Language, race and place: A critical race theory analysis of students of color in a pre-medical program at a predominately white research university

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LANGUAGE, RACE, AND PLACE: A CRITICAL RACE THEORY ANALYSIS OF STUDENTS OF COLOR IN A PRE-MEDICAL PROGRAM AT A PREDOMINATELY WHITE RESEARCH UNIVERSITY

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Abstract

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With the increasing racial diversity of the United States and the growing economic and health disparities among racial groups, there is a growing need for health professionals of color (Montoya, 2006). However, people of color are significantly underrepresented in the health professions and make up only 14% of those admitted to medical schools and only 6% of the physician workforce (US Department of Health and Human Services 2009). Much of this disparity can be linked to very high attrition rates for students of color in their first two years of undergraduate science programs (Cohen & Steinecke 2006; Smith 1993; Tobias 1990; US HHS 2009).

To better understand the complexity of the disparity, this ethnographic case study used Critical Race Theory to examine the experiences of eight students of color during their first year in a pre-medical program at a predominantly white research university. Critical Race Theory as a framework facilitates the examination of the various iterations of systemic racism including the intersecting forms of oppression and the dominant narratives used to explain and justify the relative educational success or failure of one group over another (Ladson-Billings, 1998; Solorzano & Yosso, 2001).

The major areas of analytic focus included: Assumptions and dominant narratives about students of color in science, pedagogical approaches employed by instructors in college science classes; the role and impact on students of the academic science language in course textbooks and exams; the ways that race, class, language, and immigration status impact students in the science classes and the larger university; the impact on students of various university structures and practices such as financial aid policies, science course structures, and grading practices. This analysis shows how these multiple factors function as interlocking systems of institutionalized oppression that disadvantage students of color in the science courses. In addition, the counterstories of these students show the valuable knowledge and experience these students can bring to the medical profession.

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CHAPTER ONE: Students of Color in College Science Programs

For the 28 students of color[1] in the biology class at University on the Hill, the fall semester had started with a sense of hope and possibility. The university, concerned with the high attrition rates for students of color from the pre-medical science classes, had put in place a new initiative to support these first-year students. The program included a small inquiry-based biology class that was specifically created for this group of students. This class was meant to prepare students for the cell biology class they would take second semester. Students were enrolled in the regular 150 student lecture-style chemistry class, but had a special chemistry discussion section and extra problem sets. These students also met once a week in an advising class with one of the program administrators to talk about any difficulties with course work and to receive advice on better ways to study. A threatened loss of federal funding for the university's McNair[2] program was part of the impetus to launch this new pre-medical support program. The hope was if the university could show an initiative to retain students of color in science majors and ultimately prepare them for graduate work, the federal funding for the McNair program would be maintained.

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[1] This term encompasses students who are marginalized in the university environment primarily based on their racial background. Many of these students are further marginalized in the university because of one or more additional factors which include: class, language, immigration status, and educational history. See the section "Research Purpose and Questions" below for additional detail on this term and how the students identify themselves.

[2] Further detail about the McNair program is provided in Chapter 4. There are 157 McNair programs at universities across the US. The McNair program is one of several programs funded by the US Department of Education with the goal of helping underrepresented students earn undergraduate and graduate degrees. The program's website (http://www2.ed.gov/programs/triomcnair/index.html) describes the McNair program as follows: "Through a grant competition, funds are awarded to institutions of higher education to prepare eligible participants for doctoral studies through involvement in research and other scholarly activities. Participants are from disadvantaged backgrounds and have demonstrated strong academic potential…The goal is to increase the attainment of Ph.D. degrees by students from underrepresented segments of society."

But on this particular day in mid-November, the mood in the biology classroom was grim. One of the program advisors had come to talk with the students about what to do if they were in danger of failing either the chemistry or biology courses. A majority of the students were passing the biology course, but most of the students, if they had not already dropped the chemistry class, were close to failing. Even with much of the semester yet to take place in the context of the new support program, it seemed that the experiences and outcomes for these students might not be so different from their predecessors.

My work over several years in a university summer program which provided academic support for incoming students of color made me curious about what seemed to be a sadly predictable attrition for these students past the first semester in the pre-medical science courses. A sizable percentage of these students at University on a Hill were recent immigrants to the United States and many have served as translators for parents and other family members in medical contexts. Many had excelled in high school science and have medical school aspirations. Their interest in medicine often stems from the health care challenges experienced by their family members or by the people in their home neighborhoods and home countries. All of the students in the summer program have been the top students at their mostly urban high schools, however, very few of the students are able to succeed in their first-year science courses and most switch to other programs of study by the end of their first semester of college.

My concern over the low-retention rate in science courses for students of color led me to conduct a year-long exploratory pilot study (De Rosa, 2013) focused on the experiences of one of these students, a recent immigrant from the Dominican Republic.

To better understand her challenges and the larger context of the university's science program, I conducted multiple interviews with her and her high school and college science teachers, along with science class observations and analysis of the college course textbook, lecture materials, and exams. This student tried for two years to persist with the pre-medical curriculum, but after receiving Ds in the science courses she ultimately switched to a major in sociology.

That pilot research suggested the problem of student retention was grounded in college teaching approaches and grading practices that privileged White students from suburban and private schools with their particular knowledge and educational backgrounds and disadvantaged students of color from urban high schools. In particular, the pedagogical approaches in college privileged students who were already adept at learning from science textbooks and the particular forms of academic English favored in those texts.

The pilot study also revealed that the problem was complex and linked to university policies and structures that, whether intentional or not, result in discouraging students of color from continuing in the science courses and applying to medical school. For example the university currently has a high success rate of getting students into medical school in part because so few students (both White and students of color) make it through the first-year pre-medical courses. The students who do remain in the premedical program tend to have high grades and thus a higher chance of being admitted to medical school. In addition the pre-medical advisors discourage students with lower science grades from even applying to medical school. If the university helped more students of color persist through the pre-medical program with less than top grades and these students applied to medical school, they might have a lower chance of being accepted to medical school. This would lower the university's overall medical school acceptance rate and the university's reputation and national ranking might be harmed. Thus the university has little to gain (and a lot to lose) by helping students of color who struggle in their science courses persist through the premedical program and apply to medical school.

Further, the pilot study and a related study (De Rosa, Guerrero, Pacheco & Sterling, 2013) found that one of the dominant beliefs held by faculty and administrators at the university was that students of color were pursuing medical careers to satisfy parental expectations or for financial gain and that students were just not working hard enough in the science courses. The dominant narrative at the university was that students just needed time to figure out which vocational areas better matched their capabilities and interests. These majoritarian narratives (Ladson-Billings, 1998; Solorzano & Yosso, 2001) allowed faculty and administrators to locate the problem with students and prevented the university from considering or examining the role that institutionalized racism might play in student outcomes.

Given this dominant narrative, I was surprised to learn about the university's plans for a new program aimed at supporting students of color in the pre-medical science program. I wondered how the faculty and administrators would determine the program's design and what assumptions and knowledge they had about the students who would be served by the program. Further, I wondered how institutional structures and narratives might intersect with the goals of the program. Given the complexity of the problem, I did not think this program alone would be enough to address the long-standing issues faced by students of color at the university, let alone the nation. However, it was at least a step by the university to acknowledge the challenges faced by these students and it presented a research opportunity to systemically investigate the university structures and practices in terms of how they would impact students of color with medical aspirations—students whose challenges were not so different than those at other universities. Thus, the focus of this study was to examine the experiences of eight of these students during their first year in this new pre-medical program at the university.

Students of Color and College Science

The challenges that the students at University on the Hill face with the first semester science courses are consistent with the larger college trends in the United States for students of color. The National Academies (2010) documented the low number of students of color in college science programs. In 2007 students of color made up 39 percent of K-12 public school enrollment, but only comprised 18 percent of those who earned science and engineering bachelor's degrees in that same year. Only 24 percent of underrepresented students who enroll in college with a major in science complete a science degree compared to 40 percent of White students (Chang, Cerna, Han & Sàenz, 2008).

The numbers for students of color entering a health profession are consistent with this trend. A study by the US Department of Health and Human Services (2009) found Latinos, African-Americans, Native Americans, and students from lower income brackets continue to be significantly underrepresented in health profession schools and make up only 14 percent of those admitted to medical schools and only 6 percent of the physician workforce. Other studies (Cohen & Steinecke, 2006; Smith, 1993; Tobias, 1990; US Health and Human Services, 2009) have noted similar patterns along with the very high attrition rates in undergraduate science programs during the first two years of undergraduate education for students of color. Further, while there have been increases in the number of students of color enrolled in medical school they have only paralleled the increase in overall student numbers, and no percentage gains have been evident since the in the last 30 years (American Medical Student Association, 1996; US Health and Human Services, 2009).

In spite of these well documented disparities and the low percentages of students of color who complete college science degrees, very little of the research on college science focuses specifically on students of color or examines the reasons for the different outcomes between White students and students of color. Instead researchers have tended to identify general factors that impede or support success in college science courses without considering the differences between students and their varied educational backgrounds. Much of the research focuses on either the role of middle school and high school preparation or on particular pedagogical approaches that can improve the teaching of science (Adelman, 1999, 2006; Horn, Kojaku & Carroll, 2001; National Academies, 2007, 2010).

One prominent theme in the research on pedagogical approaches is a push for more inquiry-based instruction that is designed to engage and interest students in science (Crowe, Dirks, & Wenderoth, 2008; Handelsman et al. 2004; Handelsman, Miller, & Pfund, 2007; Stokstad, 2001). A notable omission in this research on inquiry-based instruction is the lack of focus or emphasis on the language challenges of science (Yore, Bisanz, & Hand, 2003). Further detail on these research trends and themes is provided in Chapter 2.

Different Discourses on Students of Color in Science

While there is widespread concern about the low proportion of students of color in science majors, the rationales for why we should be concerned are framed in different ways depending on the eventual occupation connected to a particular science degree. For science majors and degrees leading to careers more broadly described as Science, Technology, Engineering and Math (STEM), the dominant narrative in the media and public policy documents is a concern about the United States' economic competitiveness in the global economy. This first view is the most frequently cited reason for concern about the low number of students of color in science fields. In contrast, for science degrees connected to the health care professions, the problem—more often in public policy documents—is frequently framed as a concern about racially based health care disparities for different racial groups since medical professionals of color are more likely to work in communities of color.

My own concern is connected to the issue of health care disparities along with equitable educational opportunity for students of color in health fields. However, it is important to understand the two different ways the concern is talked about and framed since particular framings of the problem lead to particular solutions and views of the students involved. Further, the discourse is suggestive of different underlying ideologies. In discussing the relationship between ideologies and discourse, Van Dijk (2006) explains that, "ideologies are foundational beliefs that underlie shared social representations…These representations are in turn the basis of discourse" (p. 120). Thus an analysis of the discourse in the various policy documents can provide some insight into the various ideologies related to students of color in college science.

Global economic competitiveness. In much of the media and policy discourse surrounding educational issues, the underlying ideology centers on the nation's global economic position. Joel Spring (2011) argues that the ideology of economic competitiveness, which he calls human capital economics, is the most prevalent educational ideology and is so pervasive that other purposes for education are often not even acknowledged. He describes the ideology as follows:

> Today the dominant educational ideology is human capital economics which defines the primary goal of education as economic growth, in contrast to other ideologies that might emphasize the passing on of culture or the education of students for social justice. Human capital economics contains a vision of school as a business preparing workers for businesses. Consequently, human capital economics values knowledge or curriculum according to how it meets the needs of the economic system (p. 6).

In terms of how this ideology relates to science education for students of color, concerns about the economy take precedence over the particular academic needs of the students. It is only when the needs of students of color converge with national economic interests that attention is paid to the needs of these students and even then, there is little concern for how individual students will benefit.

Both the National Science Foundation (NSF) and the National Academies[3] have made calls for more science training emphasis in the education system to improve the

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[3] The National Academies website (http://www.nas.edu/about/whoweare/index.html) describes the organization as follows: "The National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council are private, nonprofit institutions that provide expert advice on some of the most pressing challenges facing the nation and the world. Known collectively as the National Academies, our organization produces groundbreaking reports that have helped shape sound policies, inform public opinion, and advance the pursuit of science, engineering, and medicine."

nation's economic competitiveness. The National Academies in a 2007 report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, expressed the following concern: "Having reviewed trends in the United States and abroad, the committee is deeply concerned that the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength" (p. 4). Students of color, because of their increasing numbers in the population become a topic a concern for the report's authors. The report goes on to say the following about students of color:

> As minority groups increase as a percentage of the US population, increasing their participation rate in science and engineering is critical if we are just to maintain the overall participation rate in science among the US population… If some groups are underrepresented in science and engineering in our society, we are not attracting as many of the most talented people to an important segment of our knowledge economy (p. 179).

In this argument, with the main focus on the competitive needs of the economy, the needs of students of color are more of a footnote rather than an important concern. It should also be noted that the concern is not about all students of color, but only those who are most talented.

A more recent report from the National Academies (2010), *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*, focuses more directly on the preparation of students of color in science fields, but these students are still framed as resources that can help the country remain competitive:

> The United States stands again at the **crossroads**: A national effort to sustain and strengthen S&E [Science & Engineering] must also include a strategy for ensuring that we draw on the minds and talents of all Americans, including minorities who are underrepresented in S&E and currently embody a vastly underused resource and a lost opportunity for meeting our nation's technology needs (p. 1). (Emphasis in original.)

This 2010 report places students of color in the foreground, however these students are still positioned as resources for the economy rather than individuals with particular needs and aspirations:

> Underrepresented minority groups comprised 28.5 percent of our national population in 2006, yet just 9.1 percent of college-educated Americans in science and engineering occupations… Under representation of this magnitude in the S&E workforce stems from the underproduction of minorities in S&E at every level of postsecondary education, with a progressive loss of representation as we proceed up the academic ladder (p. 2).

In this policy report, students of color are viewed primarily as economic resources to be "produced" for the needs of the economy. This notion of students of color as resources is further underscored when the problem, in this report and others, is denoted as a "leaky STEM pipeline" calling to mind the notion of a water or oil pipeline. The report does not mention how the students themselves stand to benefit—economically or otherwise—from their participation in science fields.

The administrators of the US Department of Education's McNair program also use similar language in framing the concerns about students of color in science. As noted earlier, part of the motivation to implement the new pre-medical support program at University on a Hill was to retain funding for the university's existing McNair program. This move by the university was precipitated by the Department of Education's decision to shift some of McNair funding for college programs to the Upward Bound Math and Science program which is designed to generate more interest in science fields when students are at the high school level.

At the national level of the McNair program, there was great concern about this shift in funding and an "Action Packet"[4] from the national program office was sent to all university McNair programs. The University on a Hill administrators in turn forwarded the materials to many people in the university, myself included. The goal of the action packet was to get university administrators and faculty to write to members of congress about the funding issues. Prominent in the framing of the problem was a focus on economic competitiveness and national security. Below is an excerpt from the suggested text that university personnel might use in crafting a letter to members of congress:

> McNair helps to fill a vast void in the area of postgraduate degree attainment for low-income, first-generation college students and underrepresented minorities. This is especially critical considering that the McNair program focuses on such high priority fields as science, technology, engineering, and mathematics. As other nations continue to surpass the United States in their production of scientists and engineers, the need for TRIO programs, in general, and the McNair program, in particular, is greater than ever. As staunch supporters of McNair, we

[4] The text of the Action Packet can be found at http://www.coenet.us/files/bulletin_board-Myths_vs_Facts_on_McNair_060612.pdf. This link in on the Council for Opportunity in Education's site: http://www.coenet.us/coe_prod_imis/COE/Issues/Call_to_Action/McNair/COE/NAV_Issues/Call_to_Action_McNair.aspx.

> respectfully request that you fight to increase the federal investment in TRIO programs in FY 2013 and beyond. Without increased funds, the futures of several thousand students and their families will be at risk. Additionally, our nation will fail to capitalize on the talents of some of our most vulnerable citizens. Such a loss will ultimately threaten our national security and prosperity.

While this letter does not necessarily mean that the McNair program leaders agree with this positioning, it suggests that they understand the value of framing the issue as a matter of "national security and prosperity."

An Emphasis on "Interest in Science"

It could be argued that this economic and global competitiveness framing is not problematic as long as it means that funding and attention will be focused on helping students of color succeed in science. This might be accomplished through investigation and adjustment to the instructional and institutional barriers that drive students of color out of science. Instead this positioning of students of color as "resources" for the country reduces the problem to not enough students of color pursuing science degrees. Thus the recommended solution becomes getting more students of color focused on and interested in science degrees. This emphasis on science interest is prevalent in the media and public policy discourse and is reflected in the Department of Education's shift in funding from the McNair program to the high school Upward Bound Math and Science program. This focus is also seen at other funding entities. The National Science Foundation (NSF) which provides significant funding for science education programs at all levels uses "interest in science" as a key criteria for funding. In one of their Request for Proposals the National Science Foundation (2005)[5] makes the following recommendations about increasing and sustaining science interest:

> Because of the proven success enrichment programs have in increasing student interest, the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development recommends that these programs be made available to all students.
>
> Increasing interest alone is not sufficient, however, because many other factors are needed to *sustain* interest and aid youth in making often-difficult transitions from middle school to high school, and high school to college. It is anticipated that the ITEST program will not only increase interest in IT through the creation of effective student education programs, but also maintain interest through supportive activities that include parental involvement, career exploration, externships, research, and multi-year programs (p. 5). (Emphasis in original.)

While interest in science is clearly a relevant factor in whether students will pursue and persist in science programs, having the educational preparation to actually succeed in the coursework deemed relevant by the university seems equally, if not more, significant. Further, this framing of the problem means that government policy groups and educational institutions are not challenged to examine the much more complex educational inequities that negatively impact students' academic preparation both before and during college. Ladson-Billings (2006) argues that our focus on achievement gaps is misplaced and "instead we must look at the 'educational debt' that has accumulated over

[5] This document can be found on the National Science Foundation website at http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5467

time" (p. 3) for students of color. This debt is rooted in historical, economic, sociopolitical and moral factors that have resulted in complex and intertwined educational disparities. Framing the racial disparities in science outcomes in terms of science interest silences or obscures the complex educational disparities and further increases the educational debt owed to these students.

Equitable health care access. In contrast to the much more frequent economic competitiveness rational for getting more students of color into STEM careers, when the focus turns to the low number of students of color in the health professions, the concern is generally framed as a public health issue for communities of color. This framing also has the potential to position students of color as offering backgrounds and important social capital that can improve the health care system.

It should be noted, that this perspective about health care inequities is rarely articulated in the mainstream media and instead is a view expressed by those more closely involved with medical education or public health policy issues. With the increasing racial diversity of the United States population and the growing economic disparities among racial groups, the underrepresentation of health professionals of color impacts communities of color that already have less equitable access to health care. Health professionals of color are more likely to practice in communities of color and to better understand the health needs of their patients because they may possess forms of capital such as the cultural and linguistic knowledge needed to work in these communities. Thus this underrepresentation is not only a matter of educational equity for students of color, but has significant implications for racial disparities in health care

(Grumbach et al., 2003; Martinez, Orellana, Pacheco & Carbone, 2008; Montoya, 2006; Smith, Nsiah-Kumi, Jones & Pamies, 2009; US Health and Human Services, 2009.)

Although not explicitly noted by these authors, this culturally specific framing of the problem positions students of color as individuals who have important and valuable perspectives and capital that can help address the significant problem of health care disparities. Instead of being viewed as individuals with educational deficits, such as a lack of interest in science, that need to be addressed, this allows for these students to be seen as individuals who possess knowledge that would benefit their fellow students and future patients. The view is more explicitly expressed by Yosso (2005) who asserts that students of color bring to college a valuable set of aspirational, resistant, familial, navigational and linguistic capital. Many of these forms of capital are linked to capabilities that are becoming essential in the health professions such as the ability to communicate with patients from a range of cultural backgrounds and understand the inequities in the health care system (Farmer, 2003; Finkel, 2011).

In contrast to those who are concerned about economic competitiveness, the researchers and policy makers who frame the issue in terms of health care disparities do not stop at simply calling for programs that generate additional interest in a health related profession. Their assessment of the issue acknowledges the complex nature of the problem and academic preparation necessary to succeed. One of the conclusions reached by the authors of the report, *Strategies for Improving the Diversity of the Health Professions* (Grumbach et al., 2003) is as follows:

> The problem of underrepresentation of many minority groups in the health professions is the end-result of profound disparities in educational opportunities

> and support, beginning at the earliest schooling stages. To address racial and ethnic disparities in the health professions means to confront fundamental social inequities in educational and life opportunities in the US (p. 3).

Legal scholar Margaret Montoya (2006) concurs and notes that this can only happen when the pool of medical school applicants is increased. However, affirmative action policies in medical school admissions are not sufficient. This effort must start at the early stages of the educational system and continue through high school and college. When students of color cannot make it through high school science courses and college pre-medical programs, the inequity is perpetuated. Montoya goes one step further in arguing that the educational experience itself must change and that Critical Race Theory scholars must be part of that effort and debate:

> Critical Race Theory…must find its way into the public schools. We must hold open the doors of educational opportunity, but then we must transform the classroom experience. I believe we can help create race-conscious and culture-specific curricula and pedagogy that can keep students of color in school, engage their families in education and public policy debates, and improve their chances of navigating through the system. Scholars of Critical Race Theory…with our knowledge of law, public policy, and process within a context of race, culture, and power, have a special expertise. The truncated debates going on about education and social transformation need that expertise (pp. 1309-1310).

While it is far beyond the scope of this research to examine or address all these interconnected educational issues noted by Montoya, it is my goal to contribute to this debate and knowledge base by examining the new pre-medical support program at

University on a Hill using the systemic framework of Critical Race Theory in an ethnographic case study of the program.

Research Purpose and Research Questions

Terms and definitions. I start first with a definition of some key terms that I use in the research, including in the research purpose and the research questions which follow.

Students of Color: Instead of the more frequently used term *minority* students, I use the phrase "students of color" to mean students who are marginalized in the university environment primarily based on their racial background. Many of these students are further marginalized in the university because of one or more additional factors which include: social class, language, immigration status, and educational history (E.g. urban public, vs. suburban, vs. private high school attendance, first-generation college student.) This intersectionality of racism with other forms of oppression is further discussed in the context of the theoretical framework of Critical Race Theory.

It should be noted that the term *students of color*, while less problematic than the term *minority students* is still less than ideal because it collapses a widely different set of individuals into a single category. However, at times I use this term because it is too complicated to delineate all the possible groups. Whenever possible, I refer to the students using the terms they themselves use. The students in this study are aware that they are categorized by the university as "minority students" or "students of color" and that they are further labeled as African American, Hispanic, and Asian. However they do not typically refer to themselves using these terms or the racial categories used by the university. All of the students in this study were either born in another country or their parents were born in another country. They are more likely to use their (or their parents') country of origin when they refer to their racial or ethnic status. For example students will say, "I am Dominican." or "I am from Vietnam."

Racialization: I periodically use the terms "racialized" or "racialization" which according to Omi and Winant (1994) signifies "the extension of racial meaning to a previously racially unclassified relationship, social practice or group" (p. 16) They also note that "the presence of a *system* of racial meanings and stereotypes, of racial ideology, seems to be a permanent feature of US culture" (p. 15). A related term—*reracialization*—is the attribution of a new racial meaning to an existing racial construct or constructs. For example, the term "Asian American" creates a new group and racial meaning that is different than the constructs, Vietnamese American, or Chinese American.

Bilingual students: I use the term bilingual student instead of the more common English Language Learner (ELL) or English as a Second Language (ESL) student to acknowledge the value of knowing more than one language instead of positioning English as the more valued language. These students may have differing levels of proficiency in each language.

