms dominant and mainstream will refer to White, middle to upper class, primarily protestant Americans. This is the dominant cultural group of the United States, and that fact has many implications for the students of color in our schools. At times, the terms "white" and dominant group or mainstream culture will be interchanged.

I will use the terms people of color or students of color to describe people of African, Latin American, or Native American decent. I borrow from Tatum (1997) who said that this term more inclusive, and more accurate than using the term minorities. Minority tends to have a negative connotation, and in fact, so-called minorities are the

majority of people in the world. I also refer to students of color and low socio-economic status as marginalized. A full definition of this term will be uncovered in the history section.

I choose to use the term African American to describe people of African decent who have roots in the United States. When referring to other peoples of African decent, such as Haitian peoples, I will make that specification. I choose to use the terms Latino or Latina instead of Hispanic. Though people of Latin American decent may identify as either Latino or Hispanic, the term Hispanic tends to connote a people dominated by Spanish influence and does not consider native peoples of Central and South America (Spring, 2006). Mexican Americans are the dominate Latino group in the United States, and they dominate the literature on Latino peoples included in this examination (Campbell, 2004).

The research literature in this paper will at times blend the ideas of race and culture. Some literature will deal specifically with development of racial identities, and some literature will address the many aspects of culture that tend to be attributed to certain racial groups. The importance of using the separate terms race and culture in this literature review lies in the fact that, in most cases, judgments are often made based on race whereas a person's cultural intricacies are not often readily identifiable. This notion is important in the way a teacher and student view each other based on initial physical characteristics.

I wish to recognize that lines designating race and culture in our society can be indistinct. I acknowledge that many students will have a mix of backgrounds. It is my intent in the paper to analyze the literature in terms of race and culture as presented by

the researchers with the knowledge that developing a means of teaching certain races and cultures can be applied to other races and cultures.

Limitations

Whereas I realize that many racial and cultural groups are represented in the United States, I have chosen to narrow the focus of my analysis primarily to African American students and Latino students, particularly English language learners. Research on immigrant students of varying backgrounds and Native American students is also included as it is necessary to examine the role of culturally relevant teaching practice for all students. The reason for this limited focus is that I will be teaching in the Southeastern United States where African American and immigrant Latino students are more highly represented than other students of color.

Thought the interface of religion and science is not a large focus of the research analysis, I have chosen to include the topic for similar reasons to those listed previously. Christianity is a dominant piece of culture in the Southeastern United States, and the evolution versus creationism debate in public schools is a current hot topic. I recognize that there are many other religions represented in the United States, however for the sake of this literature analysis, Christianity will be the only one discussed.

Though I had not planned on directly addressing differences in academic achievement based on socio-economic status in this paper, it became apparent through review of the research that many of the students of color in the research are also from families of low socio-economic status. The divide between academic achievement of low and high socio-economic students is a problem that needs to be addressed. Though it is addressed implicitly, it is not explicitly expressed in this paper.

To broaden my understanding of how all students can be best served in science education, I have opted to not limit the review of research to high school students. Most attitudes toward science are established in earlier grades, and though I will be teaching at the secondary level, I feel that an understanding of my students' previous experiences with science education is important to examine.

I have also chosen to not focus on issues of gender. Gender inequity in science education is an area that has been heavily researched and merits further discussion. Issues of gender inequity in the science classroom are woven into some of the research reviewed in this paper; however gender issues were not one of my major focuses in this paper. It is a real problem that so few women enter science fields and that so few girls are encouraged to explore science in school. This issue is a paper unto itself.

Statement of Purpose

This paper examines the research literature concerning the challenges faced by students of color as they enter a school system and science classrooms that may or may not support their racial, cultural, or ethnic identities; the congruence, or lack thereof between racial and cultural identity and academic success in all school subjects, but science in particular; the dialogic challenges faced by students who are English language learners; and the impact of Christian belief on science education. These will not each be explored in great depth, but will be examined as an overview to the ways in which culture affects students' interest and success in academics, and particularly science. Finally, implications will be made about the practice of culturally relevant science teaching.

Summary

Every student that enters the science classroom brings a rich set of cultural experiences that need to be addressed and built upon for each student to achieve academic and personal success. Though there is danger in stereotyping a student's learning preferences based on perceived race or culture, there are benefits for a teacher to gain insight about different races and cultures. In order to explore the question of effective science teaching strategies for culturally and racially diverse students, this paper is a review of the research literature around this subject. Chapter two will provide a historical context for the question, connecting current issues of teaching students of color and students whose Christian beliefs conflict with concepts in science with the history of these groups in the public schools of the United States.

CHAPTER TWO: HISTORICAL BACKGROUND

Introduction

This chapter reviews the history of the experiences of students of color and varied cultural backgrounds in the U. S. public school system as well as the historical and current methods used by teachers and schools to employ multicultural teaching methods. Non-mainstream racial and cultural groups have struggled to receive an equitable education in the United States for some time. Though public schools are desegregated and the population of the United States is growing increasingly diverse, students of color still tend to fall behind in general academics and in science specifically. And though Christians are the dominant religious group in the United States, the beliefs of many fundamental Christians conflict with science concepts like evolution. Having knowledge of both the historical backgrounds and the current beliefs of students' races and cultures is a beneficial tool for teachers as they build on students' life experiences to make school more relevant, engaging, and accessible.

Educational History of Diverse Racial and Cultural Groups in the United States

An examination of the history of schooling experiences of people of color and varied cultural backgrounds in the United States starts with an important question: How did students of color, of low socio-economic status, and of varied language backgrounds come to be considered "marginalized?" Public schools in the United States were originally intended to provide opportunities for social advancement, to teach common moral and political values, and to feed a burgeoning labor market, among other things (Spring, 2006). But who were the intended recipients of social advancement? Whose moral and political values were considered correct?

In the United States, due to European settlement hundreds of years ago, the dominant culture is White and protestant. Dominated groups included people, such as Africans and Native Americans, who were incorporated into the United States against their will, often through slavery or encampment (Spring, 2006). Ogbu suggested that due to a history of slavery, discrimination, and segregation, dominated groups tend to feel that the United States government, including public schools, works only to benefit the dominant culture (Spring, 2006). Though African Americans, Native Americans, and immigrant peoples were once at the center of their respective cultural milieus, in the United States they were pushed to the margins of society, stripped of their cultural identities and expected to conform to the dominant culture. Thus the term "marginalized" refers to people who have been excluded from political processes, have received inferior education, and were seen as inferior by most members the dominant group (Osborne, 1996). It is not surprising that research has shown that students of diverse racial and cultural backgrounds historically and presently exhibit lower levels of academic interest and achievement (Norman et al., 2001).

Public schools in the United States were historically created to keep the values of a new Anglo-Saxon, Protestant culture dominate at the cost of the values and cultural norms of Native peoples, Africans, and, at the time, Germans and Irish peoples (Spring, 2005; Spring, 2006). This process was defined by Spring (2005) as deculturalization: "an educational process that aims to destroy a people's culture and replace it with a new culture" (p. 183). Not until the 1950s and 1960s did Native Americans, African Americans, and immigrants from countries such as Mexico begin to receive equal treatment under the U.S. Constitution. Equal representation in the Constitution did not

mean equal schooling however, and even today, much of the non-white population in the United States receives sub-par schooling opportunities.

Native Americans showed little interest in becoming educated by Western standards, but early colonists were determined to convert them from their religious and cultural traditions (Spring, 2005). The primary goal of colonists in educating Native Americans was to teach them English so that they could read the bible and become Christians. As time passed, colonists became increasingly concerned about the perceived uncivilized nature of Native Americans. In the late nineteenth century, a major U.S. policy goal became replacing use of Native languages with English, destroying Native customs, and teaching allegiance to the U.S. government (Spring, 2005). This goal was partly accomplished by removing children from tribal and family influences and placing them in boarding schools to acculturate the children into White, protestant cultural ways. In the mid-20th century, Native Americans began to demand greater control over their lives, including their education. With support from Presidents Kennedy and Nixon, Native Americans began to gain control in the form of the Bilingual Education Act of 1968 which provided funds to support bilingual programs in Navajo and English, and through the 1975 Indian Self-Determination and Education Assistance Act, which gave tribes the power to work with the national government to run their own education programs (Spring, 2005). By the late 20th century, Native Americans were granted freedom of religion and language, freedoms that were granted to United States citizens hundreds of year prior. Today, Native American students are still perhaps the most marginalized and underserved population in the United States. According to Klug and

Whitfield (2003), Native American students have the highest dropout rate of any ethnicity and experience levels of academic performance far below national averages.

While Native American land was being settled by Europeans, Africans were taken from their home countries and brought to the United States. African slaves struggled to maintain cultural identities while experiencing systematic deculturalization by colonists (Spring, 2005). Prior to the Civil War, most states had no requirements for the education of slaves, and in fact slave owners found it in their best interest to not have educated slaves (Watkins, 2001). At the onset of plantation farming in the 1800's, plantation owners gave their slaves English names and placed them into linguistic isolation with slaves who spoke a myriad of languages. Many enslaved Africans resisted the adoption of European culture but began to learn English so that they could fight for their freedoms. Abolitionist societies in the late 18th century worked to outlaw slavery, and with ratification of the 13th Amendment in 1865, slavery was abolished (Monk, 2003). The end of slavery was just the beginning of the struggle for African Americans to gain equal educational rights.

During the Reconstruction period after the Civil War, the Freedman's Bureau was created to assist African American peoples in their transition into non-slavery society (Watkins, 2001). Along with other groups like the YMCA and missionary organizations, the Freedman's Bureau helped establish rudimentary education for African Americans. Making the transition from slaves to regular members of American society was not a quick or easy path for African Americans, however. The view of some scientists that African Americans were genetically inferior to whites of European ancestry (Watkins, 2001). Linneaus, a prominent biologist who developed a classification system for

ordering all life, determined that white people were superior to African American people, intellectually and physically. Other scientists, including one of the signers of the Declaration of Independence, contributed to views of racial inferiority by asserting that African Americans were unclean, lazy, and had diseased minds (Watkins, 2001). In a study which seems absurd today, a scientist named Morton studied cranial capacity, and deduced, through questionable tactics, that the skulls of white European-Americans were larger than skulls of "inferior" races, including Native Americans and African Americans (Watkins, 2001). Morton concluded that the increased cranial capacity of European-Americans proved that they had higher intellectual capacity. Through various methods in the mid 19th century and into the 20th century, "scientific racism" was used to justify inequities in society as a whole, including education.

Racially segregated schools were prevalent until 1954 with the U.S. Supreme Court's ruling on Brown v. Board of Education (Spring, 2006). The Civil Rights Act of 1964 furthered the cause for integration by providing a means for the federal government to enforce integration. Integration of public schools has been in effect for a mere fifty years, and the effects of such recent discrimination are still apparent in the academic opportunities and performances of African American students. Whereas desegregation has helped solve the problem of inequitable schools, segregation still occurs in a classroom level in the form of tracking. Public schools were, and still are, geared towards promoting dominant cultural norms.

Latino immigrants have a more recent, yet equally difficult history of presence and education in the United States. The 1848 Treaty of Guadalupe Hidalgo and the end of the Mexican-American War gave U.S. citizenship to Mexicans living on land ceded to

the United States (Spring, 2006). The United States continued in its attempts to deculturalize Mexican immigrants with the discrimination in language and segregated schools. In 1855 and 1870, the states of California and Texas, respectively, mandated that only English be spoken in schools. An influx of Mexican immigrants in the early 20th century caused mixed feelings among White Americans, some of whom thought that educating Mexican children would take away from farm labor, and some of whom thought the children should be schooled so that they could be "Americanized" (Spring, 2006). In 1946 and 1948, U.S. District Courts in California and Texas, respectively, declared segregation illegal in their states. However, not until 1970 were Mexican Americans officially recognized by federal courts as a dominated group and thus finally granted the right to be included under the segregation law. Thus only 36 years ago, schools were legally allowed to discriminate against Mexican Americans.

Latino students are the majority of the population of English language learners, or language minorities, in the United States. English language learners in this country have historically struggled for educational rights. In 1973 the Supreme Court ruled that public schools had to make education available to English language learners (Lucas et al., 1991). After 1974, under pressure from the federal government, states started to push school districts to adopt curriculum for English language learners and in 1976 California passed a bill mandating bilingual education in its public schools. The current state of education for English language learners in the United States is in question, however, because amendments to the Constitution to adopt English as the national language are frequent (Mount, 2006).

Bilingual education has been a hot topic in educational literature in recent years. In bilingual education, the languages of non-native English speaking students are preserved and valued while they learn English (Spring, 2006). The goal of bilingual education is to teach a person to be proficient in two languages. With the No Child Left Behind Act of 2001, however, federal support for bilingual education has diminished and efforts to help students maintain ties to their cultures through language are diminishing.

The educational issues faced by students of diverse racial and cultural backgrounds are further exacerbated in the realm of science education. Students of all backgrounds tend to show enthusiasm and aptitude for science in early elementary school; but by high school they have fallen well behind white, middle class students in academic achievement (Rothstein, 1995). Factors that contribute to this change, though different for each student, may include difficult home lives, preoccupation with social growth over academic growth, and inability to identify with the concept of the "scientist." In addition, students of color are frequently tracked into lower level classes that prevent them from pursuing higher level math, a gateway for science classes. And students of all backgrounds, but particularly marginalized students, often find science curriculum irrelevant to their lives, thus make little effort to excel in the subject.

Educational reform efforts to promote more equitable educational opportunities have ranged from the previously mentioned bilingual programs to multicultural education and ethnocentric education programs. The multicultural education movement is characterized by the mindset that all students, regardless of race, ethnicity, or socioeconomic status, deserve a quality education (Campbell, 2004). There are many definitions for multicultural education, however basic ideals include using openly

antiracist and anti-discriminatory curriculum, studying different cultural perspectives, and affirming and giving equitable treatment to differences among students (Spring, 2006).

Some marginalized groups have chosen ethnocentric schools as a means to keep racial or cultural values intact while excelling academically (Spring, 2006). Ethnocentric schools generally serve two purposes: to preserve cultural traditions and to help students overcome set-backs faced by being a member of a marginalized group. African American and Native American ethnocentric schools have historically existed in the United States, though they are uncommon and privately funded. Whereas many people may see an ethnographic education as a better choice than traditional public schools, others feel that such an education simply creates a deeper wedge between cultures. Campbell (2004) defined ethnocentrism as a belief that one's own culture and ways of doing things are best. In the light of Campbell's definition, an ethnocentric education seems to work against building multicultural acceptance and awareness.

Absent thus far from the historical account of the educational history of diverse races and cultures is a discussion on how Christian faith and science education intersect. While history from past centuries tells stories of religion being a dominant factor in education, and in the cases of enslaved Africans and Native Americans, a reason for education, more recent history sheds light on some current issues (Spring, 2005). A court decision in 1962 disallowed school prayer, however the debate resurfaced in the 1980's and 1990's and continues to this day, primarily in Southern states.

Additionally, the debate over teaching evolution versus teaching creationism or intelligent design in schools continues in many states. As some Christians believe that evolution contradicts biblical teachings, parents in some communities have put pressure

on school districts to ban the teaching of evolution in favor of intelligent design (Spring, 2006). This debate formally began in the 1920's, with Tennessee becoming the first state to outlaw the teaching of evolution (Lawson, 1985). An anti-evolution crusade ensued, marked by such public trials as Tennessee v. Scopes and widespread examination of textbooks for the mention of evolution. More recently, in the 1980's Louisiana passed a law, later deemed unconstitutional, requiring teachers to give equal time to the teaching of creationism and evolution (Spring, 2006). And in 2005, the Kansas Board of Education altered its science standards, stating that high school students must understand major concepts in evolution, but claiming that recent scientific evidence called into doubt other concepts such as Darwin's assertion of a common ancestor and of natural chemical processes as building blocks of lie ("Kansas", 2005).

The debate over teaching evolution in public schools continues and lends an element of controversy to the science classroom. Schooling opportunities for people with beliefs that contradict concepts in science have historically included private religious schools and home schooling. In fact, around half of the parents who choose to home school do so for religious reasons (Spring, 2006). These options are typically only available to students with financial means, however.