McNair pre-medical program: As previously noted, the McNair program is a general name for one of the national college-level programs funded by the US Department of Education. McNair programs exist at over 150 college and universities where the programs may simply be referred to as the "McNair program" or the program may be given a more specialized name. At the site for this study, the university has three different programs under the McNair umbrella—each with a specialized name. To preserve the anonymity of the university where this study was conducted and to differentiate this program from the other two McNair programs, I use the term "McNair pre-medical program" instead of the program name used by the university.

Research purpose. The purpose of this research study was to understand the experiences of eight students of color and through that perspective analyze University on a Hill's pre-medical support program in the context of the larger debates and views about students of color in university science programs. The major areas of analytic focus included: Assumptions and dominant narratives about students of color in science, pedagogical approaches employed by instructors in college science classes, including the classroom environment and how those compare to approaches that students of color have experienced in their various high school settings; the role and impact on students of the academic science language in course textbooks and exams; the ways that race, class, language, and immigration status impact students in the science classes and the larger university; and the various ways university structures and practices such as financial aid policies, science course structures, and grading practices impact students of color pursuing pre-medical science courses.

I employed a critical, ethnographic case study research methodology with the principles of Critical Race Theory providing the lens to analyze the university context and make visible the role that institutional structures, policies, and practices play in perpetuating or disrupting racial inequities in science. I also used Bourdieu's (1984, 1986) theories of capital to understand the kinds of academic and linguistic capital that are privileged in a predominantly White university environment and what role that privileging plays in maintaining racialized advantages and disadvantages in science courses.

Much of the existing research on this topic includes statistical outcomes for students of color in science programs along with the perspectives of university faculty and administers, but with very little direct perspective from the students themselves. While the views of university personnel provide one perspective of the university context, the experiences and perspectives of eight students in the program are foregrounded in the research to provide a counter narrative perspective in the larger body of research. Specifically the research focused on the students' experiences in the first and second semester biology courses that have been newly developed for the program. The perspectives of these eight students were compared to and analyzed alongside those of science faculty members who were involved in the program's implementation and university administrators who support students of color at the university. These multiple perspectives provided a broad contextual understanding of the program, the university and the students along with showing how these views, structures and policies play a role in maintaining or transforming institutional inequities. In this way the study departs from many Critical Race Theory studies in education (Mayes, 2014; Mitchell, 2013; Solorzano, Ceja, & Yosso, 2001) that while valuable, tend to focus on one group in one social location instead of several.

Research questions. The main research question was: What can a Critical Race Theory perspective tell us about a predominantly White research university's program aimed at supporting students of color in pre-medical courses and the experiences of students of color in those courses? The more specific research questions were as follows:

- What are the cultural, economic and sociopolitical narratives and articulated motivations for the creation of college programs designed to retain students of color in pre-medical science programs? What kinds of racialized understandings and assumptions about students are used to formulate these programs?
- How do students of color in pre-medical college science programs make sense of their experiences, particularly in terms of the language and pedagogical practices employed in the college science courses and how do those practices compare to their earlier K-12 educational experiences?
- How do science faculty members in these programs make sense of their role and what assumptions and understandings do they have about the students' backgrounds and motivations? How do science faculty members understand the university context, especially in terms of university structures and practices, including language and pedagogical practices that reinforce or disrupt racialized advantages?
- How do university administrators who work with students of color interested in pursuing science fields make sense of students' backgrounds, motivations, and experiences in the university context? How do these university administrators understand the university context in terms of structures and practices that reinforce or disrupt racialized advantages?

Theoretical Frameworks: Critical Race Theory and Theories of Capital

Critical Race Theory. Critical Race Theory provided the primary theoretical framework through which to analyze the university context and the experiences of students of color in that context. The principles and assumptions of Critical Race Theory informed both the research design and the data analysis. Critical Race Theory scholars believe that racial analysis is required to deepen understanding of the societal barriers and inequities for people of color, as well as suggest how these barriers might be resisted and overcome. Racial analysis is the central focus of Critical Race Theory, however some Critical Race Theory scholars (Cho, Crenshaw, & McCall, 2013) also seek to understand the intersectionality of subordination for people of color, including class, gender, language, immigration status and other forms of oppression. While White students may be impacted by one or more of these other conduits of oppression such as class or gender, racism and the intersections with other forms of subordination shape the experiences of people of color very differently than Whites (Yosso, 2005).

Given the relatively recent use of Critical Race Theory in educational research, it is helpful to review the origins of the theory and the other contexts in which it has been applied. The theory grew out of work in legal studies over concern with slow progress on civil rights and social justice issues. After advances in the1950s and 1960s, progress on racial equality stalled and resistance grew to progressive racial reforms such as affirmative action. Legal scholars including Derrick Bell, Richard Delgado and Kimberlé Crenshaw began to criticize the role that the law played in the construction and continuation of racially and gender-based oppression. These individuals and other scholars worked to redefine racism as the larger, systemic, structural practices and customs that uphold and sustain oppressive group relationships, status, income, and educational attainment rather than individual acts of discrimination and prejudice (Taylor, 2009).

Gloria Ladson-Billings and William Tate (1995) brought the ideas of Critical Race Theory to the field of education and identified the parallels between laws and public policies that function to exclude people of color and educational practices that serve the same purpose. They describe some of the ways this happens within the education system as follows:

> In schooling the absolute right to exclude was demonstrated initially by denying blacks access to schooling altogether. Later it was demonstrated by the creation and maintenance of separate schools. More recently it has been demonstrated by White flight and the growing insistence on vouchers, public funding of private schools, and schools of choice. Within schools, absolute right to exclude is demonstrated by resegregation via tracking, the institution of "gifted" programs, honors programs, and advanced placement classes. So complete is this exclusion that Black students often come to the university in the role of intruders—who have been granted special permission to be there (p. 60).

Ladson-Billings and Tate argued that the use of Critical Race Theory in education could provide a cohesive theory and set of tools to examine issues of educational inequity. Since the 1995 publication of Ladson-Billings and Tate's article many more educational researchers have taken up Critical Race Theory as a way to better understand the complex issues involving race and educational inequity (Taylor, 2009).

Critical Race Theory encompasses a number of ideas, insights, and assumptions. While there are some variations depending on the particular scholar, the scholarship has a common set of themes and ideas which Taylor (2009) describes as follows:

> [Critical Race Theory] scholarship is…marked by a number of specific insights and observations, including society's acceptance of racism as ordinary, the phenomenon of Whites allowing Black progress when it also promotes their

interests (interest convergence), the importance of understanding the historic effects of European colonialism, and the preference of the experiences of oppressed peoples (narrative) over the "objective" opinions of whites (p. 4).

This first notion about racism as a normal and accepted part of American society is a fundamental starting point. One of the key approaches taken by Critical Race Theory scholars is that of making visible the institutionalized racism that is tightly intertwined with and carried out through political, legal, and educational structures and institutions (Ladson-Billings, 1998). Because this “racism is so enmeshed in the fabric of our social order it appears both normal and natural to people in this culture” (p. 11). Racial inequities in hiring, housing, criminal sentencing, education, and lending are so widespread that they are uninteresting and unconcerning to most Whites. In the context of education, this institutionalized racism permeates educational practices and structures, but goes largely unnoticed and unchallenged (Taylor, 2009). While Critical Race Theory starts from the premise that race and racism are a central and fundamental part of defining and explaining how US society functions, Critical Race Theory also “acknowledges the inextricable layers of racialized subordination based on gender, class, immigration status, surname, phenotype, accent and sexuality” (Yosso, 2005, p 73).

To fully understand and make visible the inequitable educations and educational opportunities between Whites and people of color, Critical Race Theory scholars argue there must be analysis and discussion of the historic patterns and reasons for the inequality. Without this perspective, the historic and political origins of problems such as the academic achievement gap are obscured. These are then seen as new problems, rather than the expected outcomes of intentional policies and practices (Taylor, 2009).

Historical analyses demonstrate that the interests of people of color in gaining racial equality have only been accommodated when they have converged with the interests of powerful whites (Bell, 1980). The *Brown vs. Board of Education* ruling in 1954 on school segregation in the United States is one example. Examination of the political context in which the case was argued showed that the desegregation ruling was likely motivated more by foreign policy concerns rather than concerns about equality (Bell, 1980). It was at the height of the Cold War, and technological advances with television and photography meant that the unjust racial conditions in the US were visible throughout the world. The Soviet Union, China, and India regularly carried stories about the Ku Klux Klan, including vivid pictures of lynchings, along with the living conditions of share-croppers, and prisoners (Bell, 1980; Taylor, 2009). Tied to this was a rising concern among whites about the anger of Black veterans who were returning from World War II only to face discrimination and ongoing violence. Bell (1980) notes the words of actor Paul Robeson and the impact that had on the debate:

> [The veterans] disillusionment and anger were poignantly expressed by the Black actor, Paul Robeson, who in 1949 declared: "It is unthinkable …that American Negroes would go to war on behalf of those who have oppressed us for generations… against a country [the Soviet Union] which in one generation has raised our people to the full human dignity of mankind." It is not impossible to imagine that fear of the spread of such sentiment influenced subsequent racial decisions made by the courts (pp. 524-525).

Bell and other scholars concluded that while the ruling may have had significant public relations benefit to the United States, it did little to end segregation and inequality in education. While a convergence of interests may have led to a decision with the potential for racial equality, it was not a sustainable commitment to equality. Guinier (2004) notes that the case had limited power “to promote social justice because it was shaped, not by the intentional coalescing of a transforming social movement that reached across boundaries of race and economic class, but by the calculated convergence of interests between northern liberals, southern moderates, and blacks. The resulting alliance was temporary, lacked deep populist roots, and built on a tradition of treating Black rights as expendable” (p. 94). Guinier concluded that real and lasting change must be grounded in efforts that involve a broader coalition of proponents who have equal concern about social justice for people of color.

Finally Critical Race Theory scholarship is grounded in a sense of reality that reflects and privileges the perspectives and experiences of people of color and challenges the privileged experiences of whites as the standard. According to Delgado and Stefancic (1993), "Most critical race theorists consider the majoritarian mindset—the bundle of presuppositions, received wisdom, and shared cultural understandings of persons in the dominant group—to be a principal obstacle to racial reform" (p. 161). These majoritarian narratives and claims include an embrace of color-blindness, meritocracy, and equal opportunity (Ladson-Billings, 1998; Mitchell, 2013; Solorzano & Yosso, 2001). According to Solorzano and Yosso (2001), “these traditional claims act as a camouflage for the self-interest, power, and privilege of dominant groups in US society” (pp. 472-473). Critical Race Theory scholars often use storytelling and counter narratives as a way to expose and challenge these majoritarian stories and make visible the lived experiences of people of color. Counter narratives or counter stories can also be a powerful pedagogical and research tool that allows educators and researchers to better understand the experiences of students of color.

Taken as a whole, Critical Race Theory as a framework facilitates the examination of this racism in its various iterations including the intersecting forms of oppression and the dominant narratives and claims used to explain and justify the relative educational success or failure of one group over another (Ladson-Billings, 1998; Solorzano & Yosso, 2001). In this study, while the research problem may appear to be the difficulties students of color experience in pre-medical science courses, using the lens of Critical Race Theory, these experiences must be seen in the larger institutional context of the university where affluent, US born White students are successful in these same pre-medical courses. Thus the more significant research problem becomes understanding and explaining the institutional structures and practices that advantage some groups and disadvantage others along with the explanations that either keep these patterns invisible or justify them. From this perspective, assessing this new pre-medical program at University on the Hill means understanding the ways that it either reflects or challenges these structures.

Theories of Capital. While Critical Race Theory provided a framework to understand the broader institutional structures and practices that maintain or disrupt institutional inequities, Bourdieu's Theories of Capital provided a means to understand the more granular questions of how certain kinds of academic and linguistic capital come to be the preferred, advantaged and the expected forms of capital at the university. I also used Bourdieu's (1984, 1986) theories of capital as a framework to understand what kinds of academic and linguistic capital are privileged in a predominantly White university environment and what role that privileging plays in maintaining racialized advantages and disadvantages in science courses. It should be noted that Bourdieu's work was primarily concerned with class-based power and advantage and not specific to the context of race and class in the United States. In the United States, with the long history of slavery and destruction of Native peoples, racialization was a foundational process used to secure class stratification (Harris, 1993; Omi &Winant 1994). In recounting how the racial and class stratification developed historically in the US, Harris provides the following explanation:

> The origins of property rights in the United States are rooted in racial domination. Even in the early years of the country it was not the concept of race alone that operated to oppress blacks and Indians; rather it was the *interaction* between conceptions of race and property which played a critical role in establishing and maintaining racial and economic subordination (p. 1716).

In that sense, race and class in the United States are inseparable when we think about institutionalized oppression. While this study was primarily focused on race-based disadvantages in the science courses, the intersectionality between race and class was an important aspect of the lived experience of the students included in this research and was thus part of the analysis. Combined with the insights from Critical Race Theory, Bourdieu's framework helps explain why students of color, in particular, are seen relative to their possession or lack of the preferred forms of capital at the university. This is particularly helpful in locating how racism operates in colorblind discourses (Bonilla-Silva, 2003).

Bourdieu's theories of capital have at times been misused to assert that students of color who do not succeed in academic settings need support in acquiring the preferred forms of capital. However, as Yosso (2005) notes, Bourdieu's intent was not to identify and ironically perpetuate the exaltation of preferred types of capital, but to provide a structural critique of social and cultural reproduction and explain how one class maintains power by leveraging particular kinds of capital. Further, the historical analysis that Critical Race Theory provides raises the challenging question of how a society built on racialized class stratification could transform to accommodate large populations of color who had acquired preferred forms of capital.

Bourdieu asserts a higher status in society is the result of particular kinds of social, cultural, academic and linguistic capital that is transmitted through families and schools and is recognized and rewarded by the dominant societal group. Particular kinds of academic capital are privileged in school environments and Bourdieu articulates how various forms of capital can be converted to academic capital: "Academic capital is in fact the guaranteed product of the combined effects of cultural transmission by the family and cultural transmission by the school (the efficiency of which depends on the amount of cultural capital directly inherited from the family)" (1984, p. 23). Thus the acquisition of particular kinds of academic capital is a complex outcome of both family and schooling experiences and histories.

In discussing the role of linguistic capital, Bourdieu and Passeron (1977) specifically note the long-term impact that access (or lack of access) to linguistic capital and particular patterns of linguistic habitus have on students as they progress to higher and higher levels of the education system. While their work was focused primarily on class differences in students, the intertwining of race and class in the United States allows their theories to be a helpful tool in understanding the science language challenges that experienced by the students in this study. Particularly relevant is Bourdieu and Passeron's notion of linguistic habitus which they define as a class-linked relationship to language. For upper-class students this is a familiarity and cultivation of "abstraction, formalism, intellectualism, and euphemistic moderation" (p. 116). This adeptness with particular types of language puts these students at an advantage in academic settings and—specific to this study—in working with the kind of abstract and complex language of school science. In contrast, according to Bourdieu and Passeron, the linguistic habitus of working-class students tends towards "expressionism, moving from particular case to particular case, from illustration to parable, or shunning the bombast of fine words" (p. 116). This different use of language, while not of lesser value, is less valued by the upper-classes and less rewarded in academic settings. The further students move up in the education system, the more significant the impact of these linguistic differences in terms of blocking some students and favoring others. Bourdieu and Passeron note that this blocking effect was particularly severe in science and engineering fields. In relation to the requirements and structure of college science courses, Bourdieu and Passeron's work suggests academic success under the current model of science education is in part dependent on students possessing particular types of social, cultural, and academic capital, including linguistic capital and various ways of learning and using language that are valued and rewarded in college science courses.

In an example of how capital translates into science performance, Adamuti-Trache and Andres (2008) drew on Bourdieu's work to demonstrate how the intersection between organizational structures (institutional and disciplinary) and capital either limits or enhances access in scientific fields. Students with college educated parents are more likely to understand the importance of taking rigorous science courses in high school and parents are also able to help students locate resources needed to succeed in these courses in high school and college. Students without this form of cultural capital are at a disadvantage in mastering the ways of learning that are privileged in college science courses.

Bourdieu's framework also helps put societally advantaged forms of capital in the context of other forms of capital that students of color might possess and which might be used to challenge oppressive practices in both science and medical education and imagine other possibilities. For example, one of the current challenges in medical education is helping doctors and nurses to be more culturally aware and competent as they interact with culturally and racially diverse patient populations (Finkel, 2011). Students of color may possess non-dominant forms of linguistic and cultural capital (Dixon-Román, 2014; Yosso, 2005) that enable them to provide better care to these varied communities and to be a source of knowledge for their peers. Other researchers (Moje et al., 2004; Moll, Amanti, & Gonzalez, 2005) have also discussed the ways that non-dominant forms of capital have been leveraged by marginalized youth in both academic contexts and other settings. Dixon-Román (2014) further argues that the often overlooked and discounted cultural repertoires of marginalized communities can provide youth valuable experiences and capabilities. These researchers make a case that the various educational programs that aim to help these youth must recognize and leverage these non-dominant forms of capital knowledge.

CHAPTER TWO: Research and Literature Related to Students of Color in College Science Programs

Very little of the research on student outcomes in college science focuses specifically on students of color or examines the reasons for the disparities in science degree completion between students of color and White students. Much of the research on science education focuses on discrete topics and interventions such as science interest, high school course work, and teaching approaches, but does not examine the institutional factors that privilege one group of students and disadvantage others.

While the findings may in part apply to students of color, the researchers do not identify whether the outcomes vary by race, income level, or language background. Often overlooked as well are the wide variations in secondary school experiences for students in the United States and the different language, class, and cultural backgrounds students bring to college. Viewing these research approaches through the lens of Critical Race Theory reveals the assumptions made by researchers about students and the systems of education in the United States. The research generally assumes a “normal” student where normality equates with whiteness (Leonardo, 2007). Further, the research is most often informed by a meritocratic view of the education system where students, regardless of race, language status, or income have equal opportunity to succeed.

While there is a relatively small body of research directly related to this proposed research study, it is of value to examine the research in related areas as it may inform the proposed study approach along with illustrating the ways the issue has been characterized and researched in the past. This proposed study may also suggest ways that future research on science outcomes for students of color might account for and analyze the racialized contexts in which schooling takes place in the United States.

What follows is a review of the key areas of research related to science outcomes for students of color. These include the role of middle and high school preparation, the language components of science and science education, the nature of college science courses, and finally the specific research on students of color in college science. This review is not a comprehensive recounting of all the research in each of these areas, but instead I have identified the most frequently cited studies, authors and research trends in each of these areas.

The Role of Middle and High School Experiences in College Science Outcomes

One area of focus for researchers has been on the correlations between particular middle and high school experiences and outcomes in college science. Most of this work is statistical and relies on the use of data from surveys or from high school and college transcripts. One frequently used data set is the US Department of Education's National Educational Longitudinal Study of 1988 or NELS 88/2000. The website for the National Center for Education Statistics (2013) describes the study as follows:

> A nationally representative sample of eighth-graders were first surveyed in the spring of 1988. A sample of these respondents were then resurveyed through four follow-ups in 1990, 1992, 1994, and 2000. On the questionnaire, students reported on a range of topics including: school, work, and home experiences; educational resources and support; the role in education of their parents and peers; neighborhood characteristics; educational and occupational aspirations; and other student perceptions…. For the three in-school waves of data collection (when

> most were eighth-graders, sophomores, or seniors), achievement tests in reading, social studies, mathematics and science were administered in addition to the student questionnaire.[6]

It should be noted that the survey relies on students' self-reported data on race. There is no direct question in the survey about income level or socioeconomic status. Instead questions are asked regarding parents' occupation, employment status, level of education and the available resources in a student's home. Presumably any conclusions about socioeconomic status would need to be derived from these other questions.

As was noted in Chapter One, the focus on getting students interested in science is a prominent theme in efforts to increase the number of students of color pursuing science degrees. Many of the policy documents making this recommendation cite a study by Tai, Liu, Maltese and Fan (2006). The authors of the study, using the NELS 88/2000 data set identified a link between middle school interest in science and college science outcomes. In this widely cited study published in the journal *Science*—one of the key journals for the reporting of scientific research—the researchers found that eighth grade students who believed they would have a career in science by age 30 were more likely to graduate from college with a science degree. Survey results from 3000 participants were examined and the researchers found a strong correlation between science career interest at eighth grade and obtaining a bachelor's level science degree. In contrast, the students' eighth grade mathematics achievement scores[7] were not predictors of eventual science degree attainment. In fact the researchers note the following: "An average mathematics achiever with a science-related career expectation has a higher probability of earning a

[6] National Educational Longitudinal Study of 1988. See: http://nces.ed.gov/surveys/nels88/
[7] Science achievement scores are not collected in the NELS survey, thus math scores were used as a proxy for possible science related achievement.

baccalaureate degree in the physical sciences or engineering than a high mathematics achiever with a non-science career expectation, 34 percent versus 19 percent" (p. 1144). Based on these findings, the researchers argue that more resources should be focused on encouraging interest in and exposure to science during middle school and continued into high school.

In a subsequent study using the same NELS data set, two of the same researchers, Maltese and Tai (2011) found similar patterns between high school students' science interest and the likelihood of graduating with a college science degree. Students who indicated in twelfth grade that they would pursue a science career were more likely to complete a college science degree. This factor was more important than the number and level of science courses that the students had taken. Based on these findings, Maltese and Tai suggest that the push to get more low-income students to take rigorous math and science courses is misguided and instead argue for a focus on building science interest:

> The results of this study indicate that such a focus on proficiency will not necessarily yield an increase in the number of students pursuing science and mathematics beyond high school. Focusing attention on increasing student interest in science and mathematics and demonstrating to students the utility of these subjects in their current and future roles may pay greater dividends in building the STEM workforce (p. 900).

While the authors of both the middle school (Tai, Liu, Maltese, & Fan, 2006) and high school (Maltese & Tai, 2011) studies reference low-income students in their conclusions, there is no discussion in the research about if and how income (or race) play a role in these college science outcomes. In other words, the studies do not indicate whether these middle school and high school interests in science are associated with college science completion specifically for low-income students and students of color. Further, because these studies are only examining correlations, they provide little insight into the more complex causal factors involving race, income level, language and home environment that might shed light on how a student goes from being interested in science to graduating with a science degree.

In contrast to Maltese and Tai's (2011) assertions about high school interest being more important than high school preparation, other research does suggest a link between high school course work and college science outcomes. Studies examining students' high school preparation and persistence in college science fields suggest that students who have not taken enough rigorous high school courses in math, science and English will have difficulty with college science course work (Adelman, 1999, 2006; Horn, Kojaku & Carroll, 2001; National Academies, 2007, 2010).

Adelman's work (1999, 2006) is widely cited in other research that examines links between high school coursework and college completion. Both of Adelman's studies use the NELS 88/2000 data. In addition, Adelman included an analysis of high school and college transcripts that are part of the NELS data set to determine the type and number of courses taken and the college outcomes.

Adelman's 1999 study did not specifically analyze college science outcomes, but in the 2006 study he expanded the analysis to determine what kind of high school coursework would provide sufficient momentum to complete a college science degree. The data suggest that math coursework at a level beyond Algebra 2, and three or more

Carnegie[8] units in core laboratory science (p. 184) were key factors in determining if students would complete a college science degree. In the study, the importance of taking four years of English is linked to the likelihood of graduating from college, but this variable is not mentioned in the college science momentum measurements.