Summary

Students of color in the United States have varied histories but share status as being marginalized. Only in the past half-century have African American, Native American, and Latinos enjoyed some of the freedoms that white people do. Though today's schools are integrated and purport to provide equal education for all students, students that represent marginalized groups are still falling behind. In addition, some

Christian students remain unable to reconcile their religious beliefs with concepts in science. This issue is in current debate, as some states continue to restrict student access to topics like evolution.

CHAPTER THREE: CRITICAL REVIEW OF THE LITERATURE

Introduction

The previous chapter illustrated the difficulties that students of color and of low socioeconomic status, hereafter referred to as marginalized, have historically faced in the United States. This chapter critically reviews the research literature related to effective strategies for teaching science to students of color and Christian students whose beliefs conflict with some concepts in science. Topics examined will include movement between the worlds of home culture and school culture, the influence of family and community involvement in student success, the formation or rejection of a scientific identity, learning the language of science, the influence of religious belief on science learning and effective strategies for teaching science to all students. Research included in this chapter spans several decades and covers a broad range of issues faced by students of color in the United States.

The Different Worlds of Home and School Cultures

This section will examine research surrounding the topic of the different worlds of school culture and home culture as experienced by many marginalized students. Students from typically marginalized groups often have trouble connecting the cultures of their home lives with the cultures of mainstream schools. I will critically analyze research regarding boundary crossing in non-science and science specific settings, and conflict of worldview with Western science.

Phelan et al. (1991) did a qualitative research study that questioned how students perceived and adapted to boundaries between home, peer, and school lives that exist due to cultural, ethnic, or socioeconomic factors. The researchers had school personnel ask

students to participate in the study. Phelan et al. interviewed each student in-depth three times. Informal conversations and interviews with ten of the 54 students further supplemented the data. Students varied in gender, ethnicity, achievement level, immigrant history, and intra-district transportation status. In addition, Phelan et al. used classroom observations, student data records, interviews with teachers about their perceptions of students, and demographic and descriptive data to support their research. Through open-ended interviews with 54 students at four urban, desegregated high schools, a Multiple Worlds Model emerged. Phelan et al. used a typology to exemplify four patterns of border crossing: Type I: Congruent Worlds/Smooth Transitions; Type II: Different Worlds/Boundary Crossings Managed; Type III: Different Worlds/Boundary Crossings Hazardous; Type IV: Borders Impenetrable/Boundary Crossings Insurmountable. Students represented by each Type had relatively salient characteristics.

Phelan et al. (1991) found that Type I student tended to be white, middle-class to upper-class, and academically driven. The values held by parents and teachers were consistent. Parents tended to be involved in the school and teachers tended to know the students' family backgrounds. Teachers tended to feel comfortable with Type I students because they rarely caused problems and generally had interest in learning. Type I students were generally not cognizant of a border between home and school life because of the similarities between the two worlds. In addition, these students tended to succeed in classes where interactions with other types of students was non-existent; type I students did not have friends outside of their type. Phelan et al. noted that not all Type I students were academically successful. Phelan et al. also gave an example of one student

with low grades but clear future goals and support from teachers and parents to illustrate that academic success was not always a salient characteristic of this type.

Type II students tended to be academically successful students of color. These students had a desire to fit in, socially, and they tended to model acceptable classroom and behavior norms (Phelan et al., 1991). The Type II students in Phelan et al.'s (1991) study were generally students of color or low socioeconomic status that were bused to predominately middle-class, white schools. Though Type II students tended to be academically successful, they were invisible to teachers, partially due to their good behavior and their desires to fit in. Type II students tended to purposely keep their worlds separate, and teachers were generally unaware of their home lives. Thus, though these students were able to cross difficult borders successfully, it required great energy and motivation to do so.

Type III students had a difficult time crossing the borders between their different worlds. Some Type III students had academic success when the teachers' interaction styles or learning activities are similar to the students' home lives. Phelan et al. (1991) found that when Type III students' home lives and school lives were congruent, the students tended to be academically successful. When home lives and school lives were incongruent or oppositional, students become disengaged. The perception of teachers to Type III students varied. In cases where students found academic success, teachers supported them by incorporating varied pedagogical styles. In cases of failure, teachers tended to have low expectations and become pessimistic about the students. Phelan et al. found that teachers tended to blame students or other external factors for Type III student failure, and rarely looked at classroom features or pedagogical styles for answers.

Finally, Phelan et al. (1991) found that Type IV students were unable to cross borders between home lives and school lives. Students generally failed academically and tended to embrace peer relationships over those at school. In some cases, peers devalued academic success, leading to a lessened desire to succeed in school. Type IV students found school irrelevant and parents tended to be uninvolved in students' school lives. Teachers tended to be unaware of the difficulties that these students face and

Though Phelan et al. (1991) named white, middle-class to upper-class students as generally fitting into the Type I category, and academically successful students of color as fitting into the Type II category, she did not name certain ethnic or racial groups for Types III and IV. She implied that students in the latter two categories were generally students of color, language minorities, or students with religious backgrounds that conflicted with school values. Phelan et al. did note, however, that the patterns for each type were not necessarily stable for each person over time because a variety of environmental factors can affect the degree to which a border crossing is successful or unsuccessful.

A strength of Phelan et al.'s (1991) research was that the Multiple Worlds Model was not limited to one ethnic group, achievement level, socioeconomic status, or gender. Phelan et al.'s method of asking school personnel to choose student participants probably contributed to this model in that there was no pre-designated focus group. Whereas much research focuses on a particular cultural or racial group, this study considered all types of students that cross borders between home and school cultures. Phelan et al.'s research looked at border crossing in general; however, the following study looked at border crossing among students of science.

Costa (1995) adopted Phelan's (1991) theoretical framework in her qualitative study of how students negotiate the world of classroom science. Costa sought to study not only how students negotiate movement between the worlds of school, peers, and home lives, but also how they negotiate the world of school science. As in Phelan's (1991) study, Costa's did not focus on a particular age, gender, ethnicity, or curriculum track but Costa emphasized that these factors were important in how students responded to school science. Costa interviewed 43 students from two high schools. Of the interviewees, 26 identified as white. The remaining 17 identified as African American, Hispanic American, or Asian American. The students represented every high school grade level and were all enrolled in a science course. Costa chose students for 50 minute long directed and open-ended interviews based on their willingness to participate in the study. In addition to interviews with students, classroom observations, documented interactions with science material and with teachers, and student records provided additional data.

Through the interview process, a framework emerged from which Costa (1995) was able to categorize students. Costa named five categories: potential scientists, "other smart kids," "I don't know" students, outsiders, and inside outsiders. These categories were roughly equivalent to Phelan's (1991) typology, but extended Phelan's data from simply the world of school into the world of science.

Costa's (1995) "potential scientists" category correlated to Phelan's (1991) Type I category. Potential scientists found transitions between home lives, school lives, and classroom science lives relatively effortless. Costa found the potential scientist students made up about twenty percent of the interviewees. These students were white with the exception of one African American student. Students categorized as potential scientists

found science intrinsically interesting and planned on pursuing science careers. Though Costa did not support this information with data, she claimed that these students found congruency between the worlds of family and friends and the worlds of school and science.

Costa's (1995) second category, "other smart kids," also correlated with Phelan's (1991) Type I students. "Other smart kids," 30% of the sample group, experienced congruence between the worlds of family and friends and the worlds of school and science. Though they maintained high grades in science classes and viewed science as "good," they simply were not interested in science and thought it lacked relevance to their lives. Costa did not provide information on race or ethnicity for students in this category. Both the potential scientists and the "other smart kids" were motivated to achieve academically because of college and career goals and saw academic success as a stepping stone to life success. This was not the case for the third category: "I don't know" students.

The "I don't know" category loosely correlated to Phelan's (1991) Type II category (Costa, 1995). These students found inconsistencies between the worlds of family and friends and the worlds of school and science. Costa did not provide statistical information on the number or ethnicity of students who fell into this category. The students were typically only interested in taking the minimum science requirements to graduate, but were generally motivated to succeed in school. They tended to see science as an indefinable, foreign subject matter that fell out of their realm of interest or understanding. Though the "I don't know" students tended to experience moderate

academic success, the fourth category, outsiders, experience such discord between worlds that success in school, and in science in particular, was infrequently attained.

Costa (1995) exemplified "outsiders" by their views of school as a workplace and by their disengagement from school. These students, similar to Phelan's (1991) Type IV students, cited school as being boring and science as being far removed from their lives. Teachers viewed these students as being outside of the mainstream. Two African American students composed the final category, inside outsiders. The inside/outsiders had the intellectual capacity to succeed in science, but their worlds were too different to make the transition into the worlds of school and science. Often, these students were tracked early on into lower level, non-laboratory science classes regardless of their cognitive abilities.

A common theme among Phelan's (1991) and Costa's (1995) research was that teachers attitudes toward students appeared to directly correlate with the degree to which the students experienced congruence among their worlds. Students who were unengaged in class and who experience discord between the worlds of family, friends, school, and science were generally invisible to teachers. Teachers highly regarded potential scientists, "I don't know" students, Type I and Type II students. Teachers tended to either not notice, or write off, students in other categories.

Costa (1995) stated that one implication of this research was that "curriculum should involve students in active reflection of how science makes a difference" in the lives of students and in society (p. 330). Further implications include science educators finding ways to bridge the gap between students' varying worlds and ensuring that science curriculum is made relevant to all students. Costa argued that students should be

viewed holistically, integrated students' worlds instead of reinforcing the discordance between worlds.

Though Costa (1995) made an effort to select schools that had relatively diverse student bodies, the selection process for subjects based on student willingness was problematic. It was unclear if an incentive was offered for student participation. Costa acknowledged that many students who would have been categorized as outsiders refused to participate in the study. In addition, data for numbers and ethnicity of students in each category was insufficient. Though primarily white students were cited as falling into the potential scientist category, data for other categories lacked specificity. Costa's statement that race, gender, ethnicity, and curriculum track were important indicators of success in school science was not fully supported by the reported data.

Whereas Phelan (1991) and Costa (1995) performed research on the perceived boundaries between students' multiple worlds and how those boundaries were negotiated by students without specification of race, socioeconomic status, or curriculum level, Gilbert and Yerrick (2001) focused their study on how students in a low track, rural setting negotiated the transition into the worlds of school and classroom science. Gilbert and Yerrick's ethnographic study was based on a foundation of research citing preoccupations of low achieving students with cultural and social identity over academic success. According to Gilbert and Yerrick, students tracked into lower ability level classes tended to be students of color. These students often distanced themselves from the rest of the school, creating a microculture separate from the dominant culture of the school, expressed through resistance to academic success and identities associated with academic success, and variances in language and dress. Gilbert and Yerrick's guiding

questions throughout the research focused on the key components of discourse of lower track science classrooms in rural settings, the way these components were negotiated, and what beliefs led to defining microcultural identities within the context. In addition, Gilbert and Yerrick's concern that though National Science Education Standards set forth by the National Research Council called for a goal of science for all students, adequate steps were not being taken by schools or teachers to reach this goal guided the research.

Gilbert and Yerrick (2001) selected one high school from a rural Southern community in which to conduct the research. The school had a population comprised of 40 % African American students and 59% white students. The data presented in the article was from the first year of a two year program designed to educate teachers about learning the sociocultural aspects of teaching science. Gilbert and Yerrick chose one earth science teacher to study because earth science was a lower track science course at the school. The teacher was asked to choose eight students from his class who would be representative of students enrolled in the class. He chose six African American students, one white student, and one Cuban student. The teacher's choice of seven students of color as representative of his students may have indicated that the lower track science class has a disproportionate number of students of color as compared to the student body as a whole. Gilbert and Yerrick engaged the teacher and students in interviews, reflections on classroom observations, and focus groups. Gilbert and Yerrick observed the teacher and students twice a week for four months. Focus groups and reflection interviews, meant to explore and gather experiential narratives, provided an arena for collective conversations about the meaning of the experiences, for checking interpretations of classroom observations, and for establishing trust between the

researcher and his subjects, occurred weekly. Gilbert, a white male, was keenly aware of the possible difficulties of procuring accurate interview information from students of color and took many measures to ensure accuracy in understanding and reporting of data. In addition, Gilbert noted his awareness of possible biases, assumptions, and multiple truths and took measures to portray the research subjects' stories with authenticity.

In proceeding with data collection, Gilbert and Yerrick (2001) cited numerous sources of research on the possibilities that white instructors are often seen by students as having power and that students of color, understanding the dynamics of their supposed second class status, may not report accurately or may be skeptical of white researchers. To ensure accuracy in data collection and reporting, Gilbert and Yerrick (2001) made multiple checks for validity. At times during student interviews when students spoke in slang terms, the researcher paused to ask for clarification. Gilbert and Yerrick transcribed all data from audio tapes, with transcription occurring no more than a week from data collection. Audio recordings and detailed field notes supplemented each other. In addition, Gilbert and Yerrick employed triangulation, constant-comparative analysis, and kept a reflective journal for the duration of the study to track decision making. Gilbert and Yerrick subjected each student interview to the same validity treatment due to the intricacies of discourse, individual meaning and interpretation. Through the process of data analysis, four main categories emerged.

Student ability, social membership, respect, and sociocultural interpretations of science were the emergent categories of Gilbert and Yerrick's (2001) study. Gilbert and Yerrick's findings were further structured into three "assertions." In assertion one, Gilbert and Yerrick claimed that "lower track science classroom membership was

determined by factors that transcended race and academic performance" (p. 581). The two of eight students in the study who were not African American found their way into lower track science class, not because of their race, but because of their affiliations with students of color. Other students and school administrators saw the students, one white and one Cuban, as affiliated with students of color; and both students maintained their affiliations with the lower track microculture by just getting by academically and by occasionally causing trouble. In an effort to fit in socially, the white student and the Cuban student found their niches with the lower track science students, most of whom were students of color. An interesting finding was that African American students who were enrolled in honors classes were seen by the lower track African American students as abandoning their race. This perception gave lower track students further motivation to remain within their micro-culture.

Gilbert and Yerrick's (2001) second assertion was that "unexplored and biased beliefs about one another maintained clear boundaries between students and school officials" (p. 584). Here, Gilbert and Yerrick illuminated their explorations of relationships between the teacher and the students in the study. Gilbert and Yerrick found that the teacher's general attitude was that his students were unmotivated, lacked sufficient background knowledge, and were unwilling to put forth effort. The teacher made broad judgments that the lower track students had poor parental support, were unprepared for school learning, and devalued education. The teacher had expectations that if he deviated from his pre-planned assignments, moving towards lessons that would engage students' expressed interests, the students would become too rowdy. Gilbert and Yerrick found that the students were keenly aware of their teacher's attitudes and

expectations. The students claimed that their teacher thought they were stupid. When asked in an interview to give an example of an instance when the teacher spoke to them in a condescending manner, one student responded "He'll sit there and break it down, so easy that anybody…He'll break it down like we was in kindergarten!"(p. 587). Another student responded "One time I asked him, like, something about time, and he said 'We will be done at this time,' and points to a place on the clock. I'm, like, you don't have to point to no clock to show me what time it is, man [shaking his head]" (587). In addition to the ways that their teacher spoke to them, the students were also quick to note that the honors classes had access to visible supplies in the classroom that were off limits to the lower track classes. The students in the study reported feeling devalued overall and used this perception as fodder for further alienation from school culture.

Gilbert and Yerrick's (2001) third assertion stated "students resisted teacher authority and negotiated across boundaries through mutually understood rules of engagement" (p. 590). This assertion dealt primarily with rules set by school administrators and how students dealt with those rules. Gilbert and Yerrick found that, though the students were generally willing to go along with established school rules, the rules drove a wedge even further between the lower track students' microculture and the school culture. In enforcing rules, the teacher generally valued and maintained an ordered, quiet classroom. To the teacher, a sleeping student was allowed to sleep because he was not causing a disturbance. Furthermore, Gilbert and Yerrick found that in some cases, students were able to manipulate the rules through resistance, thus causing the teacher's expectations to drop. A transcript of one instance of discourse between the teacher and a student illustrated how the student was able to shift the teacher's original

goal of asking students to answer questions individually, using well thought out, complete sentences to allowing the students to give one word answers. Gilbert and Yerrick claimed that resistance to rules empowered students to negotiate a minimum amount of work. In this case, the teacher's original open ended question became a directive.

Gilbert and Yerrick (2001) concluded their research article with a number of implications for future consideration. They stated that the problems experienced by lower track students in their attempts to negotiate the worlds of school and science need to be addressed in a common language among teachers, administrators, and reformers. A lack of commonality toward addressing this problem, Gilbert and Yerrick claimed, will only continue to worsen the disparities. Gilbert and Yerrick posited that the divide that exists between lower track students and their teachers can be overcome, in part, by efforts on the teachers' parts to get to know their students backgrounds and needs. The problem, however, is that overcrowded classrooms, lack of time for reflection, and classes with English language learners and students with learning disabilities make it difficult for teachers to enact change. Gilbert and Yerrick suggested that school structures tend to enforce racist stereotypes and keep the students who are already ahead even further ahead. He emphasized that "we must work to find ways to redefine school science success that embrace a variety of linguistic and ethnic perspectives" (p. 596).

Though Gilbert and Yerrick's (2001) research was focused on lower track students in a rural school system negotiating the worlds of school and science, there was no specific mention of how the students in his study negotiate science differently from any other school subject. Further information regarding how students negotiate lower

track science classes and whether students in these classes tended to be enrolled in all lower track subjects would further enlighten this research. No interview or observation data was given that was specific to science learning. Gilbert and Yerrick's meticulous data collection and analysis and systems for ensuring data validity made the study a valuable resource for continuing to examine the subject. Strengths of the study included Gilbert and Yerrick's efforts to ensure that they were not misinterpreting observations and interview responses due to their own perceived bias.

Barton (1998) did an ethnographic study on teaching science with homeless youth. Barton's research added an extra dimension to the research of Phelan (1991), Costa (1995) and Gilbert and Yerrick (2001) in that she examined not only the potential discord between home culture and school culture but also the difficulties faced by students of color who were homeless. Barton's interest in studying the ways that homeless youth make sense of science stemmed from previous research findings that homeless youth are disproportionately marginalized and are far less likely to succeed in courses like science that are typically geared toward mainstream youth. Barton noted that homeless youth are often seen as outsiders by other students and by teacher. In addition, Barton noted the struggles faced by homeless youth as they move often, changing to new schools or dropping out. Barton discussed challenges specific to homeless youth. For example, Barton discovered that homeless youth regularly deal with the psychological challenges of uncertainty and instability and that earning the trust of the youth began with reliably returning every week to spend time with the youth.

As part of a three-year study, Barton (1998) examined the experiences of three 13 and 14 year old female students who lived at a homeless shelter in an urban area. Barton

worked with the students, who were Latina and African American, twice a week for two years in an after school science program. Barton conducted three interviews with each girl and interviewed the girls' parents, teachers, and other adult supervisors. Other data included Barton's field notes, video and audio recordings of the science program at the shelter, and video tapes produced by the children at the shelter. Barton transcribed interview recordings and coded them. Barton also used member checks to check for intentionality and to revise interpretations and analysis.

Barton (1998) cited that one of her goals was to "validate the children's experiences by using their experiences as the starting point for our explorations" (p. 383). Barton succeeded in this goal as exemplified by two science experiences presented in the findings. The youth were curious and concerned about the conditions of their neighborhood, and Barton used their curiosity to initiate an area of long term study: pollution and the local community. The youth actively sought out information and answers to the pollution problem in their community through interviews, library research, and analysis. In another example, Barton noted the preoccupations and limitations surrounding food faced by homeless youth. After leaving school for the day, the youth often had no reliable source of food and often went to bed hungry. Food became a subject that was directly related to the youth's lives and one that Barton used multiple times for science activities.

In her quest to understand the issues and concerns faced by homeless and poverty stricken children as they learn and do science, Barton (1998) concluded that the science knowledge of the youth at the shelter was, like with other youth, heavily constructed through life experience. Finding out what interest and concerns that students have was a

start to engaging all students in science. Barton suggested that all teachers need to find ways to value the diversity of all of their students because science knowledge is so heavily shaped by social frameworks. The primary weakness of Barton's study was its small size. Though Barton immersed herself in the study for a period of two years, the experiences were unique to the three girls. This research may not have directly applicable implications, but the length of the study and Barton's data collection and analysis efforts, for example checking intentionality and revising interpretations of interviews, resulted in a strong research-based example of finding ways to engage all students in science.

Jegede and Okebula (1991) examined the way that worldview effects students learning science. The researchers defined worldview as a distinct way of seeing and understanding natural phenomena, such as the anthropomorphistic view in some tribal societies. In a quantitative study, Jegede and Okebula posited whether or not science instruction using a socio-cultural based method developed for the research would have any significant on students' attitudes toward learning science. Though the research focused on African students, the findings support the studies of students of color in the United States which conclude that differences between students' life experiences and the classroom environment can create a wedge between what students are taught and how they learn.

Jegede and Okebula studied 600 tenth grade students and 15 volunteer teachers with at least five years of science teaching experience in Nigeria (1991). The students represented 15 secondary schools. In each school, two of the tenth grade classes were selected randomly and assigned to experimental (n=300) and control groups (n=300). Jegede and Okebula created a Socio-Cultural Environment Scale (SCES) to collect data

for the study. The SCES was a 30 item instrument with five subscales in which students responded on a three-point scale to questions about authoritarianism, goal structure, African Worldview, societal standards, and sacredness of science. Jegede and Okebula scored negative items in reverse. In addition, the researchers administered the Biology Achievement Test (BAT) as a covariate for attitude change.

Jegede and Okebula's (1991) employed a pretest-posttest research design. In addition to analyzing the test scores, Jegede and Okebula conducted mostly open-ended interviews with 18 students from the experimental group. All students received instruction on the same content for a period of six months. The experimental group received instruction that incorporated socio-cultural beliefs and focused on analysis of major concepts and the beliefs in society about those concepts. Prior to taking the SCES and BAT posttests, students reviewed the new information. Jegede and Okebula administered the SCES posttest six weeks after instruction to assess whether or not students had reverted to prior beliefs.

A t-test showed no mean difference between pre-test scores of experimental and control groups on the SCES test ($t=.49$, $p=$n.s.; $t=9.25$, $p<01$, respectively) (Jegede & Okebula, 1991). The post-test results (carried out through a t-test) showed significantly more positive attitudes from the experimental group on the SCES than the control group. The mean score on the SCES posttest for the control group was 34.34; the mean for the experimental group was 45.72. ($p<.001$). Whereas the control group's SCES made no significant change pretest to posttest, the experimental group's scores increased from 35.11 to 45.72. Jegede and Okebula ran an Ancova test to confirm significance of treatment on the experimental group, as well as to confirm the magnitude of change. The

researchers treated SCES and BAT as covariates. Ancova results showed a significant mean difference between the control and experimental groups in both the SCES and BAT scores.

Though not clearly spelled out, Jegede and Okebula (1991) implied that several students were having trouble bridging the gap between traditional knowledge and school knowledge. In addition, several interviewees mentioned the influence of parental beliefs in their lives and that accepting science made them less African. Jegede and Okebula (1991) concluded that "instruction in science which is deliberately planned to involve discussion of socio-cultural views about science concepts engenders positive socio-cultural attitudes towards the study of science," but that their findings need to be taken cautiously (p. 281). Also, the content material taught to the students was chosen specifically so as to elicit a response from the students. It remains unclear whether the method would work using any science content. Finally, Jegede and Okebula did not mention administering a BAT pretest, thus it was impossible to tell if the researchers found any academic achievement differences between the control and experimental groups.

Families and Communities Influences on Academic and Scientific Achievement

In this section I will continue with the theme of the previous section and extend the literature to include the influence the families and communities have on the interactions of marginalized students with their schooling. The research that I analyze in this section starts with a study on the experiences of immigrant parents, followed by a study on the influence of community in rural and urban, low socioeconomic settings, and ends with research detailing examples of community and science education partnerships.

Pérez Carreón et al. (2005) did an ethnographic study of the involvement of immigrant parents in high-poverty urban communities in the schooling of their children. The impetus for Pérez Carreón et al.'s research came from previous findings that parental involvement can play a large role in students' academic success and attitudes toward school. In focusing their study, Pérez Carreón et al. cited a lack of equity in parent-school relationships in that parents are generally offered a variety of roles to play in schools, but do not have a voice in structuring those roles. Immigrant parents face particular problems in navigating school systems, including language barriers, a lack of knowledge of the culture of the United States, a lack of social support, and financial constraints.

Pérez Carreón et al. (2005) were interested in researching what beliefs and practices motivate immigrant parents to become engaged in their children's schooling and how immigrant parents define participation. Parental engagement was defined by Pérez Carreón et al. as "parent school involvement practices embedded in cultural spaces" (p. 469). Pérez Carreón et al.'s study focused on poor and working-class immigrant Latino parents. The study took place in two elementary schools in high poverty, high immigrant population areas of a mid-sized Texas town. The researchers selected schools for the above criteria as well as the fact that both schools were involved in science reform practices. As part of a three year research project, 17 immigrant parents (13 mothers and 4 fathers) and a non-specified number of nonimmigrant parents participated in a series of conversation groups and "talleres," Spanish for an artist's space or studio. There were three rounds of conversation groups and each round consisted of five meetings. Pérez Carreón organized the talleres into three themes. Each studio had a

different method for group discussion and, as in the conversation groups, participants were compensated and provided with free babysitting. All meetings were held in Spanish and were translated for data analysis. To ensure that meaning and intention in translations were correct, they were assessed by bilingual and immigrant project staff members.

Pérez Carreón et al. (2005) invited parents to participate through letters sent home, presentations at schools, and fliers posted at schools. The researchers held meetings in the evenings and offered some transportation assistance. At the completion of all rounds of conversation groups, Pérez Carreón et al. invited parents back to attend a series of meetings designed to help researchers revise their findings and provide narratives of personal experiences. Of the 17 original participants, nine returned for these final meetings. Data sources for the research included transcripts from conversation groups, stories constructed by participants in the talleres sessions, and transcripts of informal field notes taken at the beginning and end of group sessions. Data were coded in three ways: open, axial, and selective. Pérez Carreón et al. were particularly interested in the kinds of cultural resources that parents were able to access and use in efforts to stay engaged in their children's schooling and how the processes of accessing and using these resources were affected by the formal space of schooling. For this article, Pérez Carreón et al. highlighted the experiences of three participants who exemplified three different approaches to immigrant parents' engagement and presence in their children's schooling.

Pérez Carreón et al. (2005) labeled the three parents "strategic helper," "questioner," and "listener." The "strategic helper" parent had a high participation level in her son's school. Though she was often frustrated with lack of bilingual staff at the

school and by a perceived prejudice against her by school teachers and administrators, she remained anchored to school engagement, volunteering in the classroom and attending PTA meetings. Through all of her presence and engagement, she continued to feel distanced from the school, however, and did not feel that her presence was valued. For the most part, this parent accepted and followed the school's rules.

The parent labeled "questioner," as with the "strategic helper" parent, was very involved in his children's homework (Pérez Carreón et al., 2005). This parent, like many immigrant parents, had a rich background of struggle and cultural knowledge and informed and motivated him to learn how to navigate the world of schooling in the United States. Unlike the "strategic helper" parent whose engagement was focused on formal school grounds, the "questioner" parent focused his presence and engagement in an informal setting—at home. The "questioner" parent was not satisfied to follow the rules presented by the school and instead decided to send his children to an out of district school. It is important to note that this parent had the financial ability and social support necessary to make such a decision.

The "listener" parent experienced the most distance and difficulty of the three (Pérez Carreón et al., 2005). Though she desired to understand the skills necessary to negotiate the school system and to help her children succeed, a language barrier and fears of speaking up prevented her from doing so. The "listener" parent maintained a presence informally in the schooling of her children by having conversations at home and supervising homework. She felt no power in the formal setting of school and used conversation group meetings to elicit ideas and support from other parents.

Though each of the parents had different experiences, they shared hopes and problems common to immigrant parents in negotiating schools in the United States (Pérez Carreón et al., 2005). According to Pérez Carreón et al., though education is seen as quite valuable, most immigrant parents are unsure as to how to have positive influences over their children's schooling. In addition, many immigrant parents lack the cultural knowledge and language skills necessary to successfully inform their decisions regarding the schooling of their children. Pérez Carreón et al. stated that many immigrants, particularly immigrants of color, experienced prejudice from schools. Though many immigrants understood the necessity of gaining cultural knowledge in the United States, status as undocumented workers often created a necessity to maintain a low profile, thus lessening opportunities for cultural enrichment.

Pérez Carreón et al. (2005) concluded their research article with suggestions for future research and implication for schooling. They suggested that parents' life and cultural experiences should be used to inform the worlds of schools. According to Pérez Carreón et al., schools should listen to the concerns and needs of immigrant parents and draw insights to improve education for immigrant students. Pérez Carreón et al. found that conversation groups among immigrant parents were helpful in offering social support and encouragement; they posited that further dialogue among immigrant parents and between parents and schools must be supported.

Pérez Carreón et al.'s (2005) efforts to support parental participation in the research were strong. Providing childcare, conducting group conversations in the participants' native language, and checking for accuracy of translation supported the research findings. It was mentioned several times that the research was funded in great

part by the National Science Foundation and that schools were chosen partly based on their participation in science reforms. The results from non-participatory schools may have differed. In addition, there was no mention of science classes in the article, and though the focus of the research was not course specific.

Charron (1991) designed a research study to investigate how students in a rural school system were influenced in their perceptions of science by their community. Whereas Pérez Carreón et al. (2005) sought to examine the ways that parents were present and engaged in their children's schooling, Charron focused on how parents and community affected their students' perceptions of school and classroom science. She was most interested in studying "students' perceptions of the nature, content, and value of science" (p. 672). Furthermore, Charron's research perspectives included interpreting students' perspectives of science in and out of formal school settings. In addition, she took a perspective of relating findings across contexts. The rationale and potential applications for Charron's research were in three parts: to suggest strategies for continuation of science learning through grades; to explain how science programs support or depart from perceptions of science in communities and how to bridge discrepancies between classrooms and communities; and to examine to what degree students' perceptions of science, presumably influenced by the community, mirror perceptions of people outside of the community.

Charron (1991) chose an ethnographic approach to her research primarily to support a formative study in context, to elicit community perspectives from a local frame of reference, and to investigate the whole question in an open-ended manner. Charron chose a small, homogenous, and geographically bound community with a relatively

stable population for the study. She oriented herself to the community using county records, the local newspaper, and by frequenting local establishments. She determined that residents and school affiliates would be open to her visiting homes, schools, and local events. In keeping with the ethnographic nature of her research, Charron used a variety of data collection means over a four month period of full time study with three months of pre- and post-observations.

Charron's (1991) major source of data came from interviews with students. Charron conducted 30-60 minute long formal interviews with 101 students from grades one through 12. The students were chosen to be representative of the school age population in the county with respect to age, gender, ethnicity, and academic ability. In addition, Charron interviewed 11 teachers, five building-level administrators or resource persons, and four county school system administrators or resource persons with questions prepared based on who was being interviewed structured so as to be open-ended and flexible. The agenda for interviewing students included the following areas of questioning: school science experiences, non-school science experiences, nature of science, science content, methods of teaching and learning science, methods of practicing science, and value of science. Formal interviews were supplemented with informal interviews that occurred upon Charron's visits to schools and community events.

Charron (1991) collected additional data through participant observations and field notes as well as through maps, inventories, and document files. Charron observed 77 science lessons across grades one through 12. She noted that she tended to observe classes with more frequency that allowed her to drop in as opposed to those with restrictive schedules. Charron selectively recorded science-related conversations

throughout the school including places such as hallways, teacher lounges, lunch rooms, and libraries. Charron drew detailed classroom maps and took inventories of supplies and materials. Throughout the research, she collected science-related documents such as lesson plans, grade level science objectives and tests, inventories of science materials in school and country libraries, and articles pertaining to science from the local newspaper.

Charron (1991) analyzed data using the constant comparison method in which initial patterns in the data were identified and as new data was analyzed, patterns were added, deleted, or modified. Data that validated patterns or was discrepant to patterns was interpreted; and data was sampled and organized "until a core of well-supported patterns emerge[d]" (p. 678). Charron presented research findings as they related to three categories: articulation of pupil science experiences and perceptions across grade levels; connections between the school science program and local views; and connections between experts' views of science and local views.