There is little discussion in Adelman's work on the differences in high school quality, but he does acknowledge that the rigor and quality of courses will differ across schools because differences in parental expectations, higher quality teachers, and financial resources will likely result in more or less rigorous and comprehensive curriculums. Adelman contends that "race/ethnicity [are not] significant in the logistic narrative" and that "of student demographic characteristics, only one—socioeconomic status—was significantly associated with degree completion, though in a modest manner" (p. xxxiii). Even while noting the importance of socioeconomic status, he argues that this disadvantage can be overcome with the implementation of a rigorous curriculum.

Adelman (2006) concludes his study by encouraging "all high schools to offer the requisite curricula, to make sure they have teachers who can deliver that curricula, to believe that their students can all reach higher levels of academic intensity in preparation" (p. 26). However, his suggestion seems overly simplistic and overlooks the significant structural inequities between urban and suburban schools and the historical circumstances that result in low-income and students of color being concentrated in urban neighborhoods and school with fewer resources. Beyond urging schools and policy makers to insure all students have access to a rigorous high school curriculum, Adelman includes little analysis or discussion of the complex factors in educational achievement

[8] Adelman (2006) explains that a Carnegie unit is the basic credit system for U.S. secondary schools and notes that it is generally recognized as representing a full year (36–40 weeks) in a specific class meeting four or five times per week for 40 - 50 minutes per class session (p. 27).

involving race and income along with the longstanding structural practices that explain why some schools have rigorous curriculums and others do not (Ladson-Billings, 2006). The implication is that as long as students have access to a rigorous curriculum, these other factors are not relevant.

Other studies (Sadler & Tai, 2001; Tai, Sadler & Loehr, 2005) have looked more specifically at the impact of different pedagogical approaches in high school science courses. They found that particular high school pedagogical experiences were linked with high levels of performance in college science courses. The researchers found support for science courses that: (1) value understanding over coverage; (2) involve students in collaborative activities; (3) emphasize the quantitative over the qualitative; and (4) allow room for scientific discovery. A point emphasized in both studies was that students were more successful in college when their high school teachers concentrated on fewer concepts and covered less material, but in greater depth. The type of course (regular, honors, or AP) was not as important as these specific pedagogical variables.

However, the researchers did specifically note that Advanced Placement (AP) science courses are often designed counter to these principles because they push instructors to emphasize breath rather than depth and leave no time for inquiry activities. The AP Biology course in particular has been criticized as being “a mile wide and an inch deep” (Wood, 2009, p. 1627) because the course creators have attempted to cover the wide range and growing body of biology knowledge. There is a growing call to make the AP Biology course more inquiry-based with student centered activities and a focus on concepts (Wood, 2009).

What these researchers do not examine or consider are differences in students' race, social class and home experiences and how school practices may either reinforce or conflict with students' out of school experiences. These more in-depth, inquiry-oriented science teaching approaches that the researchers advocate in many ways parallel the science type activities that students from White, upper middle class families are exposed to at home. Middle class parents are more likely to augment their children's educational experiences through visits to science museums, exposure to science news, engage students in discussions about science and encourage students to engage in scientific experiments which supports both process-based ways of 'doing science' as well building more contact time with the science content that is found in schools. Lareau (2003, 2011) terms this kind of middle class parental intervention as "concerted cultivation" and she notes that these class-related differences in home environments and parenting have an impact on students' success in schooling. Thus it is possible that these inquiry approaches to science result in better college science outcomes because they are consistent with and reinforced by home experiences. Or it is also possible that students' home related science experiences are the main factor in college science success. In essence, the research does not tell us whether using these inquiry-oriented approaches with students of color will have the same impact on college science success. Yet, this push for inquiry-based science teaching is prevalent in the research and policy literature.

While these various findings linking high school and college science outcomes point to factors that correlate with success in college science courses, there is little analysis of why certain factors translate into college science success and whether the findings apply equally to all students. Further, the assumption in these various studies is that the problem resides with individual students or the school curriculum and simply adding more or different academic preparation will enable students to be more successful in college science. Implicit in these arguments is a meritocratic view of education where all students have equal opportunity to succeed (McNamee & Miller, 2004). There is little mention in the studies of inequitable access to science courses and experienced science teachers between lower SES schools and higher SES schools or of the different cultural and language backgrounds students bring to college or even of the college environment.

Tate (2001) however, notes that there is significant evidence that students of color, who are more likely to be concentrated in urban schools, have both lesser quantity and quality of science instruction compared to suburban students. Tate attributes this difference to several factors including the disproportionate time focused on high stakes testing preparation, the tracking of students of color into lower-level math and science courses, limited advanced level course offerings, and a shortage of qualified and experienced science teachers in urban schools. While all these structural problems have a sizable impact, the focus on high-stakes assessments has an impact on both the time and quality of science education. Tate gives one example of the complex impact of assessment:

> First, many students are subjected to instruction largely based on test preparation activities rather than on a coherent implemented curriculum. Second, many teachers do not have the time necessary to teach more advanced concepts, so for the bulk of their instruction they review low-level, decontextualized skills… This practice has serious implications for student proficiency and achievement in school science. First, high-stakes accountability examinations in mathematics

> (and reading) create a culture that inhibits allocating time to science. Schools become places where test preparation is the mission of the education process (p. 1021).

These findings are echoed in other studies examining the inequities between urban and suburban schools. Darling-Hammond (2004) notes that there are dramatically different learning opportunities between the poorest and wealthiest schools which result from disparities in qualified teachers, materials including textbooks, high quality and engaging curricula and small classes. Further the push for standards and accountability, with subsequent sanctions if the goals are not met results in more focus on test results and test preparation. Ladson-Billings (2006) put these inequities more explicitly in a racialized context and notes the complex historical, economic and sociopolitical factors that result in students of color being located in schools with less funding and, particular educational practices and less equitable different educational outcomes. Addressing and altering these many institutional practices and inequities is a complex challenge that is inadequately addressed and unusually not acknowledged by the studies that attempt to identify the correlations between K-12 educational practices and outcomes in college science.

Language and Science Learning

Many of the students this research is concerned with are bilingual[9] immigrant students and students whose schooling and home did not privilege academic English. One of the findings from the pilot study (De Rosa, 2013) was that bilingual students in the college biology course faced reading comprehension challenges with the science

[9] I use the term bilingual student vs. English Language Learner (ELL) to acknowledge the value of knowing more than one language instead of positioning English as the more valued language.

textbook and challenges with both the reading and writing elements on the science exams. However, the science teachers had not considered the language elements of the science course as something they should address in their teaching approaches or in the construction of the exams. Further, the teachers were unaware that English was not a first language for many of these students because the students' oral language skills were very strong.

While language proficiency plays a role in learning across all disciplines, the language challenges are compounded in science learning because academic science language carries within it particular abstract concepts and ways of viewing the world that are not found in other academic areas. Halliday and Martin (1993) and Schleppegrell (2004) note the distinctly different nature of science language and text structures. Nominalizations such as *photosynthesis* and *dephosphorylation* that convey a complex scientific process in a single word are particularly common to science (Schleppegrell, 2004). For students, nominalizations demand both an understanding of the nested scientific processes contained within the noun and a grammatical knowledge of how these syntactical structures allow for densely constructed clauses and sentences.

This specialized language of science developed historically to enable a consistent presentation of scientific knowledge and argument (Halliday, 2004). While the nature of the science language and genres can be explained from a functional perspective of the grammar involved, the language still presents a linguistic challenge to readers whose home or school backgrounds have not privileged this type of language use (Bernstein 1990). Despite this particular challenge involving science and language, there is often a lack of acknowledgement by educators regarding the central role that language actually plays in science education and learning.

Yore, Bisanz and Hand (2003) underscore this point in a comprehensive review of the K-12 literature on the intersections of science and language. They note that in the United States there has been a push for both science literacy standards and English language arts standards, but little connection between the two efforts. The science standards are relatively silent on the specific roles of reading and writing in science education while the English language arts standards make little mention of the language demands of science discourse and the role language plays in science learning. They argue that the language component of science must be given more attention:

> Language is an integral part of science and science literacy – language is a means to doing science and to constructing science understandings; language is also an end in that it is used to communicate about inquiries, procedures, and science understandings to other people so that they can make informed decisions and take informed actions. The over-emphasis on formulae in school science suggests to most people that mathematics is the language of science; but when the vision is expanded to include authentic science in research, applied and public awareness settings, it becomes apparent that mathematics is not the exclusive language system across all science domains. Rather, spoken and written language is the symbol system most often used by scientists to construct, describe, and present science claims and arguments (p. 691).

In the research literature on K-12 science education, the attention paid to the role of language in science has shifted over time. Yore et al., (2003) note that before 1978, researchers had a narrow view of the links between language and science learning. Researchers who focused on science learning either took a "behaviorist or a logico-mathematical perspective in which speaking, listening, reading, and writing were ignored or portrayed as unidirectional processes: speaker to listener, text to reader, or memory to text" (p. 689). From the late 1970s to the early 1990s, there was an increased realization about the role of language in science and more attention was focused on the role of oral discourse, reading and writing in science learning. During this time period, many research studies were undertaken to understand the links between science learning and reading, writing and oral language discourse. One common recommendation from the various studies was that teachers must deliberately engage in science reading and writing activities to help students master the language needed for science and to learn the science.

Despite the importance of language in science learning, since the early 1990s, the focus has shifted to more inquiry approaches to science driven in part—at least in the US—by the National Research Council's science education standards (Yore et al., 2003). The National Science Education Standards (National Research Council, 1996, 2011) recommend that science be taught as an active inquiry process where students "ask questions, construct explanations, test those explanations against current scientific knowledge" (1996, p. 2). Yore et al., (2003) argue that what is frequently lost in this inquiry-focus is the critical role that language and argument play in the construction of science knowledge and science learning. While inquiry activities may help students understand concepts at a broad level, these activities alone are insufficient to link to and build on the previous ideas of science, in part because the body of past science knowledge is most often in written form. Further they do not help students become adept at the use of more abstract scientific language that makes up most written scientific texts.

There is some focus on language in these inquiry approaches, but the emphasis is on oral language interactions and may not go beyond students discussing science concepts using more vernacular oral language. This transition to the more abstract and conceptual formal science language has to be explicitly encouraged and practiced so that students can become fluent in this specialized type of abstract discourse (Brown, Ryoo, & Rodriguez , 2010).

This ability to use specialized science language is another area where differences in family and home environments may have unequal impacts on students' school experiences. Lareau (2003, 2011) notes that the ability to use language instrumentally is an important class-based advantage. The daily language interactions between parents and children in middle and upper middle class homes is part of the "concerted cultivation" undertaken by parents that prepares their children for school. An adeptness with abstract and conceptual scientific language may be honed by these home language interactions. Middle class students would not be disadvantaged by the lack of language focus in school science activities. In contrast, students without access to these kinds of home language interactions would have no other means to make the transition to this kind of formal science language and thus would be more negatively impacted by an inquiry-focused science approach.

In spite of the more recent shift in focus to inquiry-oriented approaches, Yore, Hand, Goldman, Hildebrand, Osborne, Treagust and Wallace (2004) identified some promising approaches that attempt to enhance inquiry approaches with more attention to science reading and writing. In terms of reading activities, Yore et al. (2004) advocate for helping students take a critical stance when reading science textbooks that is similar to what scientist do while reviewing articles in their field. While scientists engage in a process of developing and testing new theories and ideas that continually challenge existing canonical knowledge, school textbooks often present science knowledge as something fixed and absolute. A more critical reading approach requires that students engage in a similar process. Yore et al. (2004) describe this critical reading approach as follows:

> Scientists read articles in their fields from a critical stance in which new information is analyzed, evaluated, and, if deemed trustworthy, synthesized with what is already known. Scientists interpret the validity and certainty of knowledge claims by contextualizing them in their sociohistorical context. That is, new knowledge claims need to be related to previous knowledge claims while taking into account the researchers, their biases, the hedging language used, and the circumstances under which the claims were established...If inconsistencies among canonical ideas, evidence, and knowledge claims are detected, scientists typically work to resolve them—a process that often results in deeper understanding of the scientific phenomenon (p. 349).

The researchers assert that if teachers can help students engage in this critical approach to reading science it will improve reading comprehension, but more importantly it will “shift the pedagogical culture [of science education] away from authoritarian sociointellectual discourse that emphasizes abstract knowledge separated from societal issues” (p. 347). They do note that this is an area where more research is needed to determine the pedagogical approaches that would assist teachers and students to engage in this practice of science reading. While not explicitly noted by these researchers, their arguments suggest a distinct difference between the real world discourse used by scientists and the school science language of textbooks where the knowledge is presented as more absolute or hegemonic.

The research also shows that writing activities in science are a way to improve students' conceptual understanding and cognitive processing of scientific concepts (Mason & Boscolo, 2000). Before students can write about a particular science concept they must mentally organize and synthesize their knowledge. This recursive process of moving between mental constructs and writing can help deepen and transform their understanding of concepts (Keys, 1999). While these writing to learn activities can develop and deepen understanding of science concepts, teachers must carefully define the pedagogic purpose of these types of assignments, craft the activity, and explicitly communicate these goals to students (Yore et al., 2004). McNeill and Krajcik (2012) emphasize the importance and value in explicitly teaching students the language of scientific argument. Brisk (2014) argues that by teaching students how to write the different scientific genres such as procedures and explanations students become more adept with the specialized science language features.

Hildebrand (1998, 2001) advocates for different forms of science writing ranging from anthropomorphic approaches to first person imaginative or poetic writing about science. For example, students might be given the following anthropomorphic narrative: "Imagine you are a water molecule: Describe five changes of state that you have recently experienced" (1998, p. 347). The goal with these hybrid forms of science writing assignments is to engage students who have been marginalized or discouraged by the formal and often absolute nature of science language as it is used in school contexts.

Science Language Barriers for Bilingual Learners

As noted earlier, concern about the language and science challenges for bilingual students is one focus of this proposed research. In their extensive review of the science education literature and research trends, Yore et al., (2003) make a strong argument for the central role of a language focus in science learning, but they do not include any review of the research on bilingual students and science language. Further, with the exception of their mention of Hildebrand, there is little focus on students who might be disadvantaged by the language of school science. While the push for more focus on the language components of science may help bilingual students, the topic is not addressed in their review of the literature.

Other researchers have examined the particular language challenges that bilingual students in grades K-12 may have with science and the educational policies and practices that further these difficulties. One area of research focus has been on the science language challenges faced by immigrant students entering the US educational system in the middle or secondary school years. In middle and secondary settings, there are often fewer supports to learn academic English and the subject matter in science classes becomes increasingly complex (Lee, 2005). In states like Massachusetts, where English-only instruction is the legally mandated practice, bilingual immigrant students do not have the opportunity to continue learning science content in their first language (de Jong, 2008). Even if students enter the US educational system with grade-level science knowledge, they can easily fall behind with the science as they struggle to learn scientific concepts in a new language (Lee, 2005).

The challenge, according to Lee and Fradd (1998) is to find a balance that makes academic content accessible, meaningful, and employs practices that can more effectively help these students learn science language. In a review of the research literature on science education for bilingual students, Lee (2005) concluded that science instruction has generally failed to help bilingual students learn science in ways that are meaningful and relevant to them, while also failing to help them develop proficiency in oral and written English. Lee advocates for hands-on, inquiry-based approaches to science instruction which helps bilingual students learn scientific concepts more actively than textbook-based instruction because the activities are less dependent on formal mastery of the language of instruction, thus reducing the linguistic burden on bilingual students. Further, an inquiry approach allows for collaborative, small-group work that provides structured opportunities for developing oral English proficiency in the context of authentic communication about science (p. 515).

Other researchers, however, have criticized these inquiry approaches for bilingual learners because they do not focus enough attention on the language aspects of science. Fang (2004, 2006) suggests that while an inquiry approach may facilitate learning of scientific concepts, it downplays the significant cognitive task of helping students master the scientific language needed for reading and writing science. Other researchers (Fang & Schleppegrell, 2008; Schleppegrell, 2004) have also noted the particular challenges posed by the language in science textbooks which tends to be highly abstract and full of nominalizations, complex vocabulary and lexically dense sentences. In many cases a single vocabulary term will stand in for a complex scientific process or concept. For bilingual students faced with science textbooks or reading materials of this nature, an inquiry approach alone will not provide them with the resources and skills needed to learn from these texts. In this context, helping students learn the specialized vocabulary and language structures of science is synonymous with helping them learn science; accordingly, students must have tools and strategies to unpack these information-dense science textbooks. Further detail on college science textbooks is provided in the subsequent section, but researchers have noted that these college textbooks are particularly problematic in terms of their structure and reliance on overly complex scientific language.

While there is some disagreement on the best way to help bilingual and other racially and culturally diverse students with science language—whether through an inquiry approach, the use of more vernacular language, or through more direct approaches to deconstructing and understanding science language—the common theme is that the language of science is a barrier for particular groups. This is Hildebrand's point in discussing the hegemonic nature of science and science language when she recommends more personal and anthropocentric science writing approaches. Martin and Rose (2008) note that access to these scientific discourses has been used as a way to maintain a stratified social structure and to control the means of production in industrial capitalism:

> The scientific construal is currently the exclusive property of the socioeconomic classes which most benefit most from the system, and its version of reality reflects

> the structures of institutional roles which members of these classes occupy in the course of making their living and negotiating power (p. 228).

Martin and Rose (2008) and others (Brisk, 2014; Halliday, 2004; Schleppegrell, 2004; Veel, 1997) argue that explicitly teaching these scientific genres is a way to ensure more students have access to this power.

Hildebrand (1998) agrees that “we ought to explicitly deconstruct and teach each genre that we expect students to use and control” (p. 352) including the more formal language of school science. However, she also advocates for ways to disrupt and counter the absolute nature of science language and asserts that these approaches can provide students a scaffold to the formal language of science. She argues for what she terms an “enabling pedagogy” that both gives students access to science discourse and also enables them to critique and challenge science and its impact on society and their own lives (p. 354).

Moore (2007), while not specifically concerned with bilingual students, examines this gatekeeping nature of science language and how it impedes science learning for some students. In a study of high school science teachers who worked with students of color, Moore concluded the uses of science language reveal how the power structures of both language and science are linked and have different impacts along race, ethnicity, gender, and language dimensions. The teachers did not see science language as having distinct features, structures, and purposes that developed as a specialized discourse in order to express scientific – often abstract – knowledge. This further maintained the gatekeeping nature of language in science learning. Moore’s recommendation is that teachers must explicitly help students understand the nature of science language and how it developed while also incorporating the use of less formal science discourses. Like Hildebrand, Moore argues this approach has the potential to break down the gatekeeping nature of science language and affirm the value of the many discourses of science:

> Teachers have to be explicit in their teaching and pointing out to students that there are varied ways of knowing, doing, writing, communicating, and engaging in science… As teachers provide opportunities for students to engage in discourses, they, at the same time, educate students to the culture of power and the culture of language inherent in these ways of knowing. How to bridge multiple worlds of language and discourses is the challenge for science educators in assisting classroom teachers in taking on this task (p. 340).

bell hooks (1994), while not specifically addressing the issues of science language, further reinforces this point about the value of different positions and discourses. She states that "marginality is more than a site of deprivation….it is also the site of radical possibility [because] it offers the possibility of radical perspective from which to see and create" (p. 341). In a science context, this suggests students who occupy this "marginalized" position have the potential to contribute in powerful ways if their capabilities are recognized and valued rather than seen as deficits.

Research on College Science Instruction

In the K-12 education literature there is a relatively rich discussion—and debate—on the role of both language and inquiry approaches in science learning. However, in the research on college science teaching, the approaches are quite narrowly focused on inquiry and active-learning pedagogies with little mention of the role of language in science learning. Further, compared to the K-12 literature, there is even less focus on any difference in schooling, language or culture that students bring to college. The assumption seems to be that improvements to college science teaching will be equally beneficial to all college students—or stated another way that all college students are similar. Even when research articles suggest there might be acknowledgement of differences in students, that turns out not to be the case. For example the title of one article, "Transforming Undergraduate Biology Education for All Students: An Action Plan for the Twenty-First Century" (Woodin, Allen & Smith, 2009) suggests there might be some focus on students from different backgrounds. However, a closer examination reveals the authors want science educators to focus on students in both science and non-science majors.

A focus on science interest. Much of the college science research is focused on increasing student interest and engagement in courses and in improving the methods of assessing student learning. In another article published in the influential journal *Science,* Handelsman et al. (2004) contrast the more desired approach with the dominant approach to teaching college science:

> Active participation in lectures and discovery-based laboratories helps students develop the habits of mind that drive science. However, most introductory courses rely on "transmission-of-information" lectures and "cookbook" laboratory exercises—techniques that are not highly effective in fostering conceptual understanding of scientific reasoning. There is mounting evidence that supplementing or replacing lectures with active learning strategies and engaging students in discovery and scientific process improves learning and knowledge retention (p. 521).

One of the groups actively working to foster this approach to college science teaching is the Howard Hughes Medical Institute (2013). Next to the National Science Foundation, Howard Hughes Medical Institute (HHMI) is the largest funding provider of grants focused on college science teaching (Stokstad, 2001). In addition to research grants, they also provide workshops and training for college science teachers and advocate in scientific journals for inquiry-based and active learning college instruction. One of the approaches endorsed by HHMI is based on Bloom's taxonomy of cognitive domains (Bloom, Krathwohl & Masia, 1956). The goal of this active-learning pedagogy is to help students synthesize and apply science knowledge rather than just memorize factual information. The developers of the approach assert it can help instructors both teach and create assessments to encourage these higher levels of knowledge (Crowe, Dirks, & Wenderoth, 2008; Handelsman, Miller, & Pfund, 2007). In applying these ideas to a college biology course, an example of a lower order cognitive skill would be something like defining what is meant by a cell signaling pathway. An example of a higher order cognitive skill would be to design or critique an experiment involving a cell signaling pathway (Crowe et al., 2008). The approach encourages instructors to teach and assess these higher order cognitive skills and there are suggestions for individual students to work in group activities that can be used in class. For example, one of the suggested group activities is, "Work together to analyze and interpret data in primary literature or a textbook without reading the author's interpretation and defend your analysis to your peers" (p. 373). According to the researchers, findings from implementations of these approaches show that students improved in their ability to answer higher order questions (Crowe, Dirks, & Wenderoth, 2008; Handelsman, Miller, & Pfund, 2007). What the research does not discuss or address in any manner is how and for what populations these inquiry approaches might lead to better outcomes in college science courses. For example, will they help bilingual students, students from urban schools or other underserved students?

The other dilemma with these approaches is that most college science course do not employ this pedagogy and the research does not address what happens when students taught with these approaches go on to other science courses taught in the more traditional manner. Handelsman et al. (2004) note that despite much agreement that college science teaching should involve "active learning strategies to engage students in the process of science….change has not progressed rapidly nor been driven by the research universities as a collective force" (p 521). DeHann (2005) makes a similar point:

> There is substantial evidence that scientific teaching in the sciences, i.e. teaching that employs instructional strategies that encourage undergraduates to become actively engaged in their own learning, can produce levels of understanding, retention and transfer of knowledge that are greater than those resulting from traditional lecture/lab classes. But widespread acceptance by university faculty of new pedagogies and curricular materials still lies in the future (p. 253).

This uneven implementation of science teaching approaches has several possible impacts on students. It is possible that students exposed to this active-learning approach in one course will benefit and be able to apply the approach to a more traditional textbook and lecture-based course. It is also possible that students may be disadvantaged in later more traditional courses, especially if they do not possess the language skills to learn from the textbook.