Charron (1991) reported that teachers and school administrators frequently expressed a need for science materials to continue building upon the previous year's materials and a need for increased communication between teachers of different grade levels. All interviewed teachers stated that a major goal of their instruction was making science exciting. Elementary students, local adults, and teachers all spoke about science as awe-inspiring and described science as "making and doing things" (p. 680). Charron found that high school students infrequently described science this way. Classroom observations provided Charron with the data that laboratory exercises were infrequent and materials were stored out of the students' view. Teachers reported that they thought

students needed more opportunities to "do science" but this was rarely the case in the high school science classes.

Another area in which the perspectives of high school students differed from those of younger students and local adults was in connections between school science and everyday science (Charron, 1991). High school students reported that science was only valuable for college-bound students seeking science careers. Younger students and local adults felt that science was intrinsically interesting and often cited natural history when asked about science. Charron noted that the presence of agriculture and natural environments in the area seemed to outweigh other science topics presented in the science curriculum at school. Though teachers made an effort to relate classroom science to students' lives, none of the interviewed students or adults could describe what practical values science held.

Charron's (1991) third category was an examination of the way the locals perceived science as opposed to the way science is viewed by experts. Charron discovered three salient points of view on science among locals. First, when asked to describe the field of science, students listed subjects and were often unable to relate them to each other. Charron attributed this to science courses and topics not relating to previous courses or topics. Second, students saw science as an already established body of knowledge and not something to be discovered. This was supported by cook-book style laboratory exercises in the classroom. Third, students believed that questions in science had one right answer and that most scientists agreed on that answer. Both parents and teachers spoke about a desire to provide opportunities for students to explore alternatives.

In conclusion, Charron (1991) found that the students' perceptions of science seemed to be a result of the perceptions of adults in the community and the nature of the community itself. Though the community and school administrators expressed a desire for students to do science and have access to better laboratory supplies, these desires were slow in being carried out. Charron suggested that in some settings, discussion of science application in classrooms is not enough and "teachers may need to develop ways to involve pupils in doing science projects that provide tangible benefits. Educators need to first identify community influences, then build upon them" (p. 686).

Charron's (1991) methods supported accurate data collection and analysis and the findings were appropriate for describing the perceptions of science in a small agriculture oriented community. The researcher's efforts to get to know the community as a whole through local publications and conversations with a variety of adults and youths gave credence to her study.

Barton et al. (2001) studied the perspectives of underprivileged urban mothers on science. The study was based on a concern that though the U.S. Department of Education, among other groups, cited the importance of parental involvement in the academic success of children, few have looked at whether families living in poverty have the financial, linguistic, or social means to be involved in positive ways to their children's schooling. The focus of Barton et al.'s research was "do parents share the beliefs and understandings similar to schools about subject matter knowledge and on what constitutes academic achievement within the academic subjects?" (p. 689).

Barton et al.'s (2001) performed a qualitative study that was part of a three year project called Linking Food and the Environment: an Inquiry-Based Science and

Nutrition Curriculum. The impetus for the study was that little research had shown the effect of parents' perceptions of science on their children's perceptions of science. In this project, the researchers were interested in working with teachers, caregivers, and elementary students in developing curriculum focused on allowing children to explore food and food systems. The study reported by Barton et al. involved 22 mothers, one aunt, and one grandmother, though all participants were referred to as "mother" in the article. Eighteen of the mothers were African American and six were Latina. Barton et al. did not specifically seek mothers, however only mothers volunteered for the study. Barton et al. concluded that this was because of a high number of single-parent households in high-poverty urban areas headed by women. The researchers found the participants through a parent organization at three elementary schools and through fliers sent home with children. Ten of the mothers ranged in age from 30-39 with the remainder ranging in age from 20 to over 50. It was unclear if Barton et al. provided transportation or child care, or if meetings were held at a time of day in which a variety of mothers could attend. These may have been limiting factors in the study.

Barton et al. (2001) used four methods of data collection. The first was a series of group interviews in which semi-structured, open ended questions on the following topics were asked: what mothers perceived science to be, what science experiences mothers remembered from their childhoods, what experiences mothers had in engaging in science with their children, and what role food might have in teaching science to children at home and at school. The interviews were audio recorded and transcribed. The second method of data collection involved a ten-part workshop series involving parent participation in school science. Detailed participant observer notes were taken during workshops. Third,

all mothers completed a written survey which asked questions about schooling histories. Fourth, informal conversation with mothers before and after interviews and workshops, and at other times, were noted and compiled into a set of field notes which were coded and analyzed for further insights into mothers' perceptions of science.

Barton et al. (2001) analyzed and coded all data using a grounded theory development process which allowed for emergent categories. The researchers used both open and axial coding, with constant adjustments and revisions made as necessary. Barton et al. held ongoing conversations to critically examine the coding process and credibility checks were carried out by two parents of similar backgrounds who were not study participants. Four categories of mothers' perceptions of science emerged through coding: science as knowledge/school work, science as fun projects, science as a tool for maintaining the home and family, and science as an untouchable domain. Baton et al. noted that these categories were dynamic and that 6 mothers fell into more than one category. Also noted was overlap between categories.

The first category, science as knowledge/school work, applied to ten of the 24 mothers (Barton et al., 2001). These mothers described science as a fact-based, text book driven, apersonal discipline that only happened at school or work. The ten mothers all referred to science negatively and expressed that, from their previous experiences with science, it was hard and not for them. Barton et al.'s data suggested that boundaries between themselves and science were created by mothers who spoke of science as school knowledge.

The second category, science as fun projects, applied to six of the 24 mothers (Barton et al, 2001). Like the mothers in the knowledge/school work category, these

mothers felt that science was book driven and filled with technical language, but these mothers saw science as project oriented, creative, and able to transpire anywhere, not just in schools or at work. In addition, the mothers in this category were eagerly involved in science projects with their children and used positive language to express their perceptions of science.

The third category, science as a tool for maintaining the home and family, applied to nine of the 24 mothers (Barton et al., 2001). These mothers saw science as quite personal and problem oriented. In group interviews, nine mothers in this category described science through household stories such as figuring out how to fix a toilet, knowing measurements for cooking, or knowing what to do when a child is sick. According to Barton et al., the mothers in this category appeared to have a different power dynamic than the other mothers in that they were active users and producers of science.

The fourth and final category, science as an untouchable domain, applied to three of the 24 mothers (Barton et al., 2001). These mothers reported that science was hard, they were scared of it, and they did not understand it. They were unable to describe experiences with science. Barton et al. noted that there was a possibility that the mothers were not comfortable enough in interviews to provide any more detail. Barton et al decided not to elaborate further on this category, primarily due to lack of supporting data.

Barton et al. (2001) found three salient themes across the four categories. The first theme was labeled “personal, dynamic, and inquiry-based perspectives of science” and included mothers from the science as fun projects and science as a tool for maintaining the home and family categories. To these mothers, science was embedded in

their lives. These mothers were part of the shift in power dynamic, allowing them to control science as it fit into their lives instead of fearing it or being controlled by it.

Barton et al. (2001) labeled the second theme "working with children" and included mothers who reported doing science related projects, activities, or home based chores with their children. This theme included all 15 mothers from the science as fun projects and science as a tool for maintaining the home categories, as well as about half of the mothers from the other two categories. Barton et al. questioned whether doing fun, home based projects allowed mothers to overcome barriers presented by typical school science. The authors also wondered whether these mothers participated in science with their children because of a preexisting comfort level with science or whether participation with their children increased their comfort with science.

The third and final theme was labeled "crossing borders" (Barton et al., 2001). The authors noted that six mothers in the study varied their perceptions of science based on the context of the conversation. Several mothers who were at first only able to describe science in terms of school knowledge made the shift to finding science personally relevant when presented with the idea science in terms of gardening or child care. Barton et al. stated that "all six of these mothers moved from a more limiting, non-dynamic, and impersonal perspective of science to one that more fully embraced a dynamic, personal, and inquiry-based perspective on science" (p. 707).

In conclusion, Barton et al. (2001) suggested that perhaps mothers' perspectives of science need to be acknowledged and supported by science educators. The authors stated that science education experiences should be rooted in home experiences and that food and nutrition education may be a strong point in which connections between home

and school science can be made. Finally, Barton et al. concluded that better articulation of the differences in understandings about and perceptions of science between families and educators is one step toward lowering barriers that mothers, and families, face in their attitudes toward science. Barton et al. offered multiple suggestions and implication, however they did not provide any solid conclusions from their research findings. It was difficult to deduce the findings, in fact, as they were presented in a context of continued discussion of the mothers.

Instead of identifying and examining community influences on students' perceptions of science, Bouillion and Gomez (2001) studied ways in which the discord between school science and real life science can be bridged by community partnerships. They sought to examine ways in which the gap between science in and out of school settings can be bridged and how that bridging effects student engagement. The research design was a case-study and the study took place at an elementary school that served a predominately Mexican-American population. The study involved students and teachers in two self-contained fifth-grade classrooms, the school's science teacher, the school's technology coordinator, and a bilingual instructor who split her time between the two participating classrooms.

Bouillion and Gomez (2001) based their research on the concept of a Mutually Beneficially Partnership (MBP) in which a student-generated, real-world problem was selected. The problem in this case involved cleaning a local, polluted river front area. Bouillion and Gomez (2001) established the framing question "What systems are we in, and how do we affect those systems" to accompany the chosen project (p. 887). The project was highly interdisciplinary, incorporating science, language arts, social studies,

and math. As part of the project, students and teachers identified a local problem and developed partnerships with several outside organizations to solve the problem. The project was inquiry based, with student collaboration guiding the activities. The students wrote letters, did investigations, and gave surveys to community members. The success of the project was in the hands of the students.

One author attended all regularly scheduled teacher planning meetings and taped and transcribed them (Bouillion and Gomez, 2001). The researchers observed classroom activity two to three times a week. In addition, Bouillion and Gomez conducted pre- and post-interviews with teachers and students. Additional data included audiotapes, observations, field notes, and media, instructional, and student artifacts. Bouillion and Gomez employed a variety of analytical methods including discourse analysis, content analysis, iterative coding.

Based on student interviews, teachers' assessments of students' work, and other demonstrations of students' competency, Bouillion and Gomez (2001) posited that the MBP framework may increase the likelihood that science instruction will engage all students in a more effective manner than classroom science alone. Interview data showed that the students in the study had increased skills and interest not only in science concepts but in abilities to access information, form questions, and analyze data. In addition, Boullion and Gomez found an increased sense of efficacy among the students: the students felt that they could make a difference in their community.

The researchers felt strongly that such a school-community partnership would be beneficial to science students. One reason a project like this might have been successful is that families were involved and many of the students in the study had backgrounds in

rural Mexico and lived close to the earth. Students were able to identify with an environmental issue. Like Barton (2001), Bouillion and Gomez recognized the value of connecting science with home experiences. This study could serve as a base for future research with MBP frameworks, however the number of contextual variables within the study preclude it from being more than a case study.

Fusco (2001) did a qualitative study in response to her concern that non-mainstream students are often unable to connect school science with real world experiences. Fusco acted as author and researcher in a nine month project which collaborated with an after school program in an inner city low-income housing project. She developed the idea for the project after conversations with teenagers about the issues and concerns that they were facing. The project was to turn an empty lot across the street from the housing project into usable community space. The teenagers related stories of teen pregnancy, AIDS, gangs, drug and alcohol abuse, and violence to Fusco. Through brainstorming sessions with Fusco, the youth decided to transform the lot into a space for sports, gardening, and performance among other things.

Initially, 40 youth participated in at least one of the project's activities (Fusco, 2001). Twenty youth attended biweekly sessions, but by the end of the project only 15 youth remained involved. Fusco based her findings on the experiences of the 15 remaining youth. The data collected during the study included Fusco's field notes, letters, fliers, attendance logs, and notes from conversations with the youth. Fusco's ongoing analysis of the data revealed emergent themes, including questions of whether science is relevant for all students.

Fusco (2001) found that the youth were excited to be involved in a science project that was not contrived for the classroom. The relevance of the project to the youths' lives kept them engaged and gave them a sense of purpose and responsibility. Fusco concluded that part of the success of the project was that the students were doing science, not just reading about it. In this case, the youth approached science from a social standpoint instead of a more mainstream task orientation. Fusco provided an illustration of the levels of potential change in the interface between youth, community, and science.

Fusco's (2001) action-based research exemplified a situation in which low-income youth not typically served by mainstream school science became engaged in a science project. However, Fusco gave minimal detail as to what the youths' attitudes toward science were to begin with or whether they would be able to apply their new found interest in doing science in the classroom.

Interface of Race and Culture with Academic and Scientific Identities

In the last two sections I reviewed literature surrounding the topics of the different worlds of home and school cultures and the influences of family and community on students' academic and scientific aptitudes and attitudes. The research articles in this section analyze the success or failure of students of color in accepting an identity of academic or scientific success that they perceive to contradict their racial or cultural identities. The section will primarily focus on African American students and will begin with critical analysis of research articles which discuss African American cultural ethos and issues faced by African American students in accepting or rejecting an academic identity. This section will conclude with an examination of several articles which discuss issues specific to students of color accepting or rejecting a scientific identity.

Boykin et al. (2005) examined cultural themes, namely socialization practices and culture-based preferences, among low-income African American students. To preface their research, Boykin et al cited literature regarding cultural themes in classrooms and the psychological repertoire that African American children bring to the classroom. Boykin et al. performed a qualitative study which included 460 observations in 21 classrooms at six elementary schools in predominately low-income African American communities as determined by high numbers (90%) of students qualifying for free and reduced lunch programs. All participating teachers were African American.

Six African American graduate students recorded all observations, and Boykin et al. and the graduate students developed a coding system to analyze observation notes (Boykin et al., 2005). The authors identified ten cultural behaviors and/or expressions, each of which were considered aspects of either mainstream or African ethos, to be coded: movement expressiveness, verve, object orientation, priority placed on cognition over affect, orality, communalism, individualism, competition, object orientation, and maintenance of a bureaucracy orientation. Boykin et al. defined and gave examples of the cultural behaviors and expressions. To clarify, verve referred "to a special receptiveness to relatively high levels of physical or sensate stimulation" (p. 531). Affect referred to emotional expressiveness. The results only codable units agreed upon by at least two coders. Of 5,530 codable units, eight percent (460) were identified as cultural behaviors or expressions. Affect, orality, cognition over affect, and object orientation accounted for only seven percent of the 460 identified behaviors or expressions. Based on this result, the authors focused their remaining analysis on the six remaining cultural codes. Individualism, bureaucracy orientation, and competition, recognized as attributes

of the mainstream, or white, cultural ethos, accounted for 87 % of the 460 codable units referring to cultural behaviors or expressions, with instances of individualism recorded most frequently. The remaining 13% of codable units were attributed to African ethos.

Boykin et al. (2005) discovered that cultural themes in the examined classrooms were dominated by the mainstream ethos, even though the teachers and most students were African American. It addition, Boykin et al. found that most behaviors or expressions representative of the mainstream ethos were initiated by the teachers. In contrast, the students demonstrated behaviors and/or expressions predominately of the African ethos. Boykin et al. concluded that this research supported previous findings which claim a misalignment between the cultural themes dominant in schools and the cultural themes most representative of African American students.

Though Boykin et al.'s (2005) research provided valuable insight into the body of research which cites cultural dissonance among African American students and public schools, there were several limitations. First, Boykin et al. eliminated 92% of the observations from coding due to an apparent lack of cultural behaviors or expressions. In some cases, the observers were not able to accurately interpret observations, and some themes may have been not as obvious. Second, Boykin et al. stated that their coding process needed refinement, particularly with respect to discerning teachers' and students' behavioral initiations from their reactions. Third, Boykin et al. posited that cultural adaptation, or "a cultural group's response to its collective history and current contextual demands of a given environment," may have been at play in the observed classrooms (p. 544). For example, students may have been employing coping strategies developed to deal with prejudice instead of displaying themes of African ethos in pure form.

In an ethnographic study, Fordham (1998) sought to examine the phenomena of "racelessness," a strategy observed in high achieving African American youth as they attempted to assimilate into mainstream school culture at the sacrifice of dis-identifying with their race. Fordham's research stemmed from an interest in the phenomena of achieving academic success as a rejection of an African American persona as perceived by some African American students. Fordham sought to examine the struggle felt by African American adolescents as they faced choosing between the dominant, individualistic ethos of school culture and the collective ethos of their communities. The findings of her study were preceded by a detailed introduction in which research and issues surrounding the African American ethos, similar to that described by Boykin (2005), opposition to social identity, and racelessness as a means for social upward mobility.