Other research confirms that most introductory college science courses rely on this knowledge transmission model. A survey of 55 colleges (Lawrenz, Huffman & Appeldoorn, 2005) found that in most introductory college science courses, students are expected to read a textbook, attend large lecture classes and quickly master a significant volume of content. Further, most college science labs are not connected to or intended to reinforce course content. Lawrenz, Huffman and Appeldoorn (2005) attribute this lack of innovative instructional models to several factors. First, they note there is a lack of a shared vision of what constitutes excellence in teaching that is tied to a lack of knowledge about the National Science Education Standards (National Research Council, 1996): "Dissemination of these standards has focused more on grades K-12, although they are relevant for grades K-16. Lack of awareness of the standards may also be related to the lower occurrence of innovative instructional approaches" (p. 44). They also note that there are several institutional barriers that prevent changes to college science courses. These involve budget decisions and priorities that result in very large science classes, lack of funding for lab materials, and requirements to cover large amounts of material in a single course.

The challenges of science textbooks. Regardless of the reasons for this approach to college science instruction it means success in most college science courses is in large part dependent on a student's ability to learn from a science textbook and lectures that largely replicate material from the textbook. This puts the textbooks and language at the center of the learning process and potentially disadvantages students who have less experience with these textbooks and students who are still learning English. As noted earlier, the language in science textbooks tends to be highly abstract, full of nominalizations, complex vocabulary and lexically dense sentences (Fang & Schleppengrell, 2008; Schleppengrell, 2004). Whether intentional or not on the part of college science programs, this practice of relying on textbooks serves as a weeding-out mechanism as it advantages some students and disadvantages others.

The college science textbooks on which students must rely have been singled out by several researchers as being particularly problematic in terms of the ideologies they reflect and the reading comprehension challenges they pose. Most college science textbooks work from particular cultural models with content more aligned with the experiences of White, male suburban students rather than the backgrounds of women, students of color and urban students (Gainen, 1995; Spanier, 1992). For example, many of the geology and ecology topics in textbooks have little focus on urban environments that students in urban schools would have encountered in their day-to-day lives (Fusco, 2001).

Beyond these substantial issues, an analysis of college science textbooks shows that most cover too many topics, use difficult vocabulary, make no attempt to link to students' background knowledge, and lack logical structures that develop concepts and relate them in a systematic way. The knowledge claims presented in the texts are often disconnected from the process of how knowledge is created in science through intuition, discovery, supposition, and argument (Goldman, 2000; Goldman & Bisanz, 2002). While these characteristics make the reading comprehension a challenge for all students, the impact on bilingual students is even more significant because the cognitive challenges are increased (Gainen, 1995; Goldman & Saul, 1994; Nassaji, 2002).

Ironically, even though the textbooks play a central role in college science courses and present many challenges to students, college science instructors are even less likely than high school teachers to provide students with science reading and writing strategies (Goldman & Bisanz, 2002). The researchers speculate this is because scientists are not explicitly aware of how they gained their own science discourse skills and critical stance to science reading. Goldman and Bisanz (2002) also argue that these issues with the textbooks have, in part, been what led to calls for inquiry and active learning strategies:

> Because [college textbooks] have so distorted the epistemology of science, scientists have tended to advocate for students to be more actively engaged in experimentation and demonstrations. However, in emphasizing the "doing" of science, science educators have tended to downplay the multiple ways in which reading and writing are involved in doing science (p. 45).

While researchers like Goldman and Bisanz (2002) and Goldman and Saul (1994) are calling attention to the importance of these science reading and writing issues in college science classes, their views are in the minority and are not taken up or discussed by influential groups like the National Academies which develop science education policies or the journal *Science* which frequently covers science education issues.

Students of Color in College Science Programs

A small body of research has begun to focus specifically on the challenges students of color face in introductory college science courses, however even these studies include little focus on the language challenges of the science courses. The focus is more on the social and psychological challenges posed by science courses rather than the particular learning and cognitive challenges. Tobias (1990) was one of the first researchers to examine the nature of college science courses and how these characteristics might discourage students of color from pursuing science. She found that the introductory science courses had several characteristics that could be problematic to women and students of color. First, many of the college science teachers expected students to already be committed to the subject and the instructors made little effort to make the material relevant or engaging. The competitive nature of the courses, with most courses and exams being graded on a curve prevented any sort of peer group or community formation in the class. At research universities students perceived this type of grading system as a way to push them out of science majors. Tobias points out that this "weeding out" does not happen as frequently at four year liberal arts colleges. She concludes this is because the science departments at small schools, rather than teaching introductory class that function as service courses for other majors, have a vested interested in retaining students in the particular department major. In addition, the classes are smaller and the instructors more accessible. The other problem Tobias identified was teaching and lab assistants were hired because of their science knowledge, but had limited abilities to teach and engage students. All of these factors together made for courses that were good at teaching students who were already inclined and prepared to tolerate the competitive and less then engaging science course. However, the courses did little to engage or encourage students who might not have the same background or intention to pursue science.

More recent research has confirmed the detrimental impact of impersonal science classroom environments and the valuable role of support structures in science course engagement. Gasiewski et al. (2012) used quantitative and qualitative data from over 2800 students at 15 universities to examine the nature of science course environments.

Students were more engaged in courses that included more discussion and where instructors signaled an openness to questions. Students who felt comfortable asking questions in class were more likely to seek out tutoring, attend extra instruction sessions and to collaborate with other students in class.

Other research has found that the type of institution or program that students of color attended also had an impact on college science persistence. There were much lower science completion rates at the most selective universities—even with similarly prepared students (Chang, Cerna, Han & Sáenz, 2008). Chang et al. (2008) suggest this is related to how science coursework structures function at highly selective institutions. While all the students admitted are high achieving, the highly competitive environments of science courses sort out students in order to identify the very best ones. Because the assumption is made that all students are on equal footing, limited resources are provided to compensate for students' prior preparation. It should be noted that this finding is in contrast to the finding that students of color have much higher college graduation rates at more selective universities compared to less selective institutions (Bowen & Bok, 1998). This presents a potential dilemma to high school counselors who advise students of color on college decisions. If these students plan to pursue science in college, should they be encouraged to attend less selective intuitions where they may be less likely to graduate?

In research more specific to pre-medical program retention, Smith (1993) found students of color drop out of science courses because they believe low grades in any class will block them from being accepted to medical school. Several studies have shown that pre-medical retention rates are much higher in combined baccalaureate medical degree programs where students must simply maintain a B average in science classes overall and where there is academic support for the students (Smith, 1993; Thomson, Ferry, King, Martinez-Wedig & Michael, 2009).

One program that significantly increased retention of low-income Black students in science majors is the Meyerhoff Scholars program at the University of Maryland (Hrabowski & Maton, 1995; Maton, Hrabowski & Schmitt, 2000). The program provides an integrated set of support services including: integration of students into the science departments and programs; science knowledge and skill development, full financial support so students do not need to work; faculty research mentors –especially faculty of color, and ongoing monitoring and advisement. Admission to the program is competitive and students must complete a detailed application so the university better understands students' backgrounds. The program receives approximately 1400 applications a year. The field is narrowed to 100-150 students and those students and their families are invited to the campus for a weekend where they learn more about the program. Ultimately 40-60 students are accepted into the program each year. Through that process the students are able to gain a much more in-depth understanding of the program's purpose and approach.

Much of the higher education research related to college science retention focuses on social and psychological factors that impact students' decisions and success in science courses. Beasley (2011) looked more closely at why some Black students opted out of more competitive college programs, including pre-medical programs. She found that while inequitable preparation in middle and high school could explain some of the attrition from science courses, it could not fully account for the scope of the problem. Beasley found that for students, stereotype threat (Steele, 1997), or anxiety that their performance might confirm negative stereotypes about Blacks' academic abilities was a significant reason why they left the programs. In essence the students self-segregated to avoid fulfilling or reinforcing racial stereotypes and to avoid this near constant anxiety about their performance. While Black students had this burden of anxiety about stereotypes, it is unlikely that White students in the classes had any comparable concern about how their performance would be understood.

Hurtado et al. (2007) identified a number of factors that were predictors of success and persistence in first-year science courses. The study examined "underrepresented minority students"[10] (p. 842) who entered college with a strong interest in pursuing science degrees. These students were compared to White and Asian students who also intended to pursue science degrees. The researchers found that family responsibilities that interfered with college had a negative impact on academic adjustment and students' sense of belonging and integration on campus. Students with concerns about their ability to finance college also had lower academic achievement and were less connected to campus life. The authors speculate that these students felt pressure to devote more time to working which took time away from studying and from being integrated into campus life. Students who were confident in their ability to communicate with faculty and were good at managing their time were more successful. This also resulted in these students seeking out resources, programs and advisors who could help them figure out the academic and social systems of college. It was particularly helpful for freshmen to seek guidance from juniors or seniors. However, seeking advice from other first-year students was detrimental to academic achievement. Students who perceived a

[10] The group consisted of mostly African-American and Latino/Latina students. Hurtado et al. do not explain why Asian students were grouped with White students, but presumably it was because their science completion rates are similar to White students.

hostile university climate or highly competitive science classes were negatively impacted. In contrast, the development of positive cross-racial interactions tended to assist all students in achieving a higher sense of belonging on campus. Another important factor was student satisfaction with the relevance of coursework to everyday life which the authors suggest promotes a psychological sense of adjustment.

Based on these findings, Hurtado et al. (2007) suggest some ways that students of color might become more integrated with the academic and social aspects of campus life. The researchers base these recommendations on frequently cited frameworks and models of college student retention (Tinto, 1987; Pascarella & Terenzini, 1991) which suggest that students are more successful if they become academically and socially integrated with mainstream campus culture. However, these models have been critiqued as they imply that students of color must abandon their own cultural backgrounds and identities to be successful in predominantly White college environments (Museus & Quaye, 2009; Tierney 1999). Further, Villalpando (2003) notes these models are based almost entirely on middle-class, White students and cannot be generalized to students of color.

Bauman et al. (2005) have also critiqued the student retention models of Tinto (1987) and Pascarella and Terenzini (1991) for locating the problem with the students and fail to consider the possibility that the issues reside with institutional or societal factors. In a report examining the issues of inequitable outcomes for students of color in science and other academic areas, Bauman et al. (2005) make the following point about institutional responsibilities:

> We regard the challenge of narrowing the college education gap and achieving equitable educational outcomes for historically underrepresented students as a

> problem of institutional responsibility and performance rather than as a problem that is exclusively related to student accountability, motivation, and academic preparation. We have chosen to emphasize inequality as a question of institutional responsibility because the majority of studies on college student success take the opposite perspective. These studies focus on characteristics such as students' social and academic integration (Braxton and Lein 2000; Tinto 1987), student involvement (Astin 1999), intensity of their high school curriculum (Adelman 1999), lack of cultural capital (Bourdieu 1985), and other risk factors associated with poor performance. Because of this, we tend to accept the findings at face value without considering the possibility of deficits at the institutional level (pp. 2-3).

This perspective expressed by Bauman et al., that the deficits reside with the institution, provides an important counter to the research on students of color in college science classes; however, this broader assessment of the problem is rarely offered or considered in the literature and research on this topic. While the various factors noted in the research on students of color in science, including inequitable preparation, language differences, and instructional approaches may provide plausible explanations for the challenges students of color face in college science courses, there is little work that examines these multiple factors and the interplay among them in the larger context of university environments with their complex social and power structures.

In a review of the ethnographic research on the high school to college transition for low-income and students of color, Koyama (2007) articulates the value of an approach that "attends to broad sociocultural contexts to explore the interactions between social actors and social structures" (p. 2314). Koyama found a rich set of research that examined the lived experiences of high school students who are negotiating the demands of preparing for college. These studies are situated in multiple communities and contexts and as a whole paint a complex picture of students' pre-college schooling experiences. However, Koyama found little research on students' college experiences:

> Anthropological studies tell us much less about the actual college experiences of racial/ethnic minority and poor students…. while we have a growing body of literature that attends to near-college schooling experiences, we need to address our lack of understanding about the actual process of being in college. Doing so will provide us with a more complete picture of the multiple college-going processes (p. 2316).

Thus, the intent of this study is to contribute to the body of research focused on the college pre-medical science experiences of students of color in predominantly White research universities.

CHAPTER THREE: Research Methods

The purpose of the research study was to analyze University on a Hill's new pre-medical support program in the context of the larger debates and views about students of color in university science programs. I employed a critical, ethnographic case study research methodology with the principles of Critical Race Theory providing the lens through which to analyze the university context and make visible the role that institutional structures, policies, and practices play in perpetuating or disrupting racial inequities in science. I also used Bourdieu's theories of capital as a framework to understand what kinds of academic and linguistic capital are privileged or marginalized in a predominantly White university environment and what role that privileging plays in maintaining racialized advantages and disadvantages in science courses.

While the views of university faculty members and administrators provided one perspective of the university context, the experiences, and perspectives of eight students in the program were foregrounded in the research. Specifically the research examined the students' experiences in the first and second semester biology courses that were newly developed for the program. The perspectives of these eight students were compared to, and analyzed alongside, those of the university administrators and science faculty members who support students of color at the university. These multiple perspectives provided a broader contextual understanding of the program, the university and the students along with showing how these views, structures and policies play a role in maintaining or transforming institutional inequities.

The main research question was as follows: What can a Critical Race Theory perspective tell us about a predominantly White research university's program aimed at supporting students of color in pre-medical courses and the experiences of students of color in those courses? The more specific research questions were as follows:

- What are the cultural, economic and sociopolitical narratives and motivations behind the creation of college programs designed to retain students of color in pre-medical science programs? What kinds of racialized understandings and assumptions about students are used to formulate these programs?
- How do students of color in pre-medical college science programs make sense of their experiences, particularly in terms of the language and pedagogical practices employed in the college science courses and how do those practices compare to their earlier K-12 educational experiences?
- How do science faculty members in these programs make sense of their role and what assumptions and understandings do they have about the students' backgrounds and motivations? How do science faculty members understand the university context, especially in terms of university structures and practices, including language and pedagogical practices that reinforce or disrupt racialized advantages?
- How do university administrators who work with students of color interested in pursuing science fields make sense of students' backgrounds, motivations, and experiences in the university context? How do these university administrators understand the university context in terms of structures and practices that reinforce or disrupt racialized advantages?

Research Design

This study employed a critical ethnographic case study research methodology (Kincheloe & McLaren, 2000; LeCompte & Goetz, 1984; Merriam, 2009; Rossman &

Rallis, 2003; Stake, 1995). Each of these aspects of the research methodology, along with my rationale for each approach is described below in more detail.

An ethnographic methodological approach facilitated the goal of understanding the broader context of the new pre-medical science program, the university, and the experiences of multiple participants involved with the new program. Ethnographic research is, in a broad sense, concerned with human society and culture, which Merriam (2009) defines as “the beliefs, values and attitudes that structure the behavior patterns of a specific group of people” (p. 27). Ethnography is both a process and a product and its origins can be traced to nineteenth century anthropologists who engaged in participant observation of various cultures. A key assumption has been that by “entering into close and relatively prolonged interaction with people (one’s own or other) in their everyday lives, ethnographers can better understand the beliefs, motivations and behavior of their subjects” (Tedlock, 2000, p. 456). This immersion in the research site as a participant is the main method of data collection with the data sources being interviews, both formal and informal, observations, and analysis of documents and other artifacts. In addition, the data includes the researcher’s views, impressions and insights related to the events and participants connected to the research site (Merriam, 2009).

Because the focus of the study was on a particular program during its pilot year, the approach can also be considered case study research with the new pre-medical program as the unit of study. Merriam (2009) defines a case study as “an in-depth description and analysis of a bounded system” (p. 40). While the research examined many aspects and actors in the new pre-medical program, the system was both bounded in time (the first year of the program) and by the potential number of participants (students, teachers, administrators) who could be interviewed or observed. The case study approach provided a way to investigate “complex social units consisting of multiple variables of potential importance in understanding the phenomenon” (p. 50). Stake (1995) notes that case study research is particularly effective for studying educational programs because the approach results in a detailed and holistic account of a phenomenon.

While one goal of the research study was to document and describe the program and the students’ experiences, the more significant goal was to make visible the systemic inequities and practices that allow some students to succeed in the pre-medical courses while others are held back. This particular research stance more closely aligns with what can be described as critical research where the goal is to critique, challenge and empower (Merriam, 2009). Questions about power—who has it, what structures in society reinforce who has power—are at the core of critical research. The focus of critical research in education is on the educational context rather than individuals. “Questions are asked regarding whose interests are being served by the way the education system is organized, who really has access to particular programs, who has the power to make changes and what are the outcomes of the way in which education is structured” (p. 35). Kincheloe and McLaren (2000) add further perspective on critical research. Their view is that critical research should be understood in the context of empowerment of individuals. “Research that aspires to the name *critical* must be connected to an attempt to confront the injustice of a particular society or public sphere within the society” (p. 291).

Because the notion of empowerment is a central component of critical research, when I began this research study, I saw value in and envisioned that I could draw on the principles of action and participatory research. Herr and Anderson (2005) broadly define action research as "inquiry that is done *by* or *with* insiders to an organization but never *to* or *on* them" (p. 3) along with a perspective that those involved in the research are active agents and participants rather than research subjects. In terms of research methods, this means that interviews are conducted in an interactive dialogic manner that calls for self-disclosure on the part of the researcher. In addition data analysis, meaning and theory are negotiated between participants and researchers (Herr & Anderson, 2005).

While it was my intent, for the most part, I was not able to conduct this study in the ways that were consistent with action or participatory research. I was able to incorporate some of these principles into the interview process. The students in the study were interested in the larger questions about students of color at the university and in the findings from the research. During the interview with students I shared my ongoing findings and insights; in addition I solicited from them additional questions and their assistance in making sense of the data and of their own experiences. At the end of each semester, several of the students took the time to review the details of the results and offer additional insight into the analysis and the context of their responses, but due to the students' busy schedules this was not possible with all the students. During the interviews with the teachers, I shared some of the ongoing findings from the students and the instructors of both the fall and spring biology courses expressed interest in any findings from the research. However, the instructors did not see my role as more than an outside observer trying to understand and document the challenges that students in the study faced with the science courses.

For this study to truly be consistent with action or participatory research all of the participants and stakeholders would have to collaboratively agree on the research problem, the purpose of the research and how the research would be conducted. This would mean involving not only the students and teachers, but the other faculty members and administrators connected to the McNair program. This was not possible, in part, because of the hierarchal structure within the university where my role was seen primarily as a doctoral student researcher conducting a study and not as a collaborator who could help develop and assess the program. In addition, I was not prepared to undertake a study of this scope. While the faculty members were willing to be interviewed and observed, they conveyed to me that the program administrators were concerned about too many people being involved with the process and they were hesitant to involve me in any of the program meetings. Several times I contacted administrators connected to the program with requests for interviews, but I did not receive any responses. In the end I was only able to interview the university administrators who were not directly connected to the program, but were involved with students of color at the university.

Positionality of the Researcher

My role in the research was that of a participant observer, but I also drew on the local knowledge and experience I have gained over ten years at the university as an English instructor, academic advisor, instructor in the summer transition program for students of color, and member of the university community. While the majority of the analyzed data was collected though formal interviews and observations, I also drew on my background knowledge as a long-time employee of the university and on the observations that happened in the course of my day-to-day work at the university.

My concern about students of color in pre-medical science courses emerged over several years as I worked with many high-achieving, students of color at the university. I taught these students over several summers in a college transition program sponsored by the university and I continued to teach some of the students during the regular academic year classes. I also served as an academic advisor to these and other students in the first-year courses. As an academic advisor I provided assistance on course selection and any other academic matters. If students wanted to withdraw from a course after the regular drop-add period, they had to consult with me allowing me to gain a sense of what classes were challenging for students.

Most of the first-year students in my regular academic year classes were White, middle and upper middle-class students who have attended suburban, private, or religious high schools. Many of these students, not just first-generation college students or students of color, come into the university with a declared pre-medical concentration. Students who are enrolled in the pre-medical program are advised to take chemistry, biology and calculus, along with two other classes during their first semester. I learned from the many students I taught and advised that the combination of these three demanding courses is often too much for students and many withdraw from one or both science courses after receiving failing or near-failing grades on the first several exams.

I began to realize that many more students of color were withdrawing from the pre-medical science courses than White students. This took a significant toll on their views of themselves as successful students and their goals for the future. One day I asked a colleague who had worked in the summer transition program for many years if he knew of any first-generation students of color who had completed the pre-medical program. While some students had made it through the nursing program, we could not identify a single student who had completed the pre-medical program, let alone been admitted to medical school.

The realization that none of these highly capable, first-generation college students had been able to complete the pre-medical program left me troubled. Based on my own experiences with students and the university system, I had several plausible explanations for this situation. Perhaps it was the nature of students' high school preparation since many had attended lower resourced urban public schools. Maybe they did not know how to study for the kind of lecture and textbook-based classes that characterized the introductory science courses at the university. Perhaps language challenges were hindering their comprehension of the textbook and exams, since many of the students were bilingual students with English as their second language. While some of these issues likely play a role, they did not explain the pervasive nature of the problem.

As I began to learn more about Critical Race Theory, I realized that the students' experiences and challenges with the various programs and people were more likely connected to broader institutional inequities and I began to focus on understanding the multiple and interrelated factors that were relevant to these students' experiences. That work led to the pilot study with one of these students that is detailed in Chapter One. My initial plan for this research had been to expand the work of the pilot study to a larger number of students. However, when I learned that the university would be developing a new pre-medical program to support these students I decided to focus on the new program for this study.

Data Sources, Participant Selection, and Site Selection

Data sources and data recording. More specific details about each of the data sources are summarized in Table 1 below. Briefly, the data sources were as follows: (1) Interviews with eight students, two science faculty members, and two university administrators, (2) Classroom observations of the college biology courses during the fall and spring semesters, (3) Review of course materials such as course texts, exams, worksheets and lecture slides, and (4) Review of mainstream media items from publications such as *The New York Times* and policy reports from different government organizations, foundations and non-profit advocacy groups.

The selection of the three groups of participants—students, science faculty members and administrators—was intended to provide a broad perspective on the university context. With the administrators, my intent was to interview two different sub-groups—the administrators who developed the pre-medical support program and those who support students of color in the university in other capacities but are not directly involved with the new program. The administrators involved with the program did not respond to my requests to be interviewed and thus I was not able to include their perspective on how and why the program was developed. Other administrators who work with students of color provided more of an outsider perspective on the program along with a sense of students' broader experiences of the program and of the university.

Table 1: Data Sources

Data Type	Details/Timeframe	Focus/Purpose
Interviews with 8 students enrolled in the biology course.	4-5 semi-structured interviews with each student conducted over the semester and continuing into a second semester. Approximately 3-4 informal conversations with each student before and after class.	Student's family, language and educational background with a specific focus on high school science coursework. Perceptions of the university, the program, instruction, and coursework.
Interviews with 2 biology instructors.	3-4 semi-structured interviews with the fall and spring biology instructors conducted over the course of the semester and the year. Several informal conversations before and after class.	Instructors' rationale and approach to the courses. Perspectives and experiences with students of color and assessment of the program. Perceptions of the larger university context along with perceptions of institutionalized racism.
Observations of the fall and spring biology courses	Attended and observed the twice weekly biology classes during the fall for a total of 28 observations. Attended and observed the spring course 1-2 times per week for a total of 18 observations. 46 total observations.	Understanding of instructional methods and materials and students' reactions to the course methods and content.
Interviews with 2 administrators who work with students of color.	1 interview with each administrator. These administrators were not directly involved with the new program, but worked directly with students of color at the university including some of the students enrolled in the program.	Perspectives on the kind of academic support students of color need with science courses. Perspectives on and assessment of the new program and institutional culture.
Course materials including textbooks, lecture slides, exams, and other materials.	Collected samples of materials used in the course. These materials came from both the instructors and the students.	These documents provided a perspective on the language and instructional approaches in the program. I also used these documents as a focal point for further conversations with students.