Fordham's (1988) study took place at an inner city public high school in a predominately African American neighborhood. The student population the school was 99% African American, with most students coming from single parent homes and 25% eligible for free or reduced lunch. The racial make-up of the school personnel matched that of the student body. The students at the school were tracked into Advanced Placement curriculum, regular curriculum, or special needs curriculum by means of standardized testing. The minimal requirements for the Advanced Placement curriculum were far greater than those for the regular curriculum. Students in the regular curriculum track generally only took the minimum courses for graduation and were thought of as strange if they elected to take more courses than necessary.

Fordham (1988) collected data over a two year period. The data for the first year consisted of formal and informal interviews with students, teachers, counselors, and parents as well as observations both in and out of class. Fordham et al. drew data for the second year from a 55-page, 201-item questionnaire given to 600 students from all grades. To establish a student sample for the first year, Fordham asked teachers and counselors to identify 11th grade high achievers and low achievers that might be willing to participate. A total of 33 students participated: 21 low achievers and 12 high achievers. Fordham presented data on six of the high achieving students to exemplify her findings.

The six students each expressed a desire to excel academically, and most saw themselves as raceless (Fordham, 1988). The three female students in the study held individualistic values in line with those of mainstream culture and held stereotypical ideas of African Americans as responsible for their lower-class status. The three male students expressed commitment to the ideology of the American social system and felt conflict about their perceived inability to identify with their race.

Fordham (1988) posited that as high achieving African American students distance themselves from their racial community, many such students face conflict in juggling school and community personae. Fordham concluded that though the male and female students were divided in their reasoning for becoming raceless, a salient characteristic among them was that education is the key to upward mobility for African Americans in the existing social system. Fordham questioned whether adopting a raceless persona is a beneficial strategy for academic success or a strategy with drawbacks that include rejecting a community. Finally, Fordham strongly suggested that

African American youth either consciously or unconsciously sense that they have to give up their racial and cultural identities to achieve academic success. Fordham (1988) did not include information on how she analyzed her data, so it is unclear if the findings drawn from interviews were member checked for accuracy. In addition, the students chosen for the study were notified of, and agreed to, an intensive, time-consuming process of interviews that required parental consent. Factors like this may have attracted a certain type of student, thus skewing the results.

Sandoval et al. (1997) performed a quantitative correlational study to examine whether or not a relationship existed between racial identity and academic achievement of African American students. The sample (n=26) included African American students from a predominately white high school in a mid-sized city who volunteered for the study. Eleven females and 15 males represented 10^{th}, 11^{th}, and 12^{th} grades with a mean age of 16 years old. Academic achievement was the dependent variable in the study and was measured with mid-semester, end of semester, and cumulative Grade Point Averages (GPA). In addition, Sandoval et al. used California Achievement Test (CAT) scores to supplement GPA data. Sandoval et al. did not calculate Cumulative GPAs for sophomores (n=12), nor did they calculate CAT scores for seniors (n=5) due to extenuating circumstances. Independent variables were racial identity and demographic data. The Racial Identity Attitude Scale (RIAS), a 50-item Likert scale test, measured racial identity. The RIAS assessed Cross' (Sandoval et al., 1997) four statutes of racial identity attitudes: pre-encounter (negating or devaluing one's own "blackness"), encounter (beginning to develop an African American identity; viewing white people negatively), immersion/emersion (high level of "black pride"), and internalization (more

pluralistic, seeing past race). To support data collected from the RIAS tests, students filled out Student Information Sheets which included information such as date of birth, educational attainment of parents, and future plans after school.

Sandoval et al. (1997) found a negative relationship between academic achievement and both the pre-encounter and immersion/emersion attitudes. One strong positive association ($p<.01$) was found between cumulative GPA and internalization attitudes. The authors posited that students with internalization attitudes may have resolved any dissonance over racial identity and thus their identity did not negatively impact their academic achievement. Sandoval et al. found that students who had immersion/emersion attitudes or who had attempted to assimilate into Euro-American culture, thus rejecting African American racial identity, had low academic achievement. Sandoval et al. reported that, based on RIAS scores, GPAs, CAT scores and attendance, students who identified most strongly with their racial identity performed lowest on academic achievement measures. The authors implied based on their limited findings, that there may be value in fostering internalization attitudes in African American youth.

Sandoval et al. (1997) reported their findings cautiously, as no generalizable data were found. Limitations to the research included a small sample size, sampling from a predominately white school, and student racial identity self-assessments using a Likert scale. It is probable that the sample did not accurately represent African American high school students as was evident by responses on the Student Information Sheet in which 88% of the sample intended on attending a four-year university post-high school. The authors noted that results may have been quite different if the sample was taken from a different context. In addition, the authors noted that it was not possible to tell based on

the findings from the study if racial identity and academic achievement were directly related.

French et al. (2000) sought to examine racial/ethnic congruence as related to racial and ethnic identity as students transitioned from middle school or junior high to high school. The researchers were interested in exploring the degree to which students' racial and ethnic identities were affected in the transition to senior high school Citing a lack of research regarding racial identity and the transition to senior high school, the researchers hoped to shed light on the identity issues faced by teenagers. In a quantitative study, French et al. studied a sample (n=144) of African American, white, and Latino students with low socioeconomic status. Like Sandoval et al. (1997), the authors adopted Cross' stage model for racial identification. French et al. used a pretest-posttest study to analyze the degree to which racial/ethnic congruence differences between junior high and high school varied and how such variations affected students' academic performances.

French et al. (2000) measured racial/ethnic identity and perceived social transactions using Likert scale tests, and racial/ethnic congruence using archival data to assess congruence or lack thereof between the race/ethnicity of the student and the race/ethnicity of the student body and school staff. Tests occurred approximately one year apart, during the spring terms of the last year of junior high and the first year of high school. French et al. found, after a hierarchical multiple regression analysis, that the Latino students (n=50) and African American (n=33) students experienced no significant changes in racial/ethnic identity in the transition between junior high and high school. White students (n=61) experienced significant ($p>.01$) change between racial and ethnic identities before and after beginning high school. French et al. posited that white students

were most often exposed to varying racial and ethnic groups in high school for the first time, whereas students of color are more likely to be faced with racial and ethnic identity issues prior to high school.

French et al. (2000) made an interesting discovery about the possibility of white students facing issues of racial and ethnic congruence in a diverse high school setting, however their research was generally inconclusive. The Likert scale system was a potential weakness of the study, leaving racial/ethnic identity and perceived social transactions to the perception of each student. In addition, the sample size was relatively small. French et al. deduced that context is significant in evaluating racial/ethnic identity. Citing previous studies, French et al. elaborated further on the academic experiences of African American students stating that such students often choose to identify less with academic success as they increase in self esteem. Finally, the researchers identified that racial and ethnic identity was always contextual. French et al.'s predictions that racial and ethnic identity would be more salient for students of color were in contrast to their findings that racial and ethnic identity was salient for white students also.

Brickhouse and Potter (2001) questioned to what extent identity formation of students of color or working class backgrounds supports or contradicts the identities associated with science. In addition, Brickhouse and Potter questioned what factors influenced that success or failure in science for typically marginalized students of color. Brickhouse and Potter did a case study of two African American, working class, seventh-grade female students. The researchers collected data over a three year period in a qualitative, longitudinal study. Brickhouse and Potter analyzed and triangulated the data to fully understand identities and claims. Data included journals kept by the girls,

transcripts, classroom observations, and annual interviews with the girls, their parents and their teachers.

Brickhouse and Potter (2001) found that one girl did very well in a science class that was predominately African American, but after a transfer into a predominately white class, her science aptitude dropped and she appeared to adopt a strategy akin to Fordham's (1988) racelessness. The teacher in the second class noted that the girl was not good at science, but was a sweet girl with good English skills. When interviewed at the end of the science class, the teacher barely remembered the girl, a phenomena that is typical of shy students. The same phenomenon was reported by Gilbert and Yerrick (2001). The researchers posited that the girl's performance in the second class may have been that result of stereotype threat, or a risk of confirming, as a self-characteristic, a negative stereotype about one's group (Brickhouse & Potter, 2001).

The second girl had a strong identity associated with computers due to extensive home exposure (Brickhouse & Potter, 2001). In her computer science class, she did not make high grades, but she was an outspoken, active participant. She was quiet in her other classes, however, and Brickhouse and Potter suggested that this was a characteristic common to high-achieving African American students. This seemed to correlate to Phelan et al.'s (1991) Type II students who tended to be academically successful students of color. Both girls seemed motivated by what they considered to be the role of an ideal student. Brickhouse and Potter hypothesized that the conflict experienced by the girls as they tried to define what it meant to be African American and what it meant to be a scientist may have hindered their likelihoods of developing scientific identities.

Brickhouse and Potter (2001) had several limitations in their study. The social and racial makeup of the researchers was different than that of the girls. In some cases, these differences prevent the subjects from providing full, accurate information to researchers. Also, the researchers provided monetary compensation to the subjects in exchange for their participation as well as assistance with college applications and providing opportunities for science related activities. This could have been problematic because girls who agreed to participate may have been intrinsically motivated to further their education, thus skewing the findings to the researchers' question.

In a qualitative study, Parsons (1997) asked what teenage, academically competent black females believe about the scientist and what attributes they ascribe to the scientist. A relatively homogenous, academically competent (2.5 or higher GPA), African American, female, tenth to 12^{th} grade pool of students (n=20) from one rural and one urban school in Western North Carolina were interviewed using 33 open ended questions regarding how the students picture a scientist. Parsons included the questions in the article. Research was analyzed using an interpretive framework of a "cultural ethos." In the Black cultural ethos, Parsons listed spirituality, harmony, movement, verve, affect, communalism, expressive individualism, orality, and social perspective of time. In the cultural ethos of the dominant culture, the following four focal values were noted: mind-body dualism, individualism, work related use of time (time as commodity), and reality as conceived and perceived in material terms.

Upon completion of the interviews, the following category systems emerged: physical appearance, characterization, motivations, endowments, attitudinal disposition, economic status, pastimes, and role personae (Parsons, 1997). Parsons read interview

transcriptions numerous times, and checked categories with two non-interviewed high school students for validity.

Parsons (1997) found that 11 respondents described the scientist as a white man, four described the scientist as an African American man, two as an African American woman, and one as a white woman. The descriptions of the white, male scientist focused on cognition and functions and activities related to the mind. In contrast to the descriptions of white scientists as cognitively driven, the descriptions of the African American scientist featured affect. In the African American cultural ethos, a premium is placed on emotional sensibilities and expression. In addition, the descriptions of the African American and white scientists differed in that the described white scientists put work ahead of family or social pursuits, whereas the described black scientists kept a balanced work and social life. In addition, the description of the African American scientists did not display the male-female dichotomy that was present in descriptions of the white scientists.

Parsons (1997) noted that traditional science teaching focuses on factual knowledge and teacher-centered instruction and use of one-right-answer assessments. Cognition and reason tend to be highly valued in science classrooms. These attributes are in contrast to the African American cultural ethos. Parsons offered that human interaction, interpretation, and interest must be part of the curriculum to incorporate African American cultural emphasis on affect, harmony, orality, expressive individualism, and communalism. This study might have had different results if younger students or students not deemed academically competent were interviewed.

Lewis and Collins (2001) conducted a qualitative study in which the science-related career decisions of three African American students were examined. Citing a small percentage of African Americans who pursue science-related fields, Lewis and Collins sought to identify and describe the reasoning behind the pursuance of science careers by three African American college students. Lewis and Collins used semi-structured interviews over a six month period. The researchers audio recorded the interviews then analyzed and categorized them into five categories including self, science, and experiences associated with being African American. Lewis and Collins used member checks to test for validity of students' responses.

Lewis and Collins (2001) found several salient characteristics among the three students. Each had substantial familial support, each desired a high income, and each excelled academically in high school. Two of the three students stated that their perceptions of the work of a scientists conflicted with the reality of the work. Two of the three students changed there minds in college about pursuing a science career because of concerns that the lifestyle of a scientist would prevent other desired pursuits such as personal interests and having a family. Lewis and Collins concluded that students in general needed to have a broader understanding of what scientists do and need to be able to distinguish between careers in science and applied science.

Though race was intended to be a factor in the research, Lewis and Collins (2001) neglected to describe the ways in which race effected the students' science-related career decisions. The authors did note that all three students claimed that race was not a determining factor in their career decisions. In addition, Lewis and Collins' research was focused on students with middle class backgrounds and dispositions toward academic

success. The students in the study were probably not representative of the overall socioeconomic and academic status of African American students nationwide.

Science for English Language Learners

Science requires learning a new language full of technical vocabulary. English language learners face increased difficulties in learning and succeeding in science classes, partly because not only are they learning English, but they are also learning the language of science. In this section, I will review literature which focuses on issues specific to English language learners in school, and in science classes specifically. Much of the literature in this section focuses on the intersection of inquiry science and language learning.

Citing a body of research that performance in science classes is influenced by prior knowledge, Lee et al. (1995) compared and contrasted the effect of diversity of language and culture on fourth graders' ability to learn scientific concepts. Using both qualitative and quantitative means, Lee et al. examined the way four groups of students, African American, white, Latino, and Haitian Creole, constructed learning during several science lessons. Lee et al. chose 32 nine and ten year old students and eight teachers from two culturally and linguistically diverse schools to participate in the study. The 32 students were placed in 16 dyads of four students of mixed gender and salient ethnicity. Lee et al. chose to use dyads because they posited that working in salient groups could promote social and academic communication. The white students were monolingual, the African American students were considered to have a specific English vernacular, and the Latino and Haitian Creole students were bilingual. The bilingual students were further subdivided into those who were proficient in English and those who were just learning

English. The eight teachers represented each ethnic and linguistic group and included both men and women.

The students participated in three science tasks involving natural and man-made phenomena (hurricanes and tornados, levers, buoyancy) that were designed to draw upon their prior knowledge and to be relevant and engaging (Lee et al., 1995). The tasks included manipulable, concrete materials. Lee et al. trained the teachers on elicitation protocols and procedures. The teachers used audio and video recordings during the science tasks and later transcribed them for analysis by the authors. Students were prompted to elicit observations, descriptions and explanations of phenomena, and applications to real-world situations. Forty-eight total task sessions were recorded during the study.

Lee et al. (1995) used the dyad as the unit of analysis. Triangulation of data occurred using an interdisciplinary team of researchers and teacher collaborators. Using a coding procedure, Lee et al. scored each dyad on science knowledge and science vocabulary. Analysis of scores for science knowledge and science vocabulary showed a distinct relationship between the two domains. Four categories of students emerged from the data: students who demonstrated science knowledge and vocabulary, students who demonstrated science knowledge but not vocabulary, students who used science vocabulary but appeared to not understand the meaning of the vocabulary, and students who lacked science knowledge and vocabulary. Of a possible 42 points for science knowledge, the dyads of white students, labeled monolingual English, scored 22.2, African Americans scored 15.5, Latinos scored 16.3, and Haitian Creoles scored 8.3. Of

a possible 21 points for science vocabulary, the dyads of white students scored 5.5, African Americans scored 4.0, Latinos scored 4.0, and Haitian Creoles scored 1.3.

Overall, Lee et al. (1995) found that students from non-mainstream backgrounds had the most difficulty with science knowledge and vocabulary. Lee et al. speculated that because bilingual or English language learning students are accustomed to a different set of vocabulary for scientific phenomena, they had more trouble expressing science knowledge. In addition, Lee et al. found differences in verbal and non-verbal discourse styles between white student dyads and the other dyads. While white students showed preference toward short, concise statements and sequential turn-taking, the other student dyads exhibited repetitive statements and simultaneous turn-taking. Though the teachers were given the same instructions for eliciting responses from students, the white teachers probed for ideas and encouraged independent performance whereas the other teachers assisted students with strong prompts, using teaching and telling.

In conclusion, Lee et al. (1995) found distinct patterns of science knowledge among the four ethno-linguistic groups. Lee et al. warned that it should not be assumed that students who lack vocabulary to talk about science or who were unable to describe their views in direct and clear terms lack science knowledge. However, Lee et al. used science vocabulary as one factor in measuring science knowledge in the study. Lee et al. never established a correlation between the four categories of science knowledge and vocabulary and the four ethno-linguistic groups. It was unclear whether there was a one to one correspondence between the categories and groups or whether overlap occurred. In addition, though the study design called for teachers of the same ethno-linguistic

background as students to be working together in dyads, it could be construed that the same students would show different results with teachers of different backgrounds.