Media items and policy reports from government organizations, foundations and non-profit groups.	Analyzed media and public policy documents related to students of color in pre-medical science fields for majoritarian stories and counter narratives. Very little of the media discourse was specific to this topic, but was more prevalent in the policy reports and documents.	These documents provided a perspective on the range of public discourse surrounding students of color in science fields and showed how they are characterized and positioned in comparison to more privileged White students.
Publically available materials on the school's website and documents such as university rankings where the university is named.	Analyzed documents related to students of color, admissions, financial aid and pre-medical program. Reviewed relevant documents that named or specifically reported on the university. As with the media and policy documents the focus was on majoritarian stories and how students of color are characterized and positioned.	These documents were used to provide a perspective on institutional practices and the public image that the university sought to convey. The documents where the university is named convey a sense of how the university is viewed by those outside the institution.

Data recording. All of the formal interviews were audio recorded and portions were selectively transcribed. The majority of the class observations were audio recorded and detailed field notes were taken during more significant parts of the class. In a few instances, class sessions were not recorded, but in those cases detailed field notes were taken during the classes. For the less formal conversations and interactions with students and instructors I kept field notes of the interactions and any other relevant events and impressions. Given that in ethnographic research immersion in the site as a participant is one of the main forms of data collection, these informal interactions provided an essential data source. Further, given the often challenging and sensitive nature of discussing issues related to race and racism, participants were more likely to comment on these issues outside of formal interview settings.

As noted earlier, my primary research question was as follows: What can a Critical Race Theory perspective tell us about a predominantly White research university's program aimed at supporting students of color in pre-medical courses and the experiences of students of color in those courses? The more specific research questions were as follows. Following each question is an explanation of which data sources helped address the question.

- What are the cultural, economic and sociopolitical narratives and motivations behind the creation of college programs designed to retain students of color in pre-medical science programs? What kinds of racialized understandings and assumptions about students are used to formulate these programs? Data Sources: Media and policy documents. Interviews with university administrators and science instructors.
- How do students of color in pre-medical college science programs make sense of their experiences, particularly in terms of the language and pedagogical practices employed in the college science courses and how do those practices compare to their earlier K-12 educational experiences? Data Sources: Interviews with students informed by class observations and examination of course materials.
- How do science faculty members in these programs make sense of their role and what assumptions and understandings do they have about the students' backgrounds and motivations? How do science faculty members understand the university context, especially in terms of university structures and practices, including language and pedagogical practices that reinforce or disrupt racialized advantages? Data Sources: Interviews with faculty members informed by class observations, examination of course materials.

- How do university administrators who work with students of color interested in pursuing science fields make sense of students' backgrounds, motivations, and experiences in the university context? How do these university administrators understand the university context in terms of structures and practices that reinforce or disrupt racialized advantages? Data Sources: Interviews with university administrators.

Site description. The site for this study is a large selective private research university in the northeast United States. Under the Carnegie Classification of Institutions of Higher Education (Carnegie Foundation, 2004) the university is classified as a medium to large research university. The total student population is approximately 15,000 with 10,000 undergraduate students. The university is representative of other predominantly White research universities with White students making up 68 percent of the undergraduate population. Students of color make up 28 percent of the undergraduate population with the following subgroup percentages: Native American, 0.2 percent; Asian, 11 percent; Black/African American, 6 percent; Latino 9 percent; Two or more races 2 percent, Other 4 percent.

According to the university's website, there are approximately 1200 undergraduate students enrolled in the pre-medical program, but this data is not disaggregated by race. The medical school acceptance rates are not published on the school website, but the undergraduate admission page directed at students of color notes that in 2009, 83 percent of the schools applicants with at least a 3.4 science GPA and at least a 9.0 on the MCAT were admitted to medical school. There is no mention of the percentage of students of color in this 83 percent. An information request was made to the university's office of institutional research, but an assistant stated that this statistic was not available. Nor could the office provide the percentage of students, who leave the pre-medical program after their first year along with a demographic breakdown by race.[11]

The university has two programs directed at supporting students of color. One is funded by the university and provides mostly social and psychological, but some academic support for students. This organization runs the six-week summer transition program for incoming first-generation college students. The academic component of the program is focused on math and English, but there is no special support in the program for students in the science classes.

The second program for students of color is federally funded and focuses on providing students with academic skills needed for both undergraduate and graduate work. This is the organization where the McNair program and new pre-medical support program is housed. The focal point for the study was the newly developed, fall semester inquiry-based biology course and the spring semester cell biology course that are part of the new pre-medical support program. I received permission from both course instructors to use their classes as study sites. I worked with one of these instructors during the earlier pilot study and she was aware of and shares my concerns about the low number of students of color who succeed in the biology courses. The class size was approximately 30 students. For the both semesters I acted as a participant observer and attended each class and followed the course readings and assignments. I audio recorded relevant class sessions and took field notes on all classes.

[11] Bauman et al. (2005) note that most universities do not collect data that is disaggregated by race because they are not required to either by the federal government or university accrediting agencies.

Participant selection. I used a convenience sampling approach for selecting students. Through my work in the summer transition program I identified eight students of color enrolled in the program to who agreed to be part of the academic year study. The summer program typically enrolls 45 low-income students of color. These students have primarily attended urban public schools and are selected for the summer program primarily because the rigor of their high school programs did not match that of the typical student admitted to the university. Approximately one quarter of these students express an interest in pursuing pre-medical studies. All of these students were encouraged to enroll in the new academic year program pre-medical support program. From the larger pool of the 45 students enrolled in the summer program, I recruited potential students who were enrolled in the new McNair pre-medical program. For interested students, I held a meeting to explain the purpose of the research and what their involvement would involve. There were ten students who planned to enroll in the McNair pre-medical program, but only eight students attended the meeting. All eight of those students agreed to participate in the study. Some of the student participants left the program or the biology class before the end of the fall semester or before the end of the year, however they continued to be part of the study through the end of the spring semester.

To select faculty members and administrators I used a convenience sampling approach as I was limited to the individuals who are involved in the program and were willing to be part of the research. The science courses were taught by one full-time tenured chemistry professor and two biology faculty members. One of the biology instructors is a tenured assistant professor and the other is full-time non-tenure track professor. All the instructors have PhDs in their fields. The two biology teachers were selected based on their willingness to participate in the research and on their willingness to allow observations of their science courses.

The university administrator participants were also selected based on their willingness to be part of the research study. I was not able interview any of the administrators who helped formulate the new pre-medical McNair program nor was I able to interview the faculty member in the biology department who was not teaching the students, but was helping design and implement the biology component of the program. I was able to interview two administrators of the other university organizations that support students of color. These two administrators regularly meet with and counsel the students who attend the summer transition programs. While these participants provided a valuable range of perspectives, this view is of the university and the program is not meant to be exhaustive.

Data Analysis

As noted earlier, all of the formal interviews were audio recorded along with many of the class observations. For the less formal conversations and interactions with students and instructors I kept field notes of the interactions and any other relevant events and impressions. Data analysis was an ongoing, systematic, constant comparison process both during and after data collection (Glaser & Strauss, 1967; LeCompte & Goetz, 1984). I periodically wrote researcher memos to capture developing ideas and insights and generate additional questions for the participants (Merriam, 2009). Formal interviews and recorded class observations were transcribed and analyzed as follows: Critical Race Theory and theories of capital were used to formulate an initial set of codes for data analysis and to guide the transcription of interviews and class observations. These codes also guided the focus of the class observations. For example, from Critical Race Theory, codes such as *institutionalized racism*, *racialized advantage, racialized disadvantage*, *intersectionality of race/class/language*, *interest convergence*, *dominant narrative* and *counter narrative* were used. From theories of capital, codes such as *privileged (cultural, academic, linguistic, family) capital* and *marginalized/unrecognized (cultural, family, academic, linguistic) capital* were used. These codes were refined and revised as data was collected and analyzed.

While most formal interviews and class sessions were audio recorded, the transcription and close coding of data was a selective process with a focus on robust and relevant areas of the data per Critical Race Theory and theories of capital. For example, during most biology classes, the entire class session was recorded; however much of the lecture focused on biological concepts. While some portions of this were relevant to transcribe and code to show the teaching approaches and kinds of knowledge that was privileged in the course, it was not be feasible or necessary to transcribe and code this kind of data from every class lecture. More relevant were discussions of how and why students should approach the material and discussions and explanations of why students did or did not do well in the course. As the data analyses proceeded, additional areas that emerged as relevant were later transcribed and analyzed as needed.

Throughout this process, constant comparisons were made between and among emerging conceptual themes (Miles & Huberman, 1994). Since this study was driven primarily by the theoretical framework of Critical Race Theory, a key part of the analysis was to identify institutional structures, policies and practices that privileged White students and disadvantaged students of color. These structures, policies and practices were viewed and interpreted differently by the different participants in the study. Previous work on the pilot study suggested that there would be conflicting views and interpretations from the various participants (students, teachers, administrators) involved with the program (De Rosa, 2013). One of the challenges was to make sense of these various views and to identify and make racialized structures and practices visible.

CHAPTER FOUR: The Students

Central to this study was gaining an understanding of the students' experiences in the larger context of the university environment. In Chapter Five, I provide a perspective on the broader discourse and context for students of color in university environments. However, before providing that wider view, I start with the eight student participants and their stories and backgrounds. Following the narrative descriptions is a table which highlights some of the key details for each student.

Student Participants

The eight student participants in the study were all enrolled in the fall McNair biology course, which had 28 students in total. All eight of the students were recruited from the summer transition program where I teach an English course. Seven of the eight participants had been students in my summer English course. The details about these students are primarily drawn from the interviews conducted in the fall and spring semesters, but some of the information comes from their written work in my summer course and my observations of and interactions with students during the summer program.

Fatima. Fatima came to the United States from Afghanistan when she was in the fifth grade. The move was precipitated by threats the family was receiving from the Taliban. One night her father and brother got word that the Taliban was coming to arrest them. Her father and brother fled leaving behind Fatima, her sister and mother. Fatima, her mother and sister left Afghanistan for Pakistan and eventually made their way to a large northeastern city in the United States where they were reunited with the father and brother.

When Fatima started school at a large urban elementary school she spoke very little English, but by high school she graduated as one of the top students in her class. She attended a large urban public high school where she did well in science but she noted that, "My high school science courses were just OK and we didn't have any science AP or advanced courses. What really helped me [with science] was the summer program at [the state university medical school] after my sophomore year. I got to study eye diseases and I saw how some people couldn't afford to get treatment they needed. I always knew I wanted to be a doctor and that summer made me more sure." Coming into the university Fatima felt very confident about her science capabilities, but she was more worried about her English and writing skills. "My senior year AP [English] teacher didn't give us much writing and therefore my writing skills were disappearing. I am kind of afraid that I am not in the level of writing and reading that I should be in order to be successful in any class that relies on that. I know with science I can just put in more time studying, but with English, I can't make up for what I don't have."

During the fall biology course, there was another student from Bangladesh who was slightly similar in appearance to Fatima with long dark hair. During class the fall biology teacher would frequently mix up Fatima with the other student and call her the wrong name. The first time it happened, Fatima just ignored the mistake, but after several similar incidents, she corrected the teacher. The mix-up continued to happen and Fatima continued to politely correct the teacher, but to me she expressed anger and frustration, "for being mixed up with someone who doesn't even look that much like me."

LeeAnn: LeeAnn's family came from Puerto Rico and Argentina, but LeeAnn has lived her whole life in a large city in New Jersey with her mother who is physically disabled and unable to work. Medicaid provides a few hours a week of nursing help for her mother, but she is dependent on LeeAnn for most logistical and physical help. During the six-week summer course, LeeAnn had to go home once to help her mother and she had to leave the program before the final closing celebration to assist her mother on a trip to Florida. LeeAnn says little to other students about her mother and is circumspect when she describes her mother's situation: "It is just what it is. I look up to my mother, I help her the best I can, but I wish her life were easier and that she had more options and people to help her. She is one reason I want to be a doctor—because she is not treated very well by her own doctors." While LeeAnn and her mother's financial situation "is a little precarious", LeeAnn talked about several uncles in Argentina who are doctors and are more financially secure. One of the uncles had gone to college and medical school in the United States and shared with her what medical school was like. He advised her just to "get through the pre-med classes because medical school was nothing like those classes."

LeeAnn attended urban public schools until high school when she received a scholarship to attend a private day school in her area. According to LeeAnn, the academics at the private school were much harder than at her public middle school, but with help from other students she figured things out. "At first I didn't think I could do it, but I got used to the way things were taught and what you had to do to do well on tests and stuff. The science classes were not that interesting, but I worked with other kids to get through them. A lot of the kids wanted to be doctors and they knew they just had to get through the boring classes and do well." When asked at the start of the year about the college science classes she said, “I can tell they will be like my high school classes. I don’t know how interesting they will be, but I think I know what to do and I will be ok.”

LeeAnn’s prediction about her performance was on target and of all the students in the study, she was the only one who did not struggle academically with the science courses during the fall semester. LeeAnn was also the most phenotypically White student and dressed and acted more like the White students at the university. Towards the end of the fall semester she commented that she was “hanging out less and less with the [summer program] students and spending more time with regular [university] students.”

Tran: Tran was born in the United States, but her parents emigrated from Vietnam and settled in a medium sized city where many different immigrant groups live. She had an older brother in college and an older sister who was attending medical school. Tran grew up speaking Vietnamese and did not learn English until she started kindergarten. “In my school there were a lot of other Vietnamese students so I wasn’t alone, but for most of the [kindergarten] year I didn’t always know what I was supposed to be doing in class.” Tran attended public elementary and middle schools and for high school was admitted to a new public charter school which had a focus on science. According to Tran “the school science classes were a lot of work and the teachers talked a lot about what college science classes were like so I felt like I was prepared for college.” However Tran also noted that, “A lot of the teachers were just out of college and in Teach for America. They tried really hard and got us interested in science ideas, but sometimes I wasn’t sure how much I was learning.”

During high school, Tran also attended the same summer program at the state university medical school that Fatima had attended, but Tran was there during a different summer. In the program she focused on bioethics and biomedical engineering projects like robotic prosthetics. The program helped give her a concrete sense of different science and medical careers she could pursue. During the summer program, she wrote the following about her career goals: "My future goal is to become a biomedical engineer and so I'm entering into [the university] as a biology major. I became interested in the field after I took the class Bioethics. My teacher discussed different areas of medical careers and after watching a movie about synthesizing organs in a lab, I found that biomedical engineering was the career I would like to venture in. My family has always support[ed] my decisions as long as I'm in the medical field. I think the one moment that exemplifies my goals and my family's goals was when I started to discuss with my family about college. My father began by stating that I should be like my sister and become a doctor. My mother was the same. My brother told me to do what I loved and at that moment I could only think about bioethics class. There, I found that the only career that seemed to fit my desires was Biomedical engineering." When Tran realized that the university did not have any kind of engineering program, she decided that the pre-medical option was the best option and she did not "want to rule out the possibility of being a doctor."

Tran felt she did not need the extra support that the McNair program provided, but during summer orientation she felt pressured to enroll in the program. "During the summer I told them I didn't want to do it, but all summer they [the program advisors] kept telling me I should be part of the classes. I wasn't sure it would be helpful, but now that classes have started, I guess it is OK." Similar to Fatima's experiences with the fall biology teacher, the teacher frequently mixed up Tran with a Chinese American student in the class. Tran was surprised because the other student had long hair and Tran had short hair. However, Tran noted that “it didn’t really bother me because this has happened to me as long as I can remember.” Tran also noted, “I can kind of understand because I have a hard time telling apart a lot of the White girls—with their long straight hair and names like Katie, Caitlyn, and Allie.”

Biju: Biju and his family are refugees from Nepal who came to the United States when Biju was in eighth grade. Unlike the other students in the study who all lived in or immigrated to urban areas, Biju’s family settled in a relatively affluent suburban New England town. They had moved to this area because a church group in the town sponsored the family’s settlement and transition to the United States. Biju says very little about what happened to his family in the refugee camp, but he spent almost two years there. “I saw many people suffering with health problems that people here [in the US] wouldn’t believe.” His formal schooling was also interrupted by the time in the camp, but there were some informal classes. “I started to learn a little English which helped me when we did get to the US. But at my school [in the US] I was the only one who needed help with English. I remember having a tutor for English but he was not that helpful. I tried to do things like watch TV and movies to learn, but I am still not very good.”

At the well-resourced high school Biju had attended most of the students went on to college and the school offered many college preparation classes and college counseling services. However, the school had little support for someone like Biju still learning English. “I never did really very well in my classes where there was a lot of reading and writing, but I did good in math and I loved chemistry—I got to take AP chem and intro to organic chemistry. I thought that work would really help me with my college science classes but I was worried about the other stuff where I needed English." During the summer English course, Biju did have some difficulty with the English coursework because it took him a lot of time to do both the reading and writing.

Sharon: Sharon was born in Jamaica and still feels very connected to the island. During the summer she had written the following in explaining where she was from: "I grew up in Eltham Park and Gordon Pen, St. Catherine in Jamaica—I call the land of wood and water, Jamaica, my home." At home she spoke Jamaican Patois and at school she learned both English and French. She lived in Jamaica until age 16 when she moved to the Northeast to stay with her aunt and attend high school. Her mother, a police officer in Jamaica, thought Sharon would get a better education in the United States and for that reason was willing to have them be apart.

Until her move to the United States, Sharon attended government funded Catholic schools in Jamaica. According to Sharon, her schools in Jamaica were much more challenging than those in the US. "At home [in Jamaica] I got a great background in science because science and art were taught together in all the grades. We would learn something like a cell or chemical structure in science and then have to draw that structure in art class. It really helped me to do that kind of visualization." However, that kind of rigor was not evident to Sharon in her US high school science classes. During the summer she wrote the following about the school: "My high school was not academically rigorous, neither was it economically diverse. My high school was overpopulated with students who came from working class homes…the majority of the students were African American and Latino. Most students didn't care about school and didn't go to college." To make matters worse, when Sharon first started at the high school, she had to repeat some classes and was placed into the lowest level of science classes even though the school had some Advanced Placement and honors classes. "I guess it's because I am Black and from Jamaica, they assumed I was behind. They put me in the worst science classes and even made me repeat a year of high school—so it took me three years to graduate. Everything I know about science came from Jamaica and even though I had a terrible experience in that [the high school] place, I still wanted to do science and go into medicine." Sharon noted that she had long been interested in medicine and public health after seeing what things were like in Jamaica for people "with no good doctors or hospitals unless you had money." When she was 17 she went on a month-long service trip with her church to Nicaragua. She saw so many health problems that could have been solved with low cost solutions like a one dollar tube of ointment for a child nearly blind with an eye infection. She wrote about her experiences during the summer program: "I always thought I wanted to be a doctor but after seeing the difference in Jose's condition in just 24 hours I decided that practicing medicine in the United States or any other first-world country would never be as fulfilling as practicing medicine in a country where technological advancements are still being made and resources are limited."

For the other students in the study University on a Hill was one of their top choices and they were happy to have been accepted to the school. However Sharon's first choice was one of the historically Black universities. "I really wanted to go there because I knew I would be better treated, but they didn't give me enough money. So instead I get stuck in [the summer program] and this [the McNair pre-medical program] where they assume I am not smart. I also like to speak my mind and I can't do that so much here or I am the angry Black person."

Alana: Alana was born in the United States, but her parents immigrated from the Dominican Republic a few years before she was born. Her family settled in a medium sized city where, according to Alana "a lot of poor people from Brazil and the DR live." Alana grew up speaking both English and Spanish, but that changed after she started elementary school. "I lost my Spanish and for a while I was embarrassed of my parents whenever they would speak Spanish. Now I wish I still knew [Spanish] partly because I have to take it in college." Alana attended public elementary and middle schools and in high school got into a charter school. Her experiences with her high school teachers were very similar to Tran's. "My teachers were very nice, but most were just out of college and didn't always know what they were doing. A lot were from Teach for American and they were smart, but they didn't know how to explain things." Alana did have some positive experiences with teachers, in particular her biology teacher who was more experienced. During the summer she wrote the following: "My biology teacher was really good and she encouraged me to go into science. She also made me really love biology. My family was always pushing me to be a doctor because I was smart. I know college science will be hard, but I am a hard worker and willing to put in the time." Compared to some of the other students in the study, Alana had less concrete reasons for wanting to be a doctor, but like all the other students she come into college being interested in and liking science and believing that she would do well in the college classes as long as she worked hard.

Juan: Ten years before Juan was born, his family had emigrated from the Dominican Republic to New York City. He grew up speaking both Spanish and English and he returned periodically to the Dominican Republic to visit family. "When I first went when I was ten, I was surprised at how poor everyone was, but how happy they were compared to what it was like living in the Bronx. But, I also saw that we had it much better here in the US with things like education and health care. That made me want to do something like medicine so I could help out." Juan had attended urban Catholic schools from elementary school through high school. "I thought my schools were pretty good at keeping me disciplined and getting me ready for college. My family, especially my older brother, make sure I know how important school was and they put a lot of pressure on me." One factor that put additional stress on Juan was that his older brother had attended and graduated from University on a Hill. Like Juan he had started out in the pre-medical program, but had switched after the first year. "My brother and my family are all expecting me to make it through pre-med and I think I can as long as I stay focused and work hard."

Sean: Sean was born on the island of St. John which is part of the United States Virgin Islands. Like most people who lived on the island, he grew up speaking both Creole and English. His mother and older brother moved to the United States when Sean was ten and left him and his sister in the care of his grandmother and aunt. In a narrative about his time on St. John, Sean described his grandmother's role in his life: "She had only been my guardian for a year, but has always been there for our family. She was there when I was born, when my sister was born, there two years later when our father left, and is here now to take care of her daughter's children while she works impossible hours in America to support our broken family." In St. John he attended the local Catholic school which went from grades one to eight and was partly funded by the government. "The schools didn't have many books or resources, but the teachers were strict and we had to work hard—much harder than I had to work in the US.” When Sean was 14 he and his sister moved to be with his mother who had settled in a large east coast city. He started at a large public high school that was under scrutiny by the US Department of Education. At the beginning of the fall semester he had the following to say about his high school: “The school was on probation because of the test scores, violence and dropout rates. I couldn’t believe how bad it was and I wished I had stayed in St. John’s.” While he was in high school he got a lot of pressure from his mother and brother to do well in school. “My brother was in jail and they both told me I would end up like that if I didn’t work hard. I ended up getting good grades, but I don’t think I learned very much of anything. That makes me nervous for how I will do in college. I am especially worried about science and math and I hope the [McNair] program will help me with that.”

Sean became interested in medicine because of what he had seen in St John and experiences with his own family. His grandmother in St. John had many health problems, but there were no doctors nearby that could help her. “One day when I was eleven I came home from school to find that she had died. It made me sad and angry that she had to die like that and I wanted to do something about the problems I saw. I was interested in why some places have worse health and no doctors.”