In a qualitative study, Westby et al. (1999) examined and identified various strategies employed by teachers working with culturally and linguistically diverse students in science classrooms. Westby et al. studied four fourth-grade classrooms which were participants in a program designed to promote scientific literacy among Latino and Haitian students from diverse linguistic backgrounds. Three teachers were Latino and one was Haitian. The classrooms averaged 35 students, and all schools were located in low socioeconomic areas with high occurrences of new students.

Westby et al. (1999) based their research on a foundation of research focused on the difficulties faced by culturally and linguistically diverse students in school in general, and in science specifically. The authors sought to examine strategies in which scientific literacy can be attained by such students. Scientific literacy is defined here as doing science, knowing science, talking science, and having scientific habits of mind. Westby et al. posited that by employing culturally congruent teaching and by using contextual experiences to learn concepts and vocabulary, all students can become scientifically literate.

In this study, Westby et al. (1999) observed and video recorded one 40 minute lesson in each classroom from a larger unit on the water cycle. Analysis was completed from two lenses: macrostructures and microstructures. The macrostructure analysis included the overall context and structure of the classroom and the lesson. Westby et al. found several common threads among the four teachers and classrooms. All classrooms had desk arrangements to support group work. The lesson involved a hands-on activity

in which active involvement and collaboration was expected of the students. In the classes taught by Latino teachers, answers and questions were called out at will. In addition, students in the three Latino teachers' classes appeared comfortable with group work and appeared to have a basic understanding of how to do science. In contrast, the Haitian teachers' students appeared uncomfortable with self-directed group work and knowledge of doing science. In this classroom, the students tended to be off-task with higher frequency.

The microstructures of the analysis included interpretations of interactions among students and between the teachers and students (Westby et al., 1999). To accomplish this analysis, videos were transcribed and interactions were coded. Three broad categories for analysis emerged: supporting student involvement, scaffolding, and questioning strategies. The four teachers supported student involvement by offering positive overt evaluations such as "good job" or repeating a student's statement. In addition, the teachers solicited responses from the whole class when asked a question by a student. The four teachers frequently used scaffolding to solicit student communication. Scaffolding was apparent in two forms: to support a desired behavior and to cue students in reviewing material. The teachers employed similar questioning strategies which encouraged knowledge and comprehension level thinking. Westby et al. found that the teachers used repetition of questions to allow students time to respond. Westby et al. noted, however, that the second time a question was asked, the cognitive demand of the question dropped. In addition, when students were unable to answer a question, the teachers tended to ask a yes/no question instead. This appears to echo Gilbert's (1999) finding that a question repeated multiple times tends to become less and less challenging.

In interpreting the analysis, Westby et al. (1999) found salient characteristics among the four observed lessons. In the "knowing science" category, Westby et al. found that all four teachers modeled scientific terms in English and used scaffolding to elicit responses in English. In the "doing science" category, experiential activities and group work were the basis of the lesson. The Haitian students had the most difficulty with this lesson structure, and Westby et al. cited that Haitian students tend to prefer more didactic, lecture based lessons. Westby et al. found that students were less capable at "talking science," but that this is a skill that tends to evolve as students gain a tighter grasp on scientific language. Specific strategies that appeared to work in engaging students in "talking science" included re-voicing a student's question or statement. Westby et al. found the "scientific habits of mind" category difficult to evaluate in the context of the study.

The most prominent limitation of this study was its size and scope. Westby et al. (1999) only examined a total of 160 minutes of classroom time and the observations took place near the start of the year when teachers and students were still getting to know each other. Also, it was unclear to what degree the teachers were influenced by the presence of the observer in the classroom. The research has implications for educators in knowing the background and culturally and linguistic preferences of their students.

Challenging a common conception that students must learn English before they can learn content area subjects, Stoddart et al. (2002) examined the integration of inquiry based science classes and English language learning. Stoddart et al. hypothesized that inquiry science is a powerful instructional context for language development as inquiry science not only provides opportunity for hands-on activities, but also requires active

thinking and discourse. Whereas the research of Lee et al. (1995) and Hampton and Rodriguez (2001) focused primarily on the effect on students of integrating inquiry science with language development, Stoddart et al.'s research focused on creating a rubric to analyze teachers' thinking in regard to science-language integration.

Stoddart et al. (2002) conducted semi-structured interviews regarding views on science-language integration with 24 first through sixth grade teachers who were participants in the LASERS (Language Acquisition through Science Education in Rural Schools) summer academy. The teachers represented a range of teaching expertise and participation in the LASERS project. Stoddart et al. transcribed the interviews and checked their accuracy by having four researchers read them. Exemplars for the rubric came from the responses of the interviewees. Stoddart et al. used the constant comparison method to assign rubric categories and tested continuums through review, coding, and identification of common themes against teacher interview responses.

Stoddart et al.'s (2002) rubric contained five levels of integration. The first level, no integration, represented teachers who considered science and language separate domains. The second level, beginning integration, included teachers who were starting to recognize the possibility of integrating science and language, but who found the idea of integration difficult to implement. At the third level, emerging integration, teachers viewed science-language integration as a one-way process in which either language or science would be the dominant content. At the fourth level, fundamental integration, teachers had a clear understanding of the dynamic, reciprocal relationship between science and language. The fifth level, elaborate integration, included teachers who

acknowledged the interdependent relationship between science and language and who had a conceptual framework for implementing such an integration of subjects.

Stoddart et al. (2002) suggested that this rubric was a useful self-assessment tool for teachers as they strive to integrate science and language learning in the classroom or for curriculum developers. Stoddart et al. stated that teacher should not expect to move across the rubric in a linear fashion. Stoddart et al. concluded by saying that the rigid walls between science teacher and language teacher need to be broken down and that the integration of language and science needs to be reconceptualized.

Hampton and Rodriguez (2001) used qualitative and quantitative means to examine effects of an inquiry approach to science in bilingual classrooms. Hampton and Rodriguez chose three elementary schools within two miles of the Mexican border to study. Children at the schools were grouped by their abilities in English and teachers taught classes based on their perceptions of their students' language abilities. Therefore, at the schools, about half of the students were taught in English and half were taught in Spanish. In addition, none of the schools had regular science curricula in place.

Hampton and Rodriguez (2001) recruited over 100 mostly bilingual interns from a local university teacher education program. Each intern taught two to three science lessons using FOSS (Full Option Science Series) kits in one of 62 classrooms at the three elementary schools. The interns, the students, and the participating teachers all contributed data to the study. The interns provided qualitative data in the form of written responses, focus group sessions, and an open-ended paper describing their experiences. The students provided quantitative data in the form of written assessments (107 fifth

graders) and an attitude survey (80 third graders). The participating teachers rated their perceptions of the experience by use of a Likert scale test.

Hampton and Rodriguez (2001) found a strong positive response from the interns, teachers, and students after implementation of the inquiry science lessons. The students' written assessments showed an understanding of science concepts equally among those who were taught in English and those taught in Spanish. Based on the descriptions of high levels of student excitement and engagement, Hampton and Rodriguez suggested that highly interactive, inquiry based approaches to science are a useful setting for language acquisition. Forty-three teachers responded to a questionnaire on student learning. Thirty-three of the respondents gave a rating of four on a scale of one to four, with four being "much learning." The interns were able to give evidence of learning and noted observation, questioning, and application skills among the students.

Hampton and Rodriguez (2001) found many implications for use of inquiry science with bilingual or English language learning students. Most importantly, they cited that inquiry science takes pressure off of students to have a correct answer and instead emphasizes collaboration, creativity, and the process of discovery. Also, inquiry science can be made relevant to students from all backgrounds. Hampton and Rodriguez warned, however, against teaching inquiry science solely in the student's first language. As part of the study, the interns held group discussions at the end of each lesson to allow students a chance to share what they had discovered. In a situation where the teacher and the students have a language barrier, such a discussion would be difficult. Several interns expressed concern over forcing students to speak in English and most opted for writing

vocabulary in Spanish and English and allowing students to dialogue in their first language.

The main limitation of Hampton and Rodriguez's (2001) study was in its short time frame. Assessing student learning after only two to three lessons may prove to be inaccurate. A comparison of bilingual students in a non-inquiry based science program versus those in an inquiry based program may add more credence to Hampton and Rodriguez's conclusions, as it is possible that the students responded so well because they were being introduced to a new subject by enthusiastic interns. The fact that the findings were strongly consistent throughout over 100 intern experiences and 62 participating teacher perceptions does support Hampton and Rodriguez's findings.

Lucas et al. (1990) explored the how success can be promoted among Latino English language learners at the secondary level. Using a case study design, Lucas et al. collected data from six high schools which served high numbers of low income students and racially diverse student bodies. The combined data included audio recordings and notes from interviews with one superintendent, two district-level bilingual program directors, six principals, six assistant principals, five school-level project and program directors, 15 counselors, 52 teachers and aides, and 135 students. In addition, the researchers collected 124 student questionnaires, 54 classroom observations and various records and documents. Of the students that Lucas et al. interviewed, 61% were Mexican born, 72% spoke Spanish at home, and 39% spoke Spanish at school.

Lucas et al. (1990) employed a recursive data analysis process in which both concrete descriptions and emergent themes were developed. Eight key features that promoted the success of Latino English language learners emerged from data analysis.

The first feature was value placed on the students' languages and cultures as demonstrated by treating students as individuals, learning students' languages, and allowing students to speak their primary languages at school except in cases where English is the focus. The second and third features were having high expectations of language minority students and ensuring that school leaders made the education of English language learners a priority. Lucas et al.'s fourth key feature involved providing staff development to help teachers serve English language learners more effectively. The fifth and sixth key features involved offering a variety of courses for language minority students and offering a counseling program wherein counselors speak the students' languages and are informed about post-high school options for English language learners. Finally, Lucas et al.'s seventh and eighth key features were encouragement of the involvement of parents by ways such as having bilingual staff and neighborhood meetings, and ensuring that school staff members share a commitment to empowering English language learners through education.

Lucas et al. (1991) viewed these eight key features as a working model for educators to use as they work with students who are learning English. Though the study took place at schools with high populations of English language learners, the researchers felt that many of the key features such as high expectation and parental involvement were applicable to other situations.

Culturally Relevant Science Teaching

While the previous sections have focused on specific aspects of marginalized students and their experiences in school and in science education, this section provides a review of research on qualities of culturally relevant teaching and effective culturally

aware teachers. The section starts with review of a research study on caring science teachers and continues with studies on teachers learning to develop culturally relevant material and a study on the effect of the use of culturally relevant materials with Native American students.

Van Sickle and Spector (1996) did a symbolic interaction study in which they sought to "identify and describe characteristics of science teachers in classrooms in which an ethic of caring was perceived to exist" (p. 434). The authors defined symbolic interaction as a way to study interactions and reactions. They chose this qualitative design for their study based on the thought that it would allow them to gain insights and understandings as to the meanings teachers hold about their discourse and interactions with students. As in the style of symbolic interaction studies, a general question was asked leaving room for emergent categories and themes.

Van Sickle and Spector (1996) chose three teachers as subjects of study based on several characteristics. First, the teachers had recent involvement in a graduate program and the authors believed that they would hold a common vocabulary. A group of 24 teachers was considered, and the authors narrowed the subjects to three after selecting for teachers that lived in a three-county area and taught secondary science full time as well as after conversations with university personnel and high school personnel about which of the teachers was the most caring. Van Sickle and Spector noted that they did not account for a range of caring, and that the teachers were chosen based on a perception that they were caring. A potential limitation of the study was in the way interviewed personnel perceived teachers as caring. Data was given in the article about the grade levels, subjects, and classroom demographics of the teacher participants' classes. The teachers

held positions at their respective schools for a range of five to nine years. Three schools were represented in the study that held a variety of types of students, from high populations of academically gifted students to high populations of at risk students.

Van Sickle and Spector (1996) collected data in three ways: through classroom observations, through interviews, and through artifacts. Also, the researchers kept diaries so as to delineate the views of researchers and teachers. Van Sickle and Spector used the participant observer method to collect 120 hours of classroom observations using field notes and audio recordings. The authors conducted and audio recorded interviews following each classroom observation using open ended questions to probe for greater insight in classroom happenings. Finally, Van Sickle and Spector collected artifacts throughout the year in the form of hand-outs, assignments, and laboratory assignments. The authors used the constant comparison method of data analysis, allowing for emergent themes to arise.

Van Sickle and Spector (1996) found several common themes among the three teachers in the study. Each teacher cited an importance of building relationships with students and practiced this by greeting students as they entered the classroom, by listening to students' stories and concerns, and by adapting lessons to make them more relevant for students. Also, citing the importance of student to student communication, each teacher used cooperative group work as their primary teaching strategy. Finally, the teachers found creative ways to apply the scientific principle of interdependence of organisms to teach and foster an ethic of caring among students and between students and teachers.

Van Sickle and Spector were able to effectively document the teacher-student and student-student interactions in science classrooms led by teachers perceived as caring. The study relied heavily on the perceptions of teachers by students, leaving the results open to interpretation. In addition, because Van Sickle and Spector situated their study in the context of symbolic interaction, the data was collected and analyzed primarily based on the interpretations of the researchers. These issues could be problematic in a different context.

In a qualitative study, Tobin et al. (2001) described the experiences of two teachers learning to teach at an urban school. The researchers were particularly interested in exploring co-teaching as a method of helping new teachers increase their effectiveness in working in large urban schools with diverse student bodies. The study took place at a school of 2300 students where 10 small learning communities were in place. The school had a population of 97 % African American students with 87 % of the students from low-income families. Only 43 % of the students at the high school graduate within four years. Tobin et al. were concerned that African American students in urban schools tend to remain marginalized and are often underserved by public schools. In the study, Tobin et al. observed the experiences of two new teachers at the school who worked alongside a cooperating teacher. Much of the data reported by Tobin et al. in the research was in the form of narrative dialogue among the co-teachers. Several meaningful realizations and themes appeared as the study progressed.

Tobin et al.'s (2001) primary finding was that co-teaching offered many benefits for new teachers at urban school as well as offering benefits to the students in the co-teachers' classes. According to Tobin et al.'s findings, a co-teaching community provided

all members of the community an opportunity to engage in critically analyzing and consequently transforming their practices through dialogue and constructive feedback. One teacher gave an example of a realization she had through dialogue with her co-teachers. She noticed, and was able to correct, that she gave virtually no wait time after posing questions to the class and that she treated the boys and girls differently. The same teacher reported learning a great deal from her more experienced co-teacher. In an example of classroom management, the teacher learned that validating the points of view of two arguing students was a more effective way of diffusing the argument than simply telling them that their argument was silly. In an example that directly benefited the students, Tobin et al. recorded an instance wherein two co-teachers talked through a science problem in front of the class, thus modeling problem solving for the students.

Tobin et al. (2001) gave a detailed example of a new teacher at the school that had previously taught at a suburban private school but was able to successfully transition into developing culturally relevant lessons. The teacher noticed that several of her colleagues spent quite a bit of time trying to keep their classrooms silent. The teacher came to realize that silence was unnatural and uncomfortable for the African American students in her class, thus she designed creative lessons that allowed her students to choose ways to express themselves. As part of a lesson on flower reproduction, the teacher provided craft supplies and instructed her students to develop a presentation to teach to younger students. The students, working in groups, excitedly created puppet shows, sitcom parodies, and raps which accurately portrayed the science content. Months later on a field trip, the teacher observed several students picking a flower and reciting the lyrics to the same rap their classmates had written. In another example, the teacher noticed the

prevalence of asthma among her students. She was able to incorporate a series of lessons focusing on the illness and its link to the African American population. This teacher was able to identify several salient categories of African American psychology and issues faced by urban, working class African American students and responded to her students, giving them opportunities to be emotional and expressive.

Tobin et al. (2001) concluded their research with a series of questions and concerns about the state of working class African American students in urban schools, and in science in particular. Tobin et al. wondered whether the cycle of social reproduction that tends to keep working class students from advancing is a cycle that can be broken by attention to culturally relevant curriculum over standard curriculum which generally best serves white, middle class students. Though the researchers noted that one of the teachers in the study had previously taught at a suburban school, they did not specify the races of the teachers that they studied. Tobin et al. drew ties between minority status, low socioeconomic status, and attendance at urban schools, however they seemed to skip over the relevance of the fact that most teachers are white and middle class.