Table 2: Summary of Student Participants

Student	Family's County of Origin	Place of Birth	First & Other Languages	Type of High School Attended
Biju	Nepal	Born in Nepal	Nepali English	Suburban Public
Fatima	Afghanistan	Born in Afghanistan	Pashto English	Urban Public
LeeAnn	Puerto Rico & Argentina	Born in US/Parents Immigrated/Moved	English Spanish	Private Boarding
Sean	St John (US Virgin Islands)	Born in St John	Creole & English	Urban Public
Alana	Dominican Republic	Born in US/Parents Immigrated	Spanish & English	Urban Charter
Sharon	Jamaica	Born in Jamaica	Patois, French & English	Urban Public
Tran	Vietnam	Born in US/Parents Immigrated	Vietnamese & English	Urban Charter
Juan	Dominican Republic	Born in US/Parents Immigrated	Spanish English	Urban Catholic

CHAPTER FIVE: The Broader University Context For Students Of Color

These portraits of individual students show that they bring a range of experiences and backgrounds that can be both strengths and challenges as they pursue their pre-medical studies at the university. For example their first-hand experiences with family members and communities that face health care challenges may give them an advantage in understanding the broader social issues connected to medical care. These experiences may make the students more attuned to the financial and quality of life issues connected to inequitable health care access. For example, both Sean and LeeAnn have mothers who were disabled and during their high school years they served as primary caregivers because financial circumstances precluded their mothers from obtaining adequate professional assistance. Additionally, many of the students attended urban high schools where they may not have had the same kind of science preparation as the more privileged White students, including intensity of material, access to material resources such as books, lab equipment, time and tutoring as well as more strained resources generally. While any one of these factors may be relevant in analyzing students' performance in science courses, the goal and challenge is to understand how these various factors play out in the larger context of the university environment and the science programs. It should be noted that depending on the environment of a particular university, and particular students' experiences and strengths are going to be recognized, validated, and expanded upon differently in different places. The goal in this chapter is to describe the context of University on a Hill not just in terms of typicality or exceptionalism but how the university structure and culture was aligned with or dissonant from these students' backgrounds.

As noted in the review of the literature in Chapter Two, many of the existing studies on students of color in college science do not address the larger university environment. Instead they focus on discrete factors or interventions that impact students of color in college science courses. These factors range from reading comprehension difficulties with science textbooks to particular college science teachers or classroom attributes that adversely affect students of color. For example, Beasley (2011) found that stereotype threat is one factor that causes students of color to leave college science programs. According to Steele (1997) stereotype threat is the anxiety that students experience when they are concerned that their performance may confirm negative stereotypes about members of their race According to Beasley (2011) the students self-segregated to avoid fulfilling or reinforcing racial stereotypes and to avoid a near constant anxiety about their performance. Importantly, the factors linked to stereotype threat in a science course are likely replicated in the broader university environment and will likely impact students in multiple ways.

Other contextual factors impacting students in science courses also are woven into the fabric of the university and when examined in isolation provide little perspective on the complexity of students' experiences. Thus to fully understand the experiences of students of color in a college science program it is necessary to situate these experiences in the larger context of the university environment with its complex social and power structures. Further, universities are both situated in and reflect larger societal norms and practices. As Koyama (2007) notes, when studying the college experiences of students of color, there is great value in an approach that "attends to broad sociocultural contexts to explore the interactions between social actors and social structures" (p. 2314). To that end, I will discuss some of the larger societal contexts and discourses that are relevant to universities and students of color. In addition, I will describe the broader context at University on a Hill with particular attention to structures and practices that impact students of color. These include admissions practices, financial aid practices, grading practices, and support structures for students of color at the university. Where possible, I note whether these practices at University on a Hill are aligned or contrasted with those at other universities.

Why and How do Universities Seek to Enroll Students of Color?

One of the broader sociocultural contexts related to this study is the discourse surrounding why universities enroll students of color, how they view those students and how they go about supporting the students once they enter the university. These first two questions are at the heart of the recent US Supreme court case of Abigail Fisher vs. University of Texas at Austin (*Fisher v. University of Texas at Austin*, 570 U. S., 2013) From the perspective of those arguing on behalf of Abigail Fisher, university admissions practices should be blind to the construct of race and simply focus on merit. In an interview prior to the Supreme Court's decision on the case, Abigail Fisher articulated this perspective: "I'm hoping, that they'll completely take race out of the issue in terms of admissions and that everyone will be able to get into any school that they want no matter what race they are but solely based on their merit and if they work hard for it" (Liptik, October 8, 2012).

When examined though the lens of Critical Race Theory, Fisher's perspective is a direct articulation of the dominant narrative around color-blindness and meritocracy (Ladson-Billings, 1998; Solorzano & Yosso, 2001). While Abigail Fisher is asserting that with hard work, achievement is possible for everyone, she makes no mention of how different starting points and levels of opportunity impact achievement. She is also making the assumption that admissions tests and grades are unbiased measures of effort and achievement. Poon (2014) notes that, "Anti-affirmative action advocates also presume that tests and grades are racially neutral in their evaluative power. However, these quantitative measures can be tainted by bias, making them unfair gauges of student potential especially if they are the only factors for admissions" (p. 186). In discussing the ideology of meritocracy, McNamee and Miller (2004) note that in America "inequality is justified by an ideology of meritocracy because America is seen as land of opportunity… You might not be responsible for where you start in life, but you are responsible for where you end up. If you are truly meritorious, you will overcome any obstacle and succeed" (p. 3). Fisher and those arguing on her behalf are not explicitly justifying inequality, but that is essentially the impact of their points.

Arguing against Fisher in support of the University of Texas at Austin were other universities who make a case for why they enroll students of color and why they take race into account during the admission process. The case has been described as an affirmative action case, however there have been relatively few arguments made by universities about providing access and opportunity to students of color who may not have had the same opportunities or advantages as White students. The more prevalent arguments from other universities that have defended taking race into account focus on the educational value of diversity at the university. An amicus brief filed by Amherst College et al. emphasizes this point. One of the first arguments in the brief is as follows: "Private, highly selective colleges have a compelling educational interest in enrolling broadly diverse—including racially diverse—classes, and cannot do so without taking the diversity they strive for into account" (p. 4). The brief goes on to note that "diversity related benefits are far ranging, spanning from benefits to individual students and the institutions in which they enroll, to private enterprise, the economy, and the broader society" (p. 5) While the phrase "benefits to individual students" can be interpreted to mean benefits to students of color, the overall emphasis in this brief and others submitted on behalf of other universities is the broader benefits of diversity to the university community such as the amicus brief filed by Fordham University et al.

After the Fisher decision was reached, sending the case back to the lower courts, the American Council on Education, on behalf of a group of 37 college associations, took out a full page advertisement in *The New York Times* in which this point is made even more explicit:

> A diverse student body enables all students to have the transformational experience of interacting with their peers who have varied perspectives and come from different backgrounds. These experiences, which are highly valued by employers because of their importance in the workplace, also prepare students with the skills they need to live in an interconnected world and to be more engaged citizens (American Council on Education, 2013, July 1).

The statement does go on to note that "Our nation's higher education institutions…, stand committed to furthering the goals of equal opportunity and diversity in education" (para. 4). Otherwise, there is little said about inequality of opportunity faced by students of color. What seems most important to the universities is the role that students of color play in preparing the other students in the university for their future roles in a global economy. The *New York Times* advertisement concludes with the following assertion: "Our economic future, democracy, and global standing will suffer if the next generation is not ready to engage and work with people whose backgrounds, experiences, and perspectives are different from their own" (para.5).

Perhaps the universities and groups arguing on behalf of the University of Texas do have a strong commitment to providing opportunities for students of color, but that is not the perspective they have chosen to emphasize in their arguments. While this focus on the broader societal benefits of diversity may be valid, it positions students of color as the means through which these educational benefits will be achieved. In most cases students of color are well-schooled in knowing how to engage and work with the majority White population (Aries, 2008; Carter, 2005; Du Bois, 1903). It is the White students who have less exposure to and experience working with individuals whose "backgrounds, experiences, and perspectives are different from their own" and they are the ones who would seem to benefit from increased diversity in this line of argument. D'Souza (1991) goes a step further and asserts that "universities are quite willing to sacrifice the future happiness of many young blacks and Hispanics to achieve diversity and proportional representation and what they consider multicultural progress" (as cited in Aries, 2008, p. 7).

An embrace at universities of this dominant argument about the educational benefits of diversity can lead to problematic views and treatment of students of color. First, their admission to and presence at the university becomes more important than their success and transformation of the university community. While universities have an interest in enrolling students at the university, they have less interest in making sure these students graduate and succeed in their chosen fields. Second, without a focus on and an understanding about the broader educational and societal inequities that students of color may have faced prior to college, there is less attention at the university on the complex impacts these inequities might have on students' academic performance.

In Chapter One I detail the dominant views in the public policy discourse for why more students of color should be in science fields. The argument is that more students of color in science will help the United States' economic competitiveness in the global economy. In many ways the discourse surrounding why the country needs students of color to pursue science parallels the argument for why universities should enroll students of color. In both instances the focus is not on providing access for students of color who may not have had equitable educational opportunities instead, the emphasis is on how the wider college community and nation can benefit from the presence of students of color. And in this case the assumed college community and nation is a pre-dominantly White college community and nation where the norms of whiteness are assumed as the default (Leonardo, 2009). While there is variation in the discourse at individual universities surrounding the desire for racial diversity of the student population, a review of college admissions' websites shows that most emphasize the value of racial diversity for the broader university population. There is little to no mention of providing access and opportunity to students of color.

Students of Color at University on a Hill

University on a Hill is typical of many large research universities in the United States in terms of the racial make-up of students. Under the Carnegie Classification of Institutions of Higher Education (Carnegie Foundation, 2004) the university is classified as a medium to large private research university. The university does have a religious affiliation that informs its mission, but students come from a range of religious and non-religious backgrounds. The total student population is approximately 15,000 with 10,000 undergraduate students. White students make up 68 percent of the undergraduate population and students of color make up 27 percent of the undergraduate population with the following subgroup percentages: Asian American, 12 percent; Black/African American, 4 percent; Latino 10 percent; Native American, 1 percent. The remaining 5 percent are international students mostly from China and South Korea.

Admission practices. Similar to almost any university admission's website, the admissions page at University on a Hill features photos of students from a range of racial backgrounds and the site notes that diversity is valued and that this gives students at the university a competitive advantage. University on a Hill's reasons for recruiting and enrolling students of color seem consistent with the arguments made on behalf of the University of Texas in the Fischer v. University of Texas case at the Supreme Court, although with less explicit emphasis on the value of racial diversity.

According to Barrons (2013), University on a Hill falls into the top category of "most competitive" in terms of admissions practices. Over the past ten years the university has moved up from the "very competitive" category to the top category—something that many at the university take pride in and would like to maintain. The university has also moved up in the various college rankings based on their admissions selectivity, and the standardized test scores of admitted students. The university admissions office sees the university as one tier below the "most selective" Ivy League universities such as Harvard, Yale, and Princeton. The university aspires to attract the students with the top test scores and grades who would otherwise attend the Ivy League schools and to that end, has a merit-based scholarship program which provides full tuition and fees to a small group of students designated as leadership scholars. With the exception of this program, the university does not provide merit-based financial aid.

According to several general presentations given by representatives of the admissions office to the university community, the university seeks to maintain a student population that is 25-28% students of color. There was no mention of the university seeking to increase this percentage and in fact, according to admissions representatives, the university competes with other top tier and Ivy League institutions for the "qualified" students of color in much the same way they compete for the students would normally enroll in the Ivy League institutions. The university defines "qualified" as having grades, test scores and extracurricular activities on par with the White applicants who are admitted to the university. From the admissions office perspective, there are not enough of these "qualified" students of color in the application pool to meet the university's racial diversity goals. According to researchers, (Hoxby, Avery, & National Bureau of Economic Research, 2012) this view that there are a limited number of qualified students of color is common at many universities. However, the researchers have shown that there are many qualified low-income students of color, but these students do not apply to selective universities and the universities do very little to find and recruit these students.

The admissions representative did not articulate a rationale for the university's goal in enrolling students of color or why they seek to maintain a population of 25-28 percent for students of color. The admissions website has a link for students of color and notes that "diversity is a hallmark" of University on a Hill. On the school's website, a letter from the director of one of the organizations that supports students of color notes that the university strives to create an inclusive community that values all students' talents and culture. The web page for the school's diversity office notes that their goal is to "make diversity a way of life at the university" however, this statement is not further explained. The web page also outlines the history of the office which was previously called the affirmative action office and was started in the 1970s. According to the web site, the original goal of the office was to increase the Black student population so they made up 10 percent of the total student population. The website does not point out that today the Black student population of the university only stands at four percent.

While the focus of the university's admissions processes does result in the university admitting students of color, their presence may not necessarily be making substantive change in terms of equity. The interest convergence principle of Critical Race Theory (Bell, 1980) suggests that the purpose of a reform will shape its reach. If the admissions goal for racial diversity is satisfied only through the maintenance of a certain percentage of qualified students of color, more effort will be focused on that goal rather than transforming the admissions process and more successfully supporting the students of color in the pre-medical track at the university. While 25-28% students of color may seem like a sizable percentage for the campus enrollment at large, this number puts University on a Hill in line with the majority of other US universities and suggests that the university only does what is needed to remain consistent with other universities. As noted above, many selective US universities do little to actively recruit low-income students and students of color who would not normally apply to more selective universities.

While it is difficult to discern the university administrators' reasons for holding the percentage of students of color at 25-28%, the narrow focus on "qualified" students of color suggests that university officials are less open to admitting and supporting students of color who might not have had the same educational opportunities as White students and may require extra support and resources from the university. When one of the administrators interviewed for this study was asked about why the university limits the number of students of color, she had the following to say: "You would think that [the university] with their [religious] mission would be admitting more of these students as part of their social justice mission, but that doesn't seem to be what motivates them. It seems more like they want just enough for appearance's sake because they rarely provide enough academic support funding for these students."

The university admissions office, working with one of the university offices that supports students of color[12] does admit a small number of students of color who, in their view, do not have the same qualifications as the majority of White students. The admissions' office maintains relationships with college counselors at a network of urban public and urban Catholic schools. The counselors at these schools in turn encourage strong students to apply to the university. Generally these students have grades on par with White students admitted to the university, but their standardized test scores are lower than the university average. According to one of the administrators interviewed, "Even though the students' grades are strong, [admissions] assume their preparation is lacking because most have gone to urban schools. They have had fewer opportunities to take rigorous high school courses or to participate in extracurricular activities. We know

[12] More details about this office and the office where the McNair program resides are provided below in the section titled, "Support for students of color at University on a Hill."

these students can do well with extra support, but sometimes we have to work hard to convince the admissions people."

To evaluate these students' potential for success at the university, the office that supports students of color uses the Non-Cognitive Admissions Variables tool developed by Sedlacek (2004) to show admissions the strengths that the students possess. The tool helps assess the following factors: positive self-concept, realistic self-appraisal, ability to understand and deal with racism (or other "isms"), preference for long-range goals, availability of a strong support person, successful leadership experience (even in unconventional settings), demonstrated community service, knowledge acquired by non-traditional means (i.e. not in an academic setting.) Sedlacek's (2003, 2004) research with students of color at different universities has shown these factors to be a much better predictor of college success than standardized test scores. It should be noted that some of the capabilities measured by the tool are akin to the forms of non-dominant capital that Dixon-Román (2014), Yosso (2005) and others (Moje et al., 2004; Moll, Amanti, & Gonzalez, 2005) argue should inform research and programs that aim to support marginalized youth.

When the applicant students are evaluated through this process, there are many more students of color who would likely succeed at the university than the admissions office is willing to admit. However, the already small number of students admitted through this process has decreased over the last several years. Ten years ago, approximately 80 students—three percent of the first-year incoming class—were enrolled through this process, but currently the number has decreased to 40-45 students per year. The reason for this decrease is not clear, however during the same time period, changes were made to the process through which these students were reviewed. According to the administrator interviewed, in the past these admission decisions were made jointly between admissions and the office that supports students of color at the university. However, more recently, the collaborative process was curtailed and admissions became the primary decision maker in regard to these applicants. Previously, admissions would give the office approximately 125 applications and the two groups would work together to evaluate the students and make decisions. However, for the past few years, admissions has given the office 60 applicants and let them choose the 45 that will receive admission offers. This had the impact of limiting the office's ability to use the non-cognitive variable tools to evaluate students and for them to have a larger say in the decisions.

The administrator from the office also noted a change in the profile of students who were recommended by admissions: "They have been sending us students with more extreme hardship stories such as being refugees, foster children, very recent immigrants, students coming from violent neighborhoods, or having parents in jail. Most of these students can do well, but they often have more psychological issues that they need help with and we can get overwhelmed trying to support them. Because we have fewer applicants to choose from, we have to take more of these students." In my own experience working with these students over the past several years I had also noticed this change in student backgrounds. The other thing I had noticed were more stories on the school's website about these students and their appreciation that they had been admitted to the university.

A more systematic review of the school website and related newsletters and publications showed many similar stories about students of color. The focus of the stories is on the students' difficult backgrounds and how grateful they are to be at the university. There is also an emphasis on how the students have overcome tremendous odds to succeed—in essence reinforcing the meritocracy myth (McNamee, &Miller, 2004). The most prominent examples of this are in the university's annual news stories about exemplar graduating seniors. Every year for the past five years the university has highlighted four or five graduating seniors. One of the seniors is always a student of color, usually one who has overcome some kind of difficulty such as being homeless or coming from a very challenging school environment. For example, one of these stories highlighted a student who came to this country as a refugee at age 14, excelled in his high school and "picked up English so quickly he did not have to take any ESL classes." When the student was asked about why he enrolled at the university, his response was that there was no question of going anywhere else and he could not be more appreciative of the opportunity. Whether it is a deliberate decision or not to admit and publicize students with more difficult backgrounds, the net effect is a portrayal of the university as caring and committed to students of color who have overcome challenging circumstances.

While this approach may serve the interests of the university and positions it as benevolent and caring—consistent with its religious affiliation—it does not necessarily serve the interests of the students being admitted if there are not adequate and appropriate resources to support these students. It also positions the students as being damaged or deficient because of their backgrounds and in need of help from others. In some ways this situation also parallels the circumstances surrounding the *Brown v. Board of Education* decision. Derrick Bell (1982) argued that the Supreme Court decision did a lot to improve the image of the United States in the world, but did little to improve the educational circumstances of African American children. Other more recent scholars like Dumas (2007) have argued that the moments of brief integration from Brown v. Board of Education relied on material suffering of Black and brown children to achieve the temporary appearance of equity. In another recent analysis of the case, legal scholar Guinier (2004) noted that the case had limited power "to promote social justice because it was shaped, not by the intentional coalescing of a transforming social movement that reached across boundaries of race and economic class, but by the calculated convergence of interests between northern liberals, southern moderates, and blacks" (p. 94). Both Bell and Guinier argue that real change must be grounded in efforts that involve a broader coalition of proponents who have concern about social justice for people of color. While some members of the university may have social justice commitments to the students, some of the actions of the admissions office do not reflect this type of concern for the students.

The other possible factor in the reduced number of students of color admitted through this process was, according to one of the administrators interviewed, an increased concern about standardized test scores. "The university has moved up in the rankings over the past several years, but there is pressure to keep it there—especially with the number of college-age students going down. The admissions people have talked about the pressure they feel from trustees and alumni to not let in too many students with low test scores." This concern about rankings and test scores is not unique to University on a Hill. Recently the chancellor of Syracuse University decided to reduce the school's admittance of students from the Posse Foundation, which recruits low income students and students of color, because of concern about test scores and college ranking. This reversed the decision of the previous chancellor who had placed less emphasis on the importance of college rankings and made a decision to increase the enrollment of low-income students and students of color (Rivard, 2014).

Most of the students of color admitted to University on a Hill through this alternative admissions process are supported—or at least followed by—two university organizations that primarily serve students of color. The students who were enrolled in the McNair pre-medical science program were recruited from the populations that are supported by these two university programs. Information about these two organizations along with details on how students are recruited to be part of the McNair pre-medical program is detailed below.

Financial aid practices. At University on a Hill all financial aid, with the exception of the leadership scholars program, is need-based and the university commits to meeting students' full financial need as calculated by the university. However, for any students receiving need-based financial aid, the university does require that students and their families pay a minimum family contribution of least $2500 a year, participate in work study, and take out approximately $5000 a year in loans. In the case where families or students are not able to cover the minimum family contribution, students often take out additional loans. This was the case for five of the eight student participants in the study. Only Fatima, Alana, and Juan did not need to take out these additional loans because they had received small outside scholarships.

An argument could be made that students should have been aware of these financial aid policies and that they had opportunities to compare the financial aid offers from different schools. However, University on a Hill does not make this information easily available on their financial aid website. There is mention of the expected family and student contribution of $2500 per year, but the yearly loan amounts are not listed on the website. This information was only obtained through my interviews with the students, reviews of their financial aid letters and through other sources such as the website www.finaid.com (Finaid, 2013) which compiles the average student loan amounts taken per institution. When the students in the study initially received their financial aid packages, many of the students in this study did not immediately understand the difference between university grants and loans. In previous interviews with students of color, (De Rosa, Guerrero, Pacheco, & Sterling, 2013) most were graduating with loans of $30,000-$50,000 primarily because their families were not able to provide any extra financial support including the required family contribution. The student with the highest loan amount of $50,000 was considered by the university as an independent student because she had no contact with or financial support from her parents. However, the university still required her to make the $2500 annual family contribution and did not account for her food and housing costs during the summer. She took out additional loans to cover the family contribution requirement and the additional expenses she incurred for food and housing during the summer months.

These financial aid practices at University on a Hill, with a required family contribution and annual loans, are consistent with many of the other institutions in this “most selective” category. Only a few schools in this category like Brown University and Duke University have instituted no-loan policies and do not have a family or student contribution requirement for students with family incomes below $40,000 (Finaid, 2013).

Amherst College has a policy of no loans and no family or student contribution for students below certain income levels. Further, Amherst increases the aid for travel so that students are able to stay connected to their homes and families and so that family members can visit students during the campus family weekend (Aris, 2012). University on a Hill does not consider travel to and from the university as part of the cost of attendance and thus financial assistance is not provided for this expense. Studies have found that universities with no-loan and no family contributions policies enroll more low-income students and students experience less financial stress during college and are more likely to graduate (Avery, & NBER, 2006; Castelman, Long, & NBER, 2013; Rothstein, Rouse, & NBER, 2007).

Most of the students interviewed for this study did not know that these financial aid policies differed across universities. Several noted that they opted to attend University on a Hill because of its wide name recognition and because their family and high school counselors emphasized the university's reputation as well. Tran relayed what her biology teacher had said: "She had gone to [the university] and she told me that whatever it cost me, I should just do it because it was so worth it. But, she didn't have to take out any loans so I don't know if it was good advice from her."

Several of the students also stated that University on a Hill had given them more money than other schools. However, in examining and comparing financial aid letters, several of the students had financial aid awards from other schools that had more grants and fewer loans. Burdman (2005) notes that this difficulty in understanding often confusing financial aid letters is a common problem that disproportionately impacts students of color. This was the case with Sharon who had opted to attend University on a

Hill over a historically Black university that was her first choice. In looking at the award letter from the other school, it seemed to offer less money, but that was because no loan amounts were listed. When she realized the impact of her decision she was upset: "Oh my god, I could have gone there. I wish someone could have helped me with this, but I didn't have anyone at home or school. My counselor was so surprised that I got into [the university] that she said I shouldn't consider anywhere else."

Most of the schools that had offered better financial aid packages were, according to the Barron's ratings, "highly selective" small liberal arts colleges. Several of the students did understand the differences in the aid, yet still opted to attend University on a Hill because they felt the school had better name recognition. Ironically the research shows that students of color are more likely to graduate with science degrees from small liberal arts colleges than from large research universities (Cech, 1999; CIC, 2014; Tobias, 1993). Researchers (CIC, 2014) found the greater success for students was connected to the role of faculty:

> This may be attributed to the faculty's emphasis on teaching, smaller class sizes, mission-centered curricula, and the fostering of active forms of pedagogy that keep students connected to the process of learning in meaningful ways… A student who encounters academic difficulty is at risk of abandoning a major in a STEM field without help from a faculty member in getting back on track, a distinctive role of faculty members at small and mid-sized private colleges and universities (p. 21).

Also, specific to Sharon's desire to attend one of the historically Black colleges (HBCUs), Hurtado et al. (2011) found that African American students have much greater success in science at HBCUs compared to predominantly White institutions. The implication of these findings suggests that students pursuing science fields might be assisted with the resources to more carefully choose their colleges.

Science course structures at the university. All of the introductory pre-medical biology and chemistry sciences courses at University on a Hill are taught primarily through a lecture and textbook based approach. There are also biology and chemistry labs that students take to learn hands-on skills. However, the labs are independent of the lecture courses and do not generally build on and reinforce the content of the courses. The lecture courses are large with a maximum class size of 225 for chemistry and 150 for biology. The biology courses do not have a required discussion section and students are not generally assigned any problems or homework assignments to reinforce the material. The chemistry courses do have a required discussion section with a maximum of 30 students. In the chemistry course students are assigned problem sets and the discussion sections, usually run by a teaching assistant, and are intended to be a venue where students can receive help with the problems. Generally exams make up the major portion of the grades in both biology and chemistry and the grades for those exams are determined by a normal distribution curve. There are normally two or three exams during the semester and an end-of-semester cumulative exam. For the new McNair pre-medical program, some of these course structures and elements were changed and are detailed in a later section.

University grading practices. The majority of students admitted to University on a Hill have been the top ranked students in their high school classes and are accustomed to receiving high academic grades. This creates a competitive environment when it comes to grades at the university, both because students expect high grades and because they are now competing with other top students like themselves. In addition, in the student information system, students can see both their grade point average, and their class rank in comparison to all the other students in their class which serves to reinforce the sense of competition. Fatima, the student from Afghanistan, was surprised when she saw this ranking: “It’s not like I don’t know I’m already behind in coming here. Now I have to see just how low I am compared to all everyone else.”

Because most students attending the university are high achieving with good grades and test scores, they should all be able to do well in the academic courses. Theoretically this could result in a situation where students, if they were evaluated based on mastery of course materials, would all receive relatively high grades. However, like many other schools, (Berrett, 2012; Young, 2011) University on a Hill is quite concerned with grade inflation or grade compression where most students in a course receive As and Bs. The academic deans at the university exert significant pressure on the department heads and faculty to limit the percentage of high grades in a course. Pressure is especially directed at instructors in humanities and social science courses where the average grades in classes range from B+ to A-. In contrast, the average grades in science courses at the university are much lower and range from C-to B-. Often the science courses are held up as examples of departments who “hold the line” on grade inflation. Most of the introductory science courses are large lecture classes where instructors assign grades based on a normal distribution and this is the primary reason for their lower average grades.

This pressure on faculty around grade inflation impacts the grading practices in various ways depending on the disciplines. In my role as an instructor, I have attended many university meetings where this topic has been discussed. For the humanities and social science courses, the instructors are pressured to limit the number of high grades and increase the distribution of grades to prevent what administrators have termed “grade compression.” The impact of this pressure is that even instructors who are evaluating students based on mastery of material or on meeting specific criteria, feel some pressure to artificially create a grade distribution where small differences in performance result in lower or higher grades. Even in “introductory” courses this means that students who have less preparation or experience with particular subject matter are more likely to receive the lower grades. Students who possess the preferred academic capital (Bourdieu, 1986) can better meet teacher expectations around class participation, deportment, punctuality, willingness to meet with a teacher and even writing and speaking patterns. These factors not directly connected with mastery of the material end up being the factors that instructors use to make decisions around grades. The pressure around keeping grade inflation in check makes it less likely that this rewarding of preferred cultural capital will be questioned.

The students of color at the university, many who are first-generation college students and have attended urban public schools, may have different academic capital than the White suburban students whose parents attended college, and this capital is often obscured by the preferred forms of capital. For bilingual students, grammatical or syntactical errors in their writing may also disproportionally and negatively influence teachers’ assessments of their work. Researchers have also have found that college instructors may have lower expectations for students of color and are more likely to give them lower grades (Richardson & Skinner, 1992; Nelson, 1995; Treisman, 1992). The researchers note the case of one student who received a D on a particular paper because the instructor thought the paper sounded “too good” and that the student could not have written it (Richardson & Skinner, p. 36). More current research (Hurtado et al., 2011; Milkman, Akinola, & Chugh, 2014) has also identified patterns where faculty members are less likely to respond to and act as mentors to students of color.

For the science faculty at University on a Hill, all of whom are White, some of these more subjective judgments and grading practices are also likely at work in their assessment of students and may be related to the expectations they have for how students should conduct themselves in relationship to the course materials and the instructor. Sometimes faculty members articulate these expectations, but often times they do not. Even when they make things explicit, there may be significant variations between teachers making it difficult for students to generalize expectations from course to course. In the following excerpts from the syllabi of two similar biology courses, there are very different expectations for what students should do when they do not understand the material. In one introductory biology syllabus, the following instructions were given:

> [The course management system] site for this course will contain additional material necessary to negotiate this course, including the syllabus, course guidelines, lecture slides, and grade management. Please check this site daily for new material and to keep up with class. We will also use [the course site] as a forum for class discussions. A series of discussion threads will be set up for each chapter of the book. **<u>DO NOT email questions about the course material to</u>**

the instructors – you will be redirected to [the course site]! (Emphasis in original.)

In contrast another biology course syllabus had different instructions and a very different tone:

> Our Expectations for You: We expect you to make clear to us when you don't understand something, preferably by asking questions in class, where other students will also benefit from clarification. Alternatively, come see us during office hours or send a note via e-mail. We can't know whether we have explained things clearly or not unless you give us feedback in the form of questions. It is our responsibility to help you learn, but what you learn will depend on your efforts in doing the reading assignments, attending class regularly, and asking for help when you need it. **You should never feel that a question is too trivial.** If you understood everything about biology, you wouldn't be taking this course. (Emphasis in original.)

In the first example, a student might be penalized for emailing the instructor for help. However, in the second example, students might be rewarded for the very same actions. In these two examples the instructors have at least articulated their expectations. In a review of five other syllabi from introductory biology and chemistry courses no information was provided on this topic or on the other subjective ways that students might be evaluated.

However, the bigger impact to the science grades of students of color comes from the practice of assigning grades based on a normal distribution which privileges, statistically, those students with school-like scientific knowledge. Because the science courses are held up as examples of courses that do not have grade inflation there is little incentive for the faculty members to critically examine their grading practices or look for alternative means of assessment. The practice of using a normal distribution for grading means that some students will do very well and other students will do poorly. Because some students do well, it is perhaps easy for instructors to assume that their teaching was what led students to learn the material or that those students are smarter. They are less likely to consider that the students who did well might already know the material from their high school coursework even though they often make that assumption about students' background knowledge. While first-year chemistry and biology courses are labeled as introductory, most of the students, a majority of whom are White, attended private or suburban schools where they have taken several years of these subjects in high school and the instructors often assume a considerable level of background knowledge.

Fatima, one of the students in the study, noted that the chemistry instructor frequently skipped certain material and made comments like "I know you already know this, so I'm not going to spend any time on it." However, this was material that Fatima did not know, and she struggled to figure out how to learn the material that was not covered. On the exams in the chemistry course—which were the sole determinant of students' course grades—the instructor also assumed a certain set of background knowledge. After one of the exams where several students scored very well, according to Alana this same instructor noted to the class "Every year students get smarter and do better on the exams. Next time I am going to have to make the exam harder and raise the curve so people better be ready." Fatima noted that she had no chance to be a top scoring student on the exams since she was always trying to learn the material he did not cover.

"Even if I learn everything he covers, I will still be at the bottom of the curve because I don't know what the other students learned in high school."

Grading with a normal distribution curve also makes it easy for instructors to assume that the students who did not do well failed to do the necessary work. This majoritarian narrative about students' short comings is a common refrain from instructors. Nelson (1995, 2010) examined surveys of the explanations instructors give about why students of color consistently receive lower grades in college science and math classes. Nelson notes that, "All suggestions (save one) proposed that something was wrong with the students (a motivation gap, inadequate preparation, lack of family support, or just a function of income), thereby exonerating the faculty of culpability for the lower achievement" (p. 166).

These explanations by faculty point to their views about the kinds of academic capital they sanction and connect to success in the science courses. While Bourdieu's theories of capital addressed the reproduction of class inequities, the explanations by instructors of why students of color do not succeed shows how racial differences become linked to the preferred and expected capital and why students of color are seen as simply lacking capital rather than possessing other kinds of capital. If instructors repeatedly see that White students are at the top of the grading curve they begin to conflate White students' capital and habitus—their habits, deportment, and disposition—with intelligence (Bourdieu, 1986). They also come to see the White students' capital and habitus as the norm or the standard for what all students need. When instructors see that students of color are most often the ones at the bottom of the curve they conclude that students of color are lacking these same things. This prevents them from looking for more systemic reasons—including their own teaching practices—for this racially based discrepancy.

However, in using the framework of Critical Race Theory what comes into sharper view are the systemic practices that disproportionately impact students of color. Using this lens it is more apparent how some university teaching and grading practices advantage White students and disadvantage the students of color who have often had different high school preparation than that of White students. In Nelson's (1995) analysis of racially based inequitable outcomes in science he concludes that:

> All traditionally taught college courses are markedly biased against many non-traditional students and, indeed against most students who have not attended elite preparatory schools. Thus when we teach merely in traditional ways we probably discriminate strongly on grounds quite different from those we intend (p. 165).

While Nelson does not use Critical Race Theory his argument points to one of the ways that racial advantage and disadvantage come to be intertwined with university practices and how those practices at first glance do not appear to be connected with race at all.

This analysis of how the admissions policies and grading practices impact students of color at University on a Hill is consistent with the findings of Chang et al. (2008) about how science coursework structures, including grading practices, function at highly selective institutions. Because the assumption is made that all students are on equal footing, limited resources are provided to compensate for students' prior preparation. When some students do better than others, it is assumed that they are simply the students more likely to do well in later science courses. This "weeding out" of students is not considered problematic; it is simply a way to identify the brightest students and it works from the assumption that intelligence can be objectively measured. Despite the demographic data of who persists and who drops out of the programs, this process is not seen as an institutional structure that advantages whites over students of color (Chang et al., 2008. At University on a Hill, because the science departments are praised for holding the line on grade inflation and in achieving a high medical school acceptance rate, they would seem to have even less reason to examine the impact these practices have on less prepared students.

The two administrators interviewed for this study provided similar perspectives on how some of these issues play out at the university. The first administrator recounted conversations with a chemistry instructor about a first-year student of color who was not doing well in introductory chemistry: “[The instructor] told me that [the student] was just not prepared to take chemistry and there was not much he could do about it and it wouldn’t be fair for the other students to slow down. He said she should wait until she got a better background, but when I asked him how she could do that, he had no idea except to maybe take a summer course at a community college.” The administrator commented that many of the students of color she worked with had trouble with the science classes, but she had never heard a teacher be so blunt about assessing a student’s chances in the course.

The other administrator echoed some of the points made by Nelson (1995) about teaching practices and grading. “I have often talked to the [science] teachers about these students and what kinds of help they need with the material, but they always make it about the students and never about the way they teach and run the classes…We have also had several workshops about grading and assessment. The idea has come up from other teachers about grading based on mastery of the material and not on a curve. But the science teachers—especially for pre-med and nursing classes—always defend their grading saying that they are just making sure students can do well on the entrance exams."

The administrator went on to talk about what she had seen with some students in the science classes and how their science grades did not correlate with their outcomes in other contexts. "I disagree with that argument about the grading being an indication of how they will do on the MCAT [Medical School Admissions Test]. I have known students who barely passed the [science] classes here, but were getting As in all their other classes. Something seems wrong when that happens. Some of those students left [the university] and went on to do very well in post-baccalaureate pre-med or nursing programs and they did fine on the entrance or certification exams. I think if they had gone somewhere else they could have done well."

Support for students of color at University on a Hill.[13] The university has two organizations directed at supporting students of color who, in the university admissions office view, are underprepared for the academic and social challenges of the university. One organization is funded by the university and the other, where the McNair program is housed, is mostly funded by federal grants from the US Department of Education. During the academic year the organization funded by the university primarily provides social and psychological support for students of color. During the summer, this office runs the six-week summer academic program for incoming first-generation college students from

[13] The information about the two programs was primarily gathered through the interviews with the two administrators. Information specific to the new McNair pre-medical program primarily came from the biology faculty members and to a lesser extent, one of the administrators. Some of the information came from a review of the university website and some came from my own work with one of the programs and with students who have participated in the programs.

which the students for this study were recruited. The academic component of the program is focused on math and English, but there is no special support in the program for students in the science classes. This is the program that in the past has enrolled 80 students in the summer academic bridge program, but now only serves 40-45 students per summer. Given that the freshman class is comprised of approximately 800 students of color, the program serves a very small number of students who could potentially benefit from the program.

The office has been in existence for 25 years and traditionally their primary focuses had been helping students adapt to the university environment and they were not generally focused on challenging the larger university community about issues faced by students of color. However, the program administrators would advocate on behalf of individual students when they had either social or academic difficulty. More recently this office has been working to more directly engage members of the university community by using Critical Race Theory to inform their work with students, faculty and university administrators. All of the staff in the office participated in a one year bi-weekly seminar where they read some of the scholarship related to Critical Race Theory. They then used the readings and ideas to revise their mission in terms of their role with the university and with students. For example, in workshops they have used Tara Yosso's article, "Whose Culture Has Capital: A Critical Race Theory Discussion of Community Cultural Wealth" to educate faculty members, first-year orientation leaders and residential staff on the rich experiences and cultural capital that students of color bring to the university.

The earlier approach used by the office is typical of the support programs at many predominantly White universities where the focus is to help students adjust to the expectations of the university rather than better educating the university community about the challenges and strengths of students of color. Many of the programs focus on social and psychological adjustment and getting students integrated into campus life. Underlying many of these support programs seems to be the college student retention framework put forward by Tinto (1987) which suggests that students are more successful if they become academically and socially integrated with mainstream campus culture. The work by Tinto is widely cited in the literature on college retention of students of color. However as noted earlier, some researchers (Bauman et al., 2005; Landry, 2002; Museus & Quaye, 2009) have critiqued these student retention models because they locate the problem with the students and fail to consider the possibility that the issues reside with institutional or societal factors.

Another critique of these programs is that they make simplistic assumptions about students which lead to programs that attempt to superficially address only some of students' needs. Richardson and Skinner (1992) note that "many of the prescriptions for improving minority achievement are based on excessively simplistic perceptions of who minority students are" (p. 30). After doing a comprehensive review of the research and of existing support programs, Kuh et al. (2007) argue for a more complex understanding of what students need: "We take a cumulative, longitudinal view of what matters to student success, recognizing that students do not come to postsecondary education *tabula rasa*. Rather, they are the products of many years of complex interactions with their family of origin and cultural, social, political, and educational environments" (p. 3). Kuh et al. also conclude that college programs tend to focus more on what they can do once students make it to college rather than trying to understand how their different backgrounds intersect with particular college environments. In framing their recommendations they also emphasize that each institution has a different mission, student characteristics and campus culture and that all those factors must be considered with any kind of program.

The McNair Program at University on a Hill

The second organization that supports students of color at University on a Hill is the McNair program which is one of the TRIO programs funded by the US Department of Education. The focus of the program is on providing students with academic skills for both undergraduate and graduate work. The program is funded and administered by the federal government and there is limited flexibility in how universities can implement the program. This kind of one size fits all program reflects some of the problems that Kuh et al. (2007) raise about college support programs not being attuned to the range of student backgrounds and the different institutional contexts. For example, the McNair program at University on a Hill helps students acquire the skills needed for undergraduate coursework primarily through a course on learning theory applications, but the curriculum for the program is provided by the US Department of Education and cannot be changed based on student needs. This organization where the McNair program resides also runs a summer session for 30-40 students, but it is a shorter two week program that is intended to familiarize students with the campus and the university resources. This organization is also where the new McNair pre-medical support program is housed, although this program is funded directly by the university.

As noted in Chapter One, the McNair program is one of eight TRIO programs funded by the US Department of Education. The McNair program at University on a Hill is one of the 157 McNair programs at universities across the United States. (McNair Scholars Program, 2013) According to the TRIO program's website (US Department of Education, TRIO Programs, 2013) the TRIO programs are, "outreach and support programs targeted to serve and assist low-income, first-generation college students, and students with disabilities to progress through the academic pipeline from middle school to post baccalaureate programs" (para. 1). The TRIO programs came out of Lyndon Johnson's 1964 Economic Opportunity Act. At its inception, there was only three programs, hence the name TRIO. The first three programs created were Upward Bound which supports middle school and high school students, Talent Search to assist students with college application and Student Support Services to support students in completing undergraduate degrees (McElroy & Armesto, 1998).

The McNair program, created in 1986 was the fifth TRIO program and is specifically focused on increasing the number of students who pursue post baccalaureate degrees. The program's website (US Department of Education, McNair Program, 2013) describes the McNair program as follows: "Through a grant competition, funds are awarded to institutions of higher education to prepare eligible participants for doctoral studies through involvement in research and other scholarly activities. Participants are from disadvantaged backgrounds and have demonstrated strong academic potential." The program typically focuses on undergraduate students in their junior year. The students identify an academic area of interest and are assigned a faculty mentor who can guide the student's research and help the student with graduate school preparation and applications.

Research that has looked at the McNair and other TRIO programs has found the programs to be of value in developing and supporting students' aspirations for education beyond secondary school. Students benefit the most when their involvement is sustained over several years between high school and college—something most students do not experience due to the lack of coordination between secondary schools and college programs (Balz & Estan, 1998). For the McNair programs the results were also better when there was a commitment and coordination between the program and the larger educational institution. However that did not happen with the majority of programs and administrators often noted difficulty influencing some of the university policies and faculty members (Grimmett et al., 1998) The researchers also examined the experiences of McNair participants at private research institutions and found that while some components of the program such as the mentoring were well implemented other aspects such as faculty direction in helping students with meaningful research were inconsistent. Overall the main critique of the TRIO programs is their inability to reach a meaningful proportion of students who would benefit from the programs and to sustain student's involvement from secondary school to post-graduate. (Balz & Estan, 1998). While the various TRIO programs provide support at the different educational levels, there does not seem to be any attempt to work with cohorts of students and follow them between institutions and similar to Kuh et al. (2007) to customize the programs for different students and institutional contexts.

While researchers urge the expansion of the programs to support more students, one of the ongoing challenges is the level of funding for the TRIO programs overall within the federal budget—a context that is deeply influenced by a political climate in which there is mixed support for educational programs for students of color and conservative concern about the growth of government programs. It should be noted that none of the TRIO programs directly talk about supporting students of color, but instead put the criteria in colorblind terms like disadvantaged, low-income, first-generation college students. This framing of the problem by the TRIO administrators keeps the TRIO programs separate from race-conscious affirmative action programs, which also obscures the role of institutionalized racism.

The funding decisions for the TRIO programs are also not immune to other national concerns around economic competitiveness. As noted in Chapter One, the funding situation that led to the creation of the McNair pre-medical program at University on a Hill was the US Department of Education's decision to shift some of the TRIO funding from the McNair program to the Upward Bound Math and Science program to increase students' interest in science at the high school level. That put at risk the funding for University on a Hill's McNair program in the upcoming grant competition. According to one of the science faculty members interviewed for the study, the university administrators were mindful of the increased emphasis on science, and created this more science-focused McNair pre-medical program with the hope it would make their McNair program more competitive in the grant renewal competition.

New McNair Premedical Science Program at University on a Hill.

The director of the McNair office, an African-American, has worked at the university for many years. He has long been concerned with the high attrition rate for students of color in the science courses. Among students of color he has a reputation for both trying to help them with strategies for the science courses and in counseling them to switch majors when a pattern of poor grades in the science courses threatens their GPA and overall retention at the university (De Rosa, Guerrero, Pacheco, Sterling, 2013). The

McNair office like the other office that supports students of color at the university is mainly focused on directly supporting students, but the program administrators at times work to educate the broader university community on the challenges faced by students of color. For example, the office has emailed faculty members on occasion to explain the challenges that students from non-dominant backgrounds face, such as the high cost of textbooks and they encouraged faculty to put copies of all the course texts and materials on reserve at the library.

According to one of the faculty members interviewed, when changes were made by the US Department of Education regarding funding for the McNair programs, the director of the McNair office saw an opportunity to do something to better support the students of color in the science courses and to be in a more competitive position for the upcoming grant competition. The university administrators did not want to lose the federal funding for the program and were willing to devote resources to the new program. This pragmatic set of decisions where the needs of minoritized students are not addressed until it is in the larger interest of the university is consistent with the interest convergence principle of Critical Race Theory (Bell, 1980; Guinier, 2004). While this kind of motivation to formulate a new program is not in itself problematic, it cannot be presumed to be an indication that the university administrators are committed to transforming longstanding practices at the university that negatively impact students of color in the science classes. That kind of commitment would have to be evident in the design and impact of the program.

In the situation at University on a Hill, the time frame in which the program was implemented did not afford a careful and thoughtful analysis of the issue or design of a new program. The news about the funding changes for the McNair program came in April. In May the university provost's office agreed to provide the funding for the new McNair pre-medical support program which had to be put in place by September. The result was a quickly conceived program that was not, for the most part, informed by any specific research on students of color or a theoretical framework of inequity that could guide the initiative. Instead of working to understand the students' interests, capabilities, and educational and language backgrounds, the general assumption was that students were lacking in the science knowledge, skills, and interest that were necessary for doing well in the college science courses. More significantly there was little effort to assess the environmental and university factors that might be contributing to students' difficulties with the classes.

Structure of the McNair pre-medical program. The overall approach of the program was to provide extra support to help the McNair students make it through the regular pre-medical program. The normal recommended pre-medical sequence of courses at the university consists of the following courses for the first semester: introductory cell biology (3 credits), introductory chemistry (3 credits), chemistry lab (1 credit), calculus (3 credits), and two other university core courses (6 credits). These courses are a total of 16 credits and are quite challenging, especially the combination of biology, chemistry and calculus. Students have the option of taking only one or two of these courses (e.g. biology and calculus); however, the pre-medical advisors encourage students to follow the recommended sequence. According to Tran, one student of color who was not in the McNair program did not want to take both chemistry and biology but was told by his pre-medical advisor, "If you can't make it through these courses, how do you expect to make it through medical school." This comment captures the competitive and military boot camp mentality that is typical of medical school and is suggestive of how these pre-medical courses are structured to narrow the number of students who can eventually apply to medical school (Coombs & Virshup, 1998; Takakuwa, Rubashkin & Herzig, 2004)

For the new McNair pre-medical program, there were some minor changes to the regular set of pre-medical courses. Students were required to take biology and chemistry, but did not have to take calculus. There would also be an introductory life sciences course that students would take before the regular cell biology course. The McNair director worked with the provost and administrators from biology and chemistry departments to formulate a plan for the new program. Faculty members from the biology department took the lead in formulating the program course structure which consisted of the following: 1.) A new fall biology course and discussion section just for the McNair students that would precede the regular cell biology course which they would take in the spring, 2.) A spring section of the regular cell biology course and discussion section, but only for the McNair students, 3.) The regular, large, lecture-style introductory chemistry course and lab taken with other university students, 4.) An additional chemistry discussion section for the McNair students with extra problem sets formulated by the instructor, and 5.) A one credit advising seminar where the McNair students would learn about larger issues in science and have a place to discuss any challenges they were facing in the science courses. Along with these courses, McNair students would also take two other university core courses. While the intent was to provide the McNair students with extra help, these courses totaled 18 credits—two credits more than the 16 credits for the regular pre-medical students.