Due to the fact that Native American students experience higher rates of poverty, rural isolation, low parental involvement, language barriers, and different learning styles than mainstream students, Native American students tend to be four or more years behind national norms of education. Matthews and Smith (1994) used quantitative data to assess the effect of culturally relevant materials on student achievement and attitudes toward science in schools that served Native American students. Matthews and Smith studied 203 students in grades four through eight from ten Bureau of Indian Affairs (BIA) school systems in four states. Sixty percent of the students were Navajo, though the students

represented eleven different tribes altogether. Matthews and Smith categorized the students as Navajo or non-Navajo.

Matthews and Smith (1994) used a pretest/posttest research design with the one independent variable being instruction. Science achievement, as determined by a 40-item science concepts questionnaire designed for the study, and attitude towards Native Americans and science, as measured by a 40-item Likert scale test also designed for the study, were the two dependent variables. Matthews and Smith randomly assigned the teachers (n=10) and their classes into experimental (n=5) and control groups (n=5). The investigation occurred over a ten week period during which teachers in the experimental groups used Native American related materials to teach science for 25 hours and related language arts for 25 hours. The materials included 12 biographical profiles of Native American peoples who used science in their daily lives and related science and language arts materials developed by teachers of Native American students who took part in a National Science Foundation teacher enhancement program. The control group teachers taught science for the same number of hours using the same instructional materials minus the Native American references.

Matthew and Smith (1994) found that the teachers did not follow specific directions. Instead of teaching science for 25 hours, the control groups taught for an average of ten hours. Matthews and Smith delineated the experimental groups into two sections: four teachers used the Native American materials for an average of 33 hours and one teacher, hereafter deemed the exceptional group, used the materials for over 50 hours.

Matthews and Smith (1994) detected a significant, positive correlation between attitude and achievement on pretests and posttests (r=.31, r=.24, respectively). Matthews and Smith ran a MANCOVA to eliminate the possibility of the dependent variables having influence over each other. The attitude test had a score range of 40-200 points based on five possible responses to each question with negative responses scored in reverse. They found that for attitude, the control group (n=85) decreased in mean test score from 134.8 to 130.0. The experimental group (n=71) increased slightly in score from a mean score of 137.3 to 139.7. The exceptional control group (n=47) dropped in score from a mean of 137.8 to 134.2. The scores on the achievement test ranged from 0-40. For achievement, the control group made no change in their pretest score of 12.0. The experimental group increased in score from a mean of 13.7 to 20.7. The exceptional control group made the greatest increase from a mean of 14.0 to a mean of 25.3. In a multivariate analysis with the treatment as the only independent variable, F values were only slightly significant ($p<.05$). Based on these results, Matthews and Smith cautiously concluded that "Native American related materials seem[ed] to have a positive effect on the attitude and achievement of Native American [students], although the mechanism of that effect remain[ed] unclear" (p. 378).

Matthews and Smith (1994) checked for validity of the attitude tests by asking the teachers of the three students who scored highest and the three who scored lowest if the test scores matched the students' behavior. The major weakness of the study was that the teachers did not follow research procedures, thus there was no consistency both within the control groups and between the control and experimental groups. The authors listed several limitations to their study. First, the sample was not randomly selected. Also, the

fact that BIA schools only serve about 10% of Native American students in this country, the study may not hold true for all Native American students. Second, the culturally relevant materials may not have been directly related to higher attitudes and achievement. For example, language skills could have been increased which may have indirectly increased achievement. Teachers who used the materials may have become more enthusiastic given the opportunity to use culturally relevant materials. The exceptional control teacher seemed to be an example of this. The authors state that eliminating the exceptional control might have made the results simpler, but they wanted to fully understand what had been uncovered in the research. Third, the research broke the tribes into "Navajo" and "non-Navajo." They noted a more significant increase in non-Navajo vs. Navajo scores in achievement. There were no significant differences between the tribes in attitude. Interestingly, the two teachers of Navajo students were White and African American, whereas the teachers of the non-Navajo students were both of the same tribe as their students. In the case of the African American teacher, she reported that the students were reluctant to open up to her about tribal beliefs.

Also interested in examining how curriculum affects science instructions in Native American students, Allen and Crawley (1998) studied the conflicts between the worldviews of students of a traditional tribe of Native Americans, the Kickapoos, and the mainstream views of science presented to them in the classroom. Their primary purpose was to determine the effect of using culturally relevant science materials in science classes with high numbers of Native American, namely Kickapoo, students. Allen and Crawley defined worldview as "the way people think about themselves, their environments, and abstract ideas such as truth, beauty, causality, time, and space" (p.

113). Allen and Crawley claimed that worldview is closely tied to culture. Though not described using the same terminology, the multiple worlds of students in studies like Gilbert and Yerrick's (2001) reflect the discord of worldview and Western science felt by many Native American students. The transition between the traditional world of the Kickapoo students and the Western world of school is particularly difficult due to tightly held conservative beliefs and resistance to Western culture. Allen and Crawley performed an interpretive study in which emergent data shed light onto the perspectives of Kickapoo students of science within the context of Western science instruction.

Allen and Crawley (1998) examined the perspectives of 28 Kickapoo students in grades five through nine at a multicultural school in which the majority of students were Latino and four percent were Kickapoo. Two teachers, both Latino and with varying degrees of experience in science, participated in the study. Data in the form of audiotapes, videotapes, field journal notes, student drawings, classroom observations and other forms were collected over an 18 month period. Allen and Crawley did loosely structured interviews with the students, individually and in groups, in out of school contexts such as at ball games, hamburger stands, and at the community center. Allen and Crawley interviewed the teachers at school. Allen and Crawley provided an 800 number for participants to visit and exchange ideas, and it ended up being a rich source of data.

Allen and Crawley (1998) engaged students in science activities on four occasions, twice all day and twice after school, at the local community center. Allen and Crawley encouraged students to express their worldviews during the hands on, exploratory activities. In addition, the researchers spent approximately nine hours in each

classroom over the course of the year. Allen and Crawley collected notes on the layout of the classrooms, the teaching styles, communication patterns, and text materials. They found that both classes were conducted in a teacher-directed manner with strong reliance on texts. In these classes, the teachers acted as authorities with little or no student input. In addition, they found that the texts were heavily weighted toward mainstream cultural views.

During data analysis, Allen and Crawley developed a coding system in an emergent fashion (1998). Allen and Crawley presented three major categories of data in their research findings: epistemology, pedagogy, and perspective. Contrary to their expectations, students and teachers presented a positivist view of science, a view which asserts that one truth about a scientific concept is waiting to be discovered. In addition, teachers leaned toward an authoritarian view of knowledge, whereas students demonstrated a more empirical view.

In regard to pedagogy, Allen and Crawley (1998) found a distinct disconnect between the teachers' teaching styles and the students' preferred learning styles. Allen and Crawley found that students' strongly preferred a holistic, cooperative approach to learning whereas the teachers relied completely on a mainstream, competitive, reductionist teaching style. Teachers reported being baffled at Kickapoo students' refusal to participate in competitive tasks and games. Allen and Crawley also noted a disconnect between the Kickapoo students' circular mode of thought and belief and the linear lay out of the texts.

The third category, perspective, provided Allen and Crawley (1998) with additional significant data. Allen and Crawley found that the students behaved

significantly different in different settings. The Kickapoo students appeared completely passive in the classroom, but were highly animated during the hands-on science activities at the community center. Allen and Crawley suggested two possible causes for this observation. One possible cause was that the students simply preferred the learning strategy in place at the community center. The second possibility was that the students, feeling a strong sense of tribal identity, viewed school as another world and acted differently there, as if they were outsiders. Allen and Crawley also found that though the teachers lived in the same community as the Kickapoo students, neither was informed about the life experiences of the students.

Continuing the perspective category, Allen and Crawley (1998) found that students expressed a harmonious relationship with nature whereas the teachers and texts presented nature as something to be dominated. In addition to perspectives of science, Allen and Crawley noted perspectives on beliefs and values among the Kickapoo students. The researchers found the presence of several social rules among the Kickapoo tribe including unwillingness to infringe on another's freedom, soft-voiced and casual interactions, and cooperation. The students also voiced feeling uncomfortable with public displays of criticism or anger.

Allen and Crawley (1998) cited several implications for their research. Perhaps most importantly, they suggested that "the worldviews which students bring with them into the science classroom may affect not only how they make sense of scientific information, but also the extent to which they are willing to participate in the educational experience" (p. 129). Allen and Crawley argued that the students holistic, ecological views of science were more in line with current Western science than the views of the

teachers or texts and that science does not have to be seen by students as a way to leave the community, but instead as a way to serve the community. Finally, Allen and Crawley suggested that teachers and text book authors need to be more culturally sensitive.

Allen and Crawley (1998), in the style of a qualitative study, seemed to immerse themselves in the community to obtain an accurate view of the experiences of Kickapoo students of science. Though the participants were few in number, similar data have been found for other Native American groups. Encouraging adult members of the Kickapoo community to participate and check for accuracy in interviews was a strength of the study. The cultural identity of the researchers was not clear, and it is possible that interview responses could have been shaped by a discord between the cultural background of researcher and student.

Christianity and Science Education

This section reviews research literature surrounding a specific aspect of culture: religion. The research in this section is specific to the impact of Christian religious beliefs on science education. Though Christian students are not considered marginalized in the United States, I included the topic because of its impact on teaching the topic of evolution. Religion is a facet of culture, and thus has direct implications to the practice of culturally relevant teaching. This section will examine the beliefs of Christian students as they learn about evolution and the impact of the beliefs of Christian biology teachers. Christianity is the focus of this collection of literature reviews not because it is the prominent religion in the United States. This is not to say that students of other religious backgrounds do not find difficulty finding common ground between their beliefs and the content of a science class.

Esbenshade (1993) studied the extent to which students' religious and spiritual concerns affect their view of science. Esbenshade recruited volunteer participants from the student body of a high school. Though the researcher did not list the total number of students who participated, he did note that the students were 94% white and Christian. Esbenshade gave the students a survey which included 20 questions about the students, their religious backgrounds, and their considerations of pursuing a science career. Sixty nine percent of respondents indicated that their personal faith could affect their career choice and about half of the students claimed to be considering degrees in science and the majority claimed to have strong religious faith. Esbenshade, though admitting this was not conclusive evidence, took note that a strong religious background does not indicate a disinterest in science. Esbenshade also noted that many respondents were unsettled by a lack of congruence between scientific facts and their religious beliefs. Though Esbenshades' findings provided some insight into religious students' perceptions of science careers, the study was limited by its type and demographics. The survey was Likert style, leaving room for individual interpretations, and the participants were a fairly homogenous group.

Lawson and Worsnop (1992) examined the factors that influence student ability to reject prior nonscientific beliefs and to learn about scientific concepts. In this study, the nonscientific beliefs in question were, as defined by the researchers, knowledge at odds with scientific belief but believed to be true, such as special creation; the scientific concept in question was evolution. Lawson and Worsnop studied 107 students in three sections of a non-tracked high school biology course. The students attended a well-equipped high school in a middle- to upper-class neighborhood. The school's population

had a low percentage of students of color and a high percentage of actively religious students (28 % Catholic, 15% Mormon).

After making a prediction that students with high levels of deductive reasoning skill would be more likely to exhibit conceptual change, Lawson and Worsnop (1992) pre-tested students on reflective reasoning skill, strength of religious commitment, prior declarative knowledge of evolution and natural selection, and prior beliefs in special creation. After a three-week unit on evolution, the students filled out questionnaires to retest declarative knowledge and belief. Lawson and Worsnop measured change in belief and change in declarative knowledge by subtracting pretest scores from posttest scores. The researchers found a mean gain of 3.6 out of 20 possible points on the declarative knowledge test, a fairly non-significant amount. Almost half of the students held nonscientific pretest beliefs about special creation and virtually the same amount of students held the same beliefs in the posttest. The data showed a lack of change in beliefs after a unit on evolution.

Lawson and Worsnop (1992) found support for their original prediction that deductive reasoning skill facilitates the rejection of nonscientific beliefs. They noted, however that the correlation may not be direct. Lawson and Worsnop also found that highly religious students are less likely to give up their beliefs based on instruction. The researchers suggested that perhaps teachers should not try to change the minds of highly religious students when teaching evolution but should instead use the opportunity to explore alternatives and provoke critical discussions and reflective thought.

To ensure a greater understanding of the importance of prior knowledge, changes in beliefs, and several other factors, Lawson and Worsnop conducted a number of

statistical analyses, including multiple regression and path analysis. Lawson and Worsnop (1992) relied on Likert scale questionnaires and multiple choice tests, possible flaws to their research design due to their contextual and subjective nature. In addition, students were post-tested immediately after instruction. Perhaps if students had been given time to digest and interpret the new material, their post-test results might have differed.

Jackson et al. (1995) examined the ways that the religious –influenced culture in the South affects science education in the region. The researchers chose the South as the location for their research based on the high prevalence of religious belief in the region. As background information for the topic, the researchers cited two theoretical approaches, the conceptual change model and multiculturalism, to teaching and learning science. The researchers noted an inconsistency between these frameworks and the tendencies for science educators to view or treat their Christian students with disrespect. This inconsistency was the impetus for the research.

Jackson et al. (1995) used heuristic inquiry, a type of qualitative research wherein the researchers acknowledge an overtly personal and subjective viewpoint, as their approach to the study. The study's participants, two university professors of science, a professor and two graduate students in science education, four high school biology teachers, and eight prospective middle- or high school teachers, volunteered based on two characteristics: they identified as Orthodox Christian and they had a strong interest in science and science teaching. The first author of the research was a participant as well. Jackson et al. initially collected data through informal, exploratory conversations. Jackson et al. collected subsequent data through loosely structured interviews with 15

participants, with one researcher interviewing one to two participants at a time. The researchers made audio recordings of eight interviews and took detailed field notes in the remaining interviews. Jackson et al. transcribed the audio recordings and verbatim field notes. The first author coded all of the data and reviewed it looking for emergent categories.

Jackson et al. (1995) presented their findings in a narrative form with interview. Jackson et al. grouped these narrative into several categories, the first being evolution versus religion as a hindrance to professional communication. The researchers found widespread thought among the Christian educators that believing in evolution went hand in hand with atheism. In addition, some of the educators lacked an understanding of the terms "fact" and "theory" when defending their beliefs. Finally, the first author, the only non-Christian participant in the study, resorted to challenging the others as adversaries in an effort to defend his belief in evolution. The first author, like others in his position, tended to take a condescending attitude toward Christians in the science fields.

Jackson et al. (1995), in an examination of the rationales and strategies of practicing science teachers, found that several of the educators dealt with teaching evolution by never mentioning religion. These educators were unable to marry the ideas of their religious convictions with evolution, thus they ignored any connection. One teacher was willing to grapple with the ideas and use her struggles to engage students in the scientific process. Other teachers grappled with the notion of being able to reconcile their views of science and religion while still maintaining the integrity of both belief systems.

Jackson et al. (1995) warned that when teachers try to use propaganda or coercion to teach evolution they become intellectual enemies to their Christian students. Christian students may become closed-minded toward evolution as a subject and may become inwardly hostile to teachers who do not make an effort to understand their personal values. Jackson et al. claimed that attachments to cultural belief structures, like religion, formed early in life are quite powerful and to ignore these attachments is a disservice to students.

Jackson et al.'s (1995) research illustrated the viewpoints of Christian science teachers as they tried to make sense of the seemingly opposite beliefs. The nature of the research was inherently personal, thus open to interpretation. The first author openly admitted his biases in favor of biological evolution and against Judeo-Christian religion. Though not stated, it seems obvious that the other participants were equally biased against biological evolution. Jackson et al. made several references to the naïve and incorrect beliefs held by the Christian educators. Though the beliefs of the educators did not correspond with what is considered to be scientific fact, calling their beliefs naïve and incorrect may have been contradictory to the conclusions drawn by the researchers.

Summary

This chapter was a critical analysis of the research literature on the academic and scientific experiences of marginalized students in the United States. Topics of analysis included the different worlds of school and home cultures, family and community involvement in students' academic and scientific achievement, the interface of race and culture with scientific and academic identities, science for English language learners, the impact of Christian beliefs on science education, and various other topics in culturally

relevant teaching. Most of the research confirmed that marginalized students do not identify with the culture of school. In addition, marginalized students tend to be treated differently by teachers, tend to struggle with developing racial and academic identities, and tend to prefer social, group-work oriented approaches to learning. Finally, Christian students, though not marginalized, deal with similar issues of incongruence between religious belief and science concepts.

CHAPTER FOUR: CONCLUSION

Introduction

A critical analysis of the research literature regarding culturally relevant teaching of science uncovered three broad themes: teacher perceptions and expectations of students, use of relevant curriculum that values student diversity and life experience, and building relationships with students and communities. The conclusion of this paper will discuss these themes and their connections to each other and to the practice of teaching. I will also examine how these themes are connected to the educational history of marginalized students. Finally, I will make implications about the practice of teaching science to students of color and various cultural backgrounds based on the research findings.

Summary of Findings

A critical review of the research literature uncovered several themes important to culturally relevant science teaching. The first of those themes was teacher perceptions and expectations of students. Multiple researchers found that not only did teachers of marginalized students tend to lower their expectations for their students, but that students were aware of being treated differently than their normalized peers (Bouillion & Gomez, 2001; Charron, 1991; Costa, 1995; Gilbert & Yerrick, 2001; Phelan et al., 1991). Westby et al. (1999) and Gilbert (2001) gave particularly interesting examples of teachers simplifying a question originally intended to be more cognitively demanding after being repeatedly asked for clarification by students. Other researchers found evidence supporting the fact that when teachers exhibit high expectations for their students, students tend to experience greater academic success (Lucas et al., 1991).

In Gilbert and Yerrick's (2001) research, students were aware of materials in the science classroom that were off limits to them but available to students in higher tracked science classes. The same problem was noted in Pérez Carreón et al.'s (2005) and Charron (1991) research. The teacher in Gilbert and Yerrick's case spoke of his doubt that the students in his lower track science class could be trusted with the materials. Though not explicitly stated, the researchers in all of these cases implied that often teachers of marginalized students oversimplify lessons because of their lowered expectations, thus keeping marginalized students even further behind. Phelan et al. (1991), Costa (1995), and Bouillion and Gomez (2001) noted instances of students of color trying to remain unnoticed who consequently were invisible to teachers. In another case, Brickhouse and Potter (2001) related the story of an African American girl who, though normally outspoken, learned to remain quiet in science class because she felt that was they key to academic success. Due to her silence, an interview with her teacher a year later revealed that the teacher could barely remember her.

The second emergent theme from review of the research literature was the importance of building relationships with students and their families and communities. Several researchers noted the importance of teachers getting to know the community and of creating a dialogue between schools and parents (Allen & Crawley, 1998; Barton, 1998; Charron, 1991; Pérez Carreón et al., 2005; Van Sickle & Spector, 1996). Building relationships with students and their communities gives students a reason to become involved in academics, thus breaking down the barriers between home and school cultures.

Allen and Crawley (1998) found, in a study of Native American students, that the teachers did not know their students and did not understand when their students refused to compete against other or acted overtly passive in the classroom. Lee et al. (1995) found that many educators associate inability to use scientific language with lack of science knowledge. If teachers of English language learners knew the backgrounds of their students they might come to find a wealth of information hidden behind an unfamiliar vocabulary. And Van Sickle and Spector (1996) studied science teachers, perceived as caring by colleagues and students, who used the interface of science and community to create a safe space, respect for life, and cooperation.

The third theme that emerged out of review of the research literature was use of relevant curriculum that values students' diversity and life experiences. This theme relates directly to the second theme in that creating culturally relevant materials starts with building relationships. Much of the research supported the assertion that if normally marginalized students are expected to become interested in engaged in academics and science, effort must be made to create curriculum that relates to their lives (Barton, 1998; Westby et al., 1999;. A specific strategy uncovered in the research for teaching diverse groups of students is cooperative group work (Allen & Crawley, 1998; Slavin & Oickle, 1981; Westby et al., 1999; Van Sickle & Spector, 1996). In addition, a number of researchers found that an inquiry based approach to science, which typically involves group work, was successful with English language learners (Hampton & Rodriguez, 2001; Lee et al., 1995; Stoddart et al., 2002). Westby et al. (1999) found, however, that students unaccustomed to group work tend to be less self-sufficient and need more

guidance. Incorporating group work into lessons on a regular basis will make it a more fruitful learning process for all.

Tobin et al. (2001) and Gilbert and Yerrick (2001) found that squelching the emotional and oral tendencies of African American students can drive a wedge further between the cultures of home and school. Both researchers suggested creating lessons that allowed for expressiveness and creativity. Research on the racial and academic identities of African American students emphasized that marginalized African American students often see their identities as incongruent with academic or scientific identities. Boykin et al. (2005) examined the African cultural ethos in classrooms and found that a misalignment between the ethos of African American students and the mainstream ethos of most teachers. Teachers need to be aware that are multiple means of expression and expanding lessons and assessments to give students some creative license is an effective technique for teaching diverse students.

Several researchers provided examples of using community involvement as a means of creating relevant curriculum. Interestingly, Barton (1998), Barton et al. (2001), Fusco (2001), and Tobin et al., (2001) all studied the use of community gardening or food as tie-ins to the lives of students. The researchers theorized that because food plays such a large role in students' lives, and because of the community aspect of gardening, that students would be able to learn science by doing science. In addition, Bouillion and Gomez (2001) explored the idea of allowing students to voice concern about a problem in their community and then take action to solve it. Another facet of building culturally relevant curriculum is simply valuing the life experiences of students and their communities. Barton et al. (2001) recommended listening to mothers' perspectives on

science, as the perspective of parents directly affects that of students. Barton et al. (2001) suggested using the experiences of students as a starting point for lessons. These varied techniques are bold examples of the many was that teachers can turn classroom science from mundane into personal, relevant, and exciting.

The research implied that teachers need to be attentive to all of their students, not just the few that stand out due to racial or cultural status or personality. A lack of attention from teachers, in the cases of the reviewed research, seemed to fuel students' already present feelings that they could not attain academic or scientific success. Though paying close attention to the needs of every student is a daunting task, it appears that failing to notice students feeds the cycle of student failure in school. Creating culturally relevant lessons is not always easy, but it appears to be the most effective way to reach all students, both normalized and marginalized.

The research findings appear to mirror the experiences of marginalized students on a historical level. Just as marginalized students have typically only had access to inferior educational opportunities in public schools in the United States, these students tend to get left behind in academics and in the field of science today. Also, the history of the interface of science education and Christianity continues in some states, though teaching of evolution has become fairly standard. Much progress has been made in previous decades, and though the future of the public schools may be in question, teachers willing to embrace culturally relevant curriculum will continue to increase the academic success of students of color and students from varied cultural backgrounds.

Classroom Implications

The research literature reviewed in this paper collectively suggested ways in which science can be make accessible to students from typically marginalized populations. According to the research literature, treating all students with confidence regarding their abilities to succeed academically, particularly in science, can increase the likelihood of student success. In addition, being transparent with students by assuring them that teachers are always learning and that the collective knowledge and experience of everyone in the classroom is valuable is an overarching strategy that can be used. Tobin et al. (2001) provided an example of two co-teachers modeling problem solving in front of a class. Using modeling or other methods such as real world investigations to help students develop questioning and problem solving skills can be used as a foundation for science concepts, thus giving students skills to succeed. Furthermore, practicing and using techniques such as cooperative group work can help students build on their collective knowledge and learn how to accept and appreciate diversity.

As research show that marginalized, and in some cases normalized, students find science incongruent with their lives, teachers need to find out about students' life experiences and build relevant curriculum. Giving surveys, having class discussions, and keeping in contact with families are examples of how a teacher can find inspiration for relevant science lessons. Also, using existing controversies, such as evolution or the obvious inequities between rich and poor neighborhoods, has the potential to inspire students to become actively involved in their learning. A teacher can encourage thoughtful examination of all sides of a situation, a useful life skill. Teachers can use

students' concerns about their lives-like safety or injustice-to engage them in inquiry based problem solving activities that go beyond book knowledge. It is important for teachers to realize that all students come into the classroom with a set of beliefs and life experiences that cannot be ignored, but should instead be used as a springboard for culturally relevant teaching.

Implications for Future Research

The research analyzed in this paper speaks of the need for teachers to increase their knowledge of culturally relevant teaching. The importance of building relevant lessons, gaining an understanding of students' communities, and keeping high expectations cannot be understated. However, there seems to be a lack of research regarding practical ways in which these aspects of culturally relevant teaching are put into practice and the effect on student learning that may occur as a result. For example, what are the best ways to encourage and maintain parental involvement, particularly in single parent, low income households? How can teachers learn about the communities in which they teach? What is the impact of culturally relevant curricula on students from the dominant cultural group in the United States? I conclude with the questions, and many others, in hope that some answers will come with mindful experience in the classroom and in the community.

REFERENCES

Allen, N. J. & Crawley, F. E. (1998). Voices from the bridge: Worldview conflicts of Kikapoo students of science. *Journal of Research in Science Teaching. 35*(2), 111-132.

Barton, A. C. (1998). Teaching science with homeless children: Pedagogy, representation, and identity. *Journal of Research in Science Teaching. 35*(4), 379-394.

Barton, A. C., Hindin, T. J., Contento, M. T., Trudeau, M.,Yang, K. Sumi, H., Hagiwara, S., & Koch, P. D. (2001). Underprivileged urban mothers' perspectives on science. *Journal of Research in Science Teaching. 38*(6), 688-711.

Bouillion, L. M. & Gomez, L. M. (2001). Connecting school and community with science learning: Real world problems and school—community partnerships as contextual scaffolds. *Journal of Research in Science Teaching, 38*(8), 878-898.

Boykin, A. W., Tyler, K. M., & Miller, O. (2005). In search of cultural themes and their expressions in the dynamics of classroom life. *Urban Education. 40*(5), 521-549.

Brickhouse, N.W. & Potter, J.T. (2001) Young women's scientific identity formation in an urban context. *Journal of Research in Science Teaching. 38*(8), 965-980.

Campbell, D. E. (2004). *Choosing democracy: A practical guide to multicultural education.* Pearson Education, Inc.: Upper Saddle River, New Jersey.

Charron, E. H. (1991). Classroom and community influences on youths' perceptions of science in a rural country school system. *Journal of Research in Science Teaching. 28*(8), 671-687.

Costa, V. B. (1995). When science is "another world": Relationships between worlds

of family, friends, school, and science. *Science Education*. *79*(3), 313-333.

Esbenshade, Jr., D. H. (1993) Student perceptions about science and religion. *The American Biology Teacher*. *55*(6), 334-338.

Fordham, S. (1988). Racelessness as a factor in Black students' school success: Pragmatic strategy or Pyrrhic victory? *Harvard Educational Review*. *58*(1), 54-84.

French, S. E., Seidman, E., Allen, L., & Aber, J. L. (2000). Racial/ethnic identity, congruence with the social context, and the transition to high school. *Journal of Adolescent Research*. *15*(5), 587-602.

Fusco, Dana. (2001). Creating relevant science through urban planning and gardening. *Journal of Research in Science Teaching, 38*(8), 860-877.

Gilbert, A. & Yerrick, R. (2001). Same school, separate worlds: A sociocultural study of identity, resistance, and negotiation in a rural, lower track science classroom. *Journal of Research in Science Teaching*. *3*(5), 574-598.

Hampton, E. & Rodriguez, R. (2001). Inquiry science in bilingual classrooms. *Bilingual Research Journal*. *25*(4), 461-478.

Jackson, D. F., Doster, E. C., Meadows, L., & Wood, T. (1995). Hearts and minds in the classroom: The education of a confirmed evolutionist. *Journal of Research in Science Teaching*. *32*(6), 585-611.

Jegede, O.J. & Okebula, P.A.O. (1991). The effect of instruction on socio-cultural beliefs hindering learning in science. *Journal of Research in Science Teaching*. *28*(3), 275-285.

"Kansas board redefines science: New standards question accuracy of theory."

(November 8, 2005). Retrieved December 20, 2006 from http://www.cnn.com/2005/EDUCATION/11/08/evolution.debate.ap/

Klug, B. J., & Whitfield, P. T. (2003). *Widening the circle: Culturally relevant pedagogy for American Indian children*. New York: RoutledgeFalmer.

Lawson, A. E. & Worsnop, W. A. (1992) Learning about evolution and rejecting a belief in special creation: effects of reflective reasoning skill, prior knowledge, prior belief and religious commitment. *Journal of Research in Teaching Science*, *29*(2), 143-166.

Lee, O., Fradd, S. H., & Sutman, F. X. (1995). Science knowledge and cognitive strategy use among culturally and linguistically diverse students. *Journal of Research in Science Teaching. 32*(8), 797-816.

Levine, D., Lowe, R., Peterson, B., & Tenorio, R. (Eds.). (1995). *Rethinking schools: An agenda for change.* New York: The New York Press.

Lewis, B. F. & Collins, A. (2001). Interpretive investigation of the science-related career decisions of three African-American college students. *Journal of Research in Science Teaching. 38*(5), 599-621.

Lucas, T., Henze, R., & Donato, R. (1990). Promoting the success of Latino language Minority students: An exploratory study of six high schools. *Harvard Educational Review. 60*(3), 315-339.

Matthews, C. E., & Smith, W. S. (1994). Native American related materials in elementary science instruction. *Journal of Research in Science Teaching*. *31*(4), 363-380.

Miller, Patricia H. (2002). *Theories of developmental psychology*. New York: Worth

Publishers.

Monk, L. R. (2003). *The words we live by: Your annotated guide to the constitution*. New York: Hyperion.

Mount, S. (2006). *Constitutional topic: Official language*. Retrieved August 10, 2006 From the U. S. Constitution Online web site: http://www.usconstitution.net/consttop_lang.html

Norman, O., Ault, C. R., Bentz, B., & Meskimen, L. (2001). The Black-White "achievement gap" as a perennial challenge of urban science education: A sociocultural and historical overview with implications for research and practice. *Journal of Research in Science Teaching. 38*(10), 1101-1114.

Osborne, A. B. (1996). Practice into theory into practice: Culturally relevant pedagogy For students we have marginalized and normalized. *Anthropology and Education Quarterly. 27*(3), 285-314.

Parsons, E.C. (1997). Black high school females' images of the scientist: Expression of culture. *Journal of Research in Science Teaching*. *34*(7).

Pérez Carreón, G., Drake, C., & Barton, A. C., (2005). The importance of presence: Immigrant parents' school engagement experiences. *American Educational Research Journal. 42*(3), 465-498.

Phelan, P., Davidson, A. L., & Cao, H. T. (1991). Students' multiple worlds: Negotiating the boundaries of family, peer, and school cultures. *Anthropology and Education Quarterly. 22*(3), 224-250.

Rothstein, S. W. (Ed.) (1995). *Class, culture, and race in American schools: A handbook*. Westport, Connecticut: Greenwood Press.

Sandoval, S. R., Gutkin, T. B., & Naumann, W. C. (1997). Racial identity attitudes and school performance among African American high school students: An exploratory study. *Research in the Schools. 4*(2), 1-8.

Slavin, R. E. & Oickle, E. (1981). Effects of cooperative learning teams on student achievement and race relations: Treatment by race interactions. *Sociology of Education, 54*(3), 174-180.

Spring, J. (2006). *American Education*. San Francisco: McGraw Hill Books.

Spring, J. (2005). *The American School 1642-2004*. San Francisco: McGraw Hill Books.

Stoddart, T., Pinal, A., Lutzke, M., & Canaday, D. (2002). Integrating inquiry science and language development for English language learners. *Journal of Research in Science Teaching. 39*(8), 664-687.

Tatum, B. (1997). *"Why are all the black kids sitting together in the cafeteria?" and other conversations about race.* New York: Pegasus Books.

Tobin, K., Roth, W-M., & Zimmermann, A. (2001). Learning to teach science in urban schools. *Journal of Research in Science Teaching, 38*(8), 941-964.

Watkins, W. H. (2001). *The white architects of black education: Ideology and power in America, 1865-1954.* Teachers College Press: New York.

Westby, C., Dezale, J., Fradd, S.H., & Lee, O. (1999). Learning to do science: Influences of language and culture. *Communications Disorders Quarterly. 21*(1), 50-64.

Van Sickle, M. & Spector, B. (1996). Caring relationships in science classrooms: A symbolic interaction study. *Journal of Research in Science Teaching. 33*(4), 433-453.