One common concern expressed by students throughout the year was that they spent so much time in these various discussions and advising sessions that they had little uninterrupted time to study on their own and figure out how to learn the material. Tran, one of the McNair students made the following comment:

> I didn't really learn how to study science in high school, but we spend so much time doing things the way they [the McNair teachers] think we should, but it doesn't really help me learn what I should be doing. Doing the extra chemistry problems is just more of the same and doesn't help me. I try to read the textbook but I still don't get the material and I don't have any time to figure out the best way for me to study and learn the material.

Similar comments about the lack of time and the rigid approach to learning were repeated by other students in the program. Sharon noted that "They treat us like we can't figure things out by ourselves. Instead of making suggestions of things to try, they tell us exactly how to solve a problem." Sean was having difficulty with the amount of time he had to spend doing all the extra problems and in the advising class. "They think that they are helping, but I have my job and all of this makes it hard to actually spend the time I need studying." All this work by the program directors to structure students' time and efforts seemed intended to make up for something they thought was lacking in students' backgrounds that more well-off White students already possessed through the concerted cultivation of science knowledge they had experienced at home and in school (Lareau, 2003). While the students might have benefited from assistance in gaining certain study skills, however because the program directors had taken little time to understand their specific needs, the students instead found the extra work to be a distraction and hindrance to their studying efforts.

Recruiting students for the new McNair program. Because of the short time frame to implement the program, there was little time to recruit students and help them understand the details and purpose of the program. As noted above, there are two summer transition programs at the university that support incoming students of color at the university. The students are required to attend these programs because they had been identified by the university as "at risk" given their standardized test scores, income status and the nature of the high schools from which they graduated. The decision was made by the McNair program to target the students already attending these two summer programs. Within these two programs, the McNair administrators further targeted the students who had declared a pre-medical concentration. Students in each program were provided with a brief, 15-20 minute overview of the program. Students were told that they would take biology, chemistry, and a special advising class and that the program would provide extra academic support for students interested in the pre-medical program or other life sciences majors.

According to several students who attended the overview, they were not told that the program was targeted at students of color and many were surprised on the first day of class when they realized that the biology class was almost all students of color. Some of the students were not bothered by this, but several students in this study felt they were being segregated and/or labeled as having as not being prepared. Other students however thought they were being targeted at the summer orientation program based on skin color.

One of the McNair administrators, a biology department faculty member also served as an advisor during the summer student orientation program. The administrator had been assigned to work with Sharon at the orientation. Sharon offered the following perspective on the recruitment process: "At first she kind of ignored me but when she found out I was pre-med she got all excited and started telling me about the [McNair] program. There was another pre-med White girl in my orientation group, but [the administrator] didn't pay any attention to her. It was like she saw my Black self and wanted me to be in the program. At first I didn't want anything to do with the program, but I decided to at least try."

These various recruiting efforts to enroll students in the program contributed to the problematic feelings the students already had about attending one of the required summer transition programs. Sharon articulated the concern voiced by several students: "I just finished going to [the summer transition program] and I thought that was over. It took me all summer to get over feeling like I wasn't good enough for [the university] and then I walked into that class and it started all over again." This is in contrast to the general message given to White students that they have been admitted to the university because they are exceptionally talented and high achieving. The pre-medical students in the two summer programs were not required to be part of the new McNair program, but those who did not initially enroll reported feeling pressured by the biology faculty members. By the end of the summer all but two of the pre-medical students in the summer programs had relented and enrolled in the program.

This rushed recruitment and communication process for the McNair program is in profound contrast with the approach used by the Meyerhoff Scholars program at the

University of Maryland. The program significantly increased retention of low-income Black students in science majors (Hrabowski & Maton, 1995; Maton, Hrabowski & Schmitt, 2000) by providing an integrated set of support services which included the following: Integration into the science departments and programs; science knowledge and skill development; full financial support; faculty research mentors –especially faculty of color; and ongoing monitoring and advisement. Admission to the Myerhoff program is lengthy and competitive and instead of students feeling like they were pushed into a program because of some deficit in their background, the admitted students feel a sense of accomplishment (Hrabowski & Maton, 1995; Maton, Hrabowski & Schmitt, 2000). The program receives approximately 1400 applications a year. The field is narrowed to 100-150 students and those students and their families are invited to the campus for a weekend where they learn more about the program. Ultimately 40-60 students are accepted into the program each year. Through that process the students were able to gain a much more in-depth understanding of the program's purpose and approach.

While it is understandable that the McNair program had to quickly recruit students for the first year of the program, the program continued for the second year and the recruitment process was the same. The McNair program could adopt some of the recruitment and communication approaches used by the Myerhoff program. The profiles of the accepted students in the Meyerhoff program are similar to the students in the McNair program. All are low income and most attended urban public schools and achieved top grades, but reported lower standardized test scores (Hrabowski & Maton, 1995; Maton, Hrabowski & Schmitt, 2000). Changing the McNair recruitment approach could position students as capable scholars with the potential to succeed in the science programs rather than conveying to students that they have deficits that increase their chance of failure and that their stories are ones of damage that they need to overcome.

Science faculty members involved with the program. As previously noted, the program details had to be put together very quickly during the summer. One of the challenges was getting science faculty members integrated into the program. According to one of the instructors interviewed, two faculty members from the biology department agreed to co-teach the new biology course for the students. One teacher, Dr. Lake would design and teach the new introductory life sciences course in the fall and Dr. Burke would serve as the course assistant. In the spring, Dr. Burke would teach the regular cell biology course, but a small section just for the McNair students. Finding a faculty member from the chemistry department to participate was more challenging and was not finalized until the very end of the summer. Finally one of the chemistry faculty members agreed to participate. However, this instructor did not have any specific experience working with students of color and in my own experience in working at the university I know he had a reputation of being the hardest chemistry teacher in the department. However, according to one of the biology instructors interviewed, “He might be hard, but he does this so that students can really be prepared for later chemistry work. And he really does want to help these students so that should help.” The McNair program administrators decided that students would attend the regular large lecture chemistry class and the instructor would create supplemental problem sets for the students and work with the teaching assistant who would run the separate discussion section for the McNair students. This meant that the students would have the regular problem sets to complete along with the extra problems specially created for them. However, as noted previously students saw this extra work as not helpful and more importantly it reduced available study time in their already difficult schedules.

CHAPTER SIX: The Fall Biology and Chemistry Courses

In the previous chapter I provided the broader context of the university environment including the admissions, financial aid and grading practices, the structure of the science programs, and the programs and structures intended to support students of color at the university. This chapter, which covers the fall semester and Chapter Seven, which covers the spring semester, are intended to provide different vantage points including the students' and teachers' experiences and perspectives within the context of specific McNair pre-medical program courses. Throughout these two chapters I also include analysis that utilizes the theoretical frameworks of Critical Race Theory and theories of capital.

During the fall semester I primarily focused on the biology course where I observed every class during the semester and where I was given access to all of the course materials. The observations of the fall class were the focal point of my data collection and I used these class observations to inform my ongoing interviews with the eight students and the two biology instructors. The fall class met twice weekly and I attended every class, except on days when there were exams. Throughout the semester I conducted both formal and informal interviews with the students and the instructor. This was the same instructor I observed and interviewed during the pilot study (De Rosa, 2013) and some of the information from that previous study is included here as well. Additionally, I provide some perspective on the chemistry course based on what I learned from students during the interviews and not through any course observations or teacher interviews. I also include a view of other issues students were experiencing in other areas of the university during the fall semester.

Seven of the eight student participants in the study completed the fall biology course, but only three of the eight students completed the fall chemistry course although they stayed in the course until the final withdrawal date two weeks before the end of the semester. The fall outcomes for each student are summarized in the following table:

Table 3: Fall Student Outcomes

Student	**Fall Biology**	**Fall Chemistry**
Biju	Completed	Completed
Fatima	Completed	Completed
LeeAnn	Completed	Completed
Sean	Completed	Dropped
Alana	Completed	Dropped
Sharon	Completed	Dropped
Tran	Completed	Dropped
Juan	Dropped	Dropped

Instructional Goals and Assumptions

Several, sometimes contradictory goals—preparing students for the cell biology course, generating interest in science, and using inquiry-based instructional approaches—seemed to inform the design of the fall biology course. During interviews Dr. Lake articulated some of the objectives she had for the course. “So many students come to college excited about science, but we are pushing them away with how we teach the introductory courses. We have to make it more interesting and relevant. Getting students to focus more on knowledge application and inquiry-based science will help them learn the core things they need for later classes."

Dr. Lake had been teaching at the university for over ten years and frequently taught the introductory cell biology course. Normally the course was taught as a large lecture and textbook-based course with little interaction between students and the instructor. For the last two years, Dr. Lake had been following the literature and arguments from the journal *Science* (Handelsman et al., 2004; Stokstad, 2001; Wood, 2009) about the value of teaching college science in a more inquiry-based manner. She had attended a training session for college biology teachers at the Howard Hughes Medical Institute (2013) which strongly advocates for inquiry-based science education and uses some of the ideas and research from the journal *Science* (Handelsman, Miller, Pfund, 2007) in their instructional materials. Dr. Lake had incorporated some of these inquiry-based science activities into her large lecture-style courses and as she worked to design the new fall course for the McNair program, she saw an opportunity to substantively implement some of the inquiry-based teaching approaches that she had been using in the larger cell biology class. "I think they involved me in the [McNair] project because I have been working on teaching science in a different way in the [regular cell biology] for many years." She did not have a particular interest in working with the population of students who would be part of the McNair program, but she was supportive of the goals of the program. "I don't know a lot about the students, but I know they often don't end up continuing in science. I did work with a student during the regular summer McNair program and I helped her with research on endocrine disruptors in fish embryos."

As the instructor worked to design and teach the new fall course for the McNair program, her assumption was that these inquiry-based approaches would help students' master key science concepts and thus be better prepared for the spring course. "If students learn to apply knowledge through more active learning, they should have a better foundation in the concepts." However, this key assumption was never tested or fully examined by the program administrators or the instructor in terms of how this teaching and learning approach would transfer to the way students would need to learn in subsequent science courses. For example, even though students would have to rely on a textbook in the spring course, Dr. Lake decided not to use the textbook in the fall course as the main source of science content. She did require that students purchase the book with the intent of using it to supplement the course material, "They will use it was a reference when they don't understand some of the content." However, there was little reference to the book during the course and students were a little confused why they had purchased the book. Several like Biju, the student from Nepal, noted a desire to be able to use the book: "It would be so much easier to know what to read in the book instead of trying to follow the different things that she covers in the class. Sometimes I try to match up the book to the different things [in class] but it is kind of confusing and the book is really hard to read and understand."

Biju, like several of the students in the study was bilingual and had only learned English when he came to the United States at age 13. When the instructor was interviewed for the pilot study (De Rosa, 2013) she had noted that she had little direct experience working with bilingual students and students of color who had come from backgrounds similar to those of the students in the McNair pre-medical program. While she was concerned about and aware that few students of color did well in the regular cell biology course she did not have a lot of interaction with the students to understand why they were not doing well. She explained the lack of interaction in the earlier class as connected to the size of the class, “Because the class is so big, I don’t talk with a lot of the students. Sometimes the students do come to see me when they haven’t done well on an exam. When I ask them how they are studying, it seems like they are trying to memorize everything and not work on applying it. I try to tell them that approach won’t work.” Her explanation of their performance did not include any sense that language issues might be at work.

As she designed the new biology course she did not have much input from the McNair office director or others who had worked more closely with students of color. She noted that, “They seem happy when I tell them my plans for the course and how my approach has helped in other classes. I’m not sure how they will be evaluating the class but I heard that someone from the [education] school will be following students in the chemistry class.” In my conversations with her as she was planning the course, I shared some of my knowledge of students who had attended the summer bridge program. I described some of the students’ high school experiences and the differences between their science courses and those of students who had attended suburban or private high schools such as the limited access the students had to science textbooks and labs. However, she felt that this information would negatively impact how she viewed the students: “If I know all those things, I will expect less from these students so I would rather not know and just assume they can all work hard and do what is needed.”

On one hand it seems helpful that she did not want to have lower expectations for students of color as some researchers have found is the case (Richardson & Skinner, 1992). However, these comments also suggested her adherence to the dominant narrative about colorblindness and meritocracy where anyone, no matter their background, can do well as long as they work hard (McNamee & Miller, 2004; Ladson-Billings, 1998; Solorzano & Yosso, 2001). This belief has the impact of obscuring an understanding of the institutional inequities that have impacted these students throughout their educations (Ladson-Billings, 1998; McNamee & Miller, 2004). This comment, along with others made by her and other members of the university reminded me of the difficulty of balancing both my role as a researcher trying to document and analyze the barriers to a more equitable education and my role as a teacher and advisor where my goal is to support the students that I have worked with in the summer program.

The start of the semester. Most of the introductory science classes at the university are held in 150-student capacity lecture halls with fixed auditorium style seating. However with only 32 students enrolled in the fall McNair biology course, the class was held in a classroom with individual desks that could be moved around. With the exception of one White student, all the students in the course were students of color. The racial make-up of the McNair class was significantly different than other courses—especially science courses—at the university where almost all the students are White. Most students of color at the university are typically enrolled in classes where they are one of a few students of color in a course and they report initially being both surprised and discomforted by this situation (DeRosa, Guerrero, Pacheco, Sterling, 2013). The McNair students who were part of this study reported being both happy to be in a course with other students of color, but also concerned about why they had been put in a separate and special class. LeeAnn commented “I was surprised about the class and I just hope they are not going to treat us like we are dumber than the other students [at the university.]”

During the first few days of class, the overall demeanor of the students in the McNair class differed from that of other first-year classes that I have both observed and taught. Before class started, students were chatting with each other, laughing and generally seemed very comfortable with each other. When class started, they paid attention to the teacher, but also continued talking with each other and asked the teacher a fair number of questions about the purpose and her approach to the course. This behavior is in contrast to the usual classroom atmosphere at the beginning of a semester where students in most first-year classes are fairly quiet and do not interact with each other as they are waiting for class to begin. During class time, especially in the large science lecture courses, students are attentive to the teacher and there is little talking between students. Students may be more or less engaged in the lecture material, but overall both the teacher and students seem to buy into what Freire describes as the banking model of education where the instructor is the holder of knowledge and expertise that is to be deposited with students (Freire, 1968). As Dr. Lake encountered the McNair students during the first day of class, she commented to them that they were “certainly a lively group” perhaps her way of expressing that the students did not seem serious enough. As they talked and asked questions, she seemed a bit unsure of how to manage the interactions between students and respond to their inquiries, which suggests that students were perhaps not following the student model that she expected (Field notes).

Thinking like a scientist. During the first week of the fall biology course the students were given an overview of the course and the philosophy underlying the instructor's approach. Dr. Lake explained the rapid growth of life science knowledge and the difficulty of learning such a wide range of content. Although the teacher mentioned that students would be taking the regular cell biology course during the spring semester, there was little emphasis on how the fall course would connect to and prepare them for the spring course. Instead the instructor focused on the importance of learning key biology concepts and she read the following excerpt from the course overview:

> The sheer volume of biological information has expanded more than 10 fold since 1950. Along with this information explosion, many new sub-fields of biology have emerged. Regulatory molecules critical for ALL life were discovered just over 10 years ago. In order to organize, process and effectively use this information, students of biology need the ability to think like scientists combined with a strong foundation in biology concepts. The primary goal for this course is to learn how to think like a scientist. We'll develop and practice this skill in different contexts, working with real-world situations, such as choosing foods and supplements, understanding sickle cell anemia and other ailments.

The instructor did not initially discuss the role the course was intended to play in the overall McNair pre-medical program or how it would prepare students for their future biology coursework. However in the summer orientation students had been told that the course would better prepare them for the cell biology class, and during the first class several students asked questions about how that would happen. Her reply was that, "Students have to more deeply learn some of the fundamental concepts of science and learn to think like scientists in order to do well in the spring cell biology class."

The language in the course syllabus and her response about what students needed to take from the course suggested an assumption by the teacher that the students did not yet know how to "think like scientists" and were lacking in some fundamental concepts of science. She perhaps was using the phrase "think like a scientist" as a proxy for formal academic science. Nonetheless she seemed to imply that the students in the course were somehow lacking in scientific thinking and several of the students in the study commented on this point. Tran, one of the students who had attended the state medical school summer program while in high school, articulated what several students thought of this emphasis in the course: "That [description] sounds like every other science class that I have had. If I didn't think I could think like a scientist, why would I be going into science?" Tran's comment perhaps suggests a broader understanding that scientific thinking involves the general process of questioning, gathering data, and testing hypotheses.

Notably the teacher never surveyed students about their prior science coursework, or extracurricular science experiences and instead seemed to assume that they did not have the depth of knowledge, science experience or the scientific thinking skills required to succeed in a college biology class. Nor did she ask students any questions about their own interests, knowledge or reasons for being in the McNair program. By not asking students about their own science knowledge and experiences the instructor was further positioning the science curriculum as a fixed entity with unchangeable core concepts. If she had asked the students about where they saw links between science and their own lives it would have positioned the course content as permeable and the students as already possessing science knowledge.

The Construct of Interest: What Does it Mean to "Make Science Interesting"

In addition to a focus on deeper learning of fundamental science concepts, the course instructor and the two other biology faculty members involved with the McNair pre-medical program emphasized the goal of making science more relevant and interesting for students. The fall teacher commented that, "Even if students do not continue in a science major after the first semester, they will hopefully be interested and have a better sense of the relevance of science in society." However, the students in the study already largely had an interest and sense of the broader importance of science. Interviews with the eight students in the study found that they had long standing interest and experience both with school science and real-world experience with science issues. Six had taken Advanced Placement or IB[14] biology courses in high school and two of them had taken AP Chemistry. Additionally, six of the eight students had been involved in at least one summer or academic year science enrichment program. Both Fatima and Tran, at different times, had attended the same highly competitive ten-week summer program affiliated with the state university medical school. In the program they had conducted weeks-long lab experiments involving genetic diseases and DNA testing. Through the program Tran had also been exposed to the field of bio-mechanical engineering and had a sense that she might pursue that field. Biju had participated in summer science programs at two different Ivy League colleges. These programs furthered

[14] IB courses are part of the International Baccalaureate program and are similar to AP courses in terms of their rigor. Advocates of the IB program argue that the courses are more focused on depth of understanding vs. the breath of content emphasized in AP courses. (About the IB, 2014, http://www.ibo.org/en/about-the-ib/)

his goal to study medicine and public health science which had developed during the two years he spent in a refugee camp in Nepal. Sharon did not have the opportunity to attend any science enrichment programs, but she also developed an interest in the field of public health. In her home country of Jamaica she had seen first-hand the connection between poverty and health issues. She had also been involved in a church service trip to Nicaragua and observed how the lack of a clean water supply was linked to various health problems in the people she came to know through the program. So while the instructor may have assumed that students came from science-impoverished backgrounds, their actual experiences told a rich and more complex story.

The instructors' perspectives around making science interesting and relevant echo the political and public discourse around the need to make science interesting so that more students of color will pursue science fields. As noted earlier, the funding issues faced by the McNair program at University on a Hill were a direct result of the shift in TRIO funding from graduate school preparation programs to the Upward Bound Math and Science program which has the goal of getting more students interested in pursuing science at the college level (US Department of Education, TRIO Programs, 2013).

It is reasonable to assume students will not pursue science in college unless they start college with an interest in science (Tai, Liu, Maltese and Fan, 2006). The experiences of the students in this study demonstrate the role that pre-college science enrichment programs can play in the choice of a college major. What is problematic about the discourse on science interest and the biology instructors' perspectives is the implicit assumption that the students in the McNair program (or the high school Upward Bound program) do not already possess an interest in science and an understanding of the relevance of scientific issues. As the experiences of Sharon and Biju suggest, their interests in public health and medicine are long standing and tied to important and powerful personal experiences. Had the fall biology instructor in the program been more aware of students' knowledge and experiences, she might have used them as opportunities instead of assuming a deficit in the students' science knowledge. Further if the instructor had asked the students about what interested them and where they saw the links between science and their lives, it would have conveyed the fluid nature of science knowledge and the fact that students were already engaged in science learning. However, given the banking model of education (Freire, 1968) that informs the instructional model in most college science courses, this view of students as lacking in science knowledge and science interest is not surprising. This majoritarian narrative (Ladson-Billings, 1998; Solorzano & Yosso, 2001) which says that students of color do not grasp the relevance of science also functions to obscure the systemic reasons why students of color may not persist in college science programs. The students own lived experiences with their rich awareness of public health issues serve as counter stories to this dominant narrative.

The Nature of the Biology Course Curriculum

While the instructor had started the semester with a discussion of the growth and rapidly changing nature of life science knowledge, the actual curriculum in the fall science course did not reflect this fluidity of science theories and knowledge. Instead the course curriculum focused on what the teacher called some "fundamental concepts of life science" reiterating the narrative that the science curriculum is fixed. These fundamental concepts included: the importance of carbon and water in the environment; covalent bonds and hydrogen bonds; amino acids and how they form proteins; and how genes code for proteins. A sizable portion of the semester was focused on genes and the role they play in inheritance and physical traits.

As I sat through the lectures during the semester, I started to compare what these students were learning about inheritance to what I had learned in my own college biology class. I realized that a more complex theory of inheritance was being presented to these students. When I took biology, the focus of the genetics section was on Gregor Mendel's work with physical traits of peas and dominant and recessive genes. We also learned about eye color and how brown was dominant and thus anyone with blue eyes had to have gotten a blue eye gene from both parents.

In contrast, in the McNair biology class, the teacher never mentioned Mendel or eye color inheritance and instead a more complex and current theory of inheritance was presented to students. For example, one of the points the teacher made during class was that "the nucleotide sequence in a gene is read and translated by cell signaling to produce a chain of amino acids which in turn spontaneously fold into proteins." The instructor went on to explain how these differences in gene expression lead to different physical traits. However, there was nothing in the lecture about how the theory itself had changed. While this new explanation did not necessarily conflict with what I had learned about inheritance, the explanation was much more complex and reflected what scientists had learned through DNA sequencing. The instructor never articulated how this new theory and understanding had changed and evolved as researchers learned more about genes. In the optional readings for this lecture, there was mention of Mendel, but the new theory was presented as the objective explanation on how genes influence inheritance:

Even something as straightforward as eye color involves multiple genes and a

> variety of gene expressions. When pairs of homologous chromosomes line up during meiosis I and the homologs separate, a variety of combinations of maternal and paternal chromosomes can result. Each daughter cell gets a random assortment of maternal and paternal chromosomes. This phenomenon is known as the principle of independent assortment (Freeman, 2011, p. 221).

In other words, the explanation of genetics and inheritance was presented both by the teacher and the textbook as certain and fixed rather than a theory that has evolved over the last 150 years and that might further evolve in the future. As I compared what was presented to what I had learned, there seemed to be a loss of opportunity to show science as a process and continuum where theories are challenged and improved over time.

While most of the course was focused on these "fundamental concepts" which characterized science knowledge as fixed and absolute, the instructor did try to incorporate activities and topics that were more applied and would presumably be interesting to students. The two applied units covered the discovery of the disease Kuru in Papua, New Guinea and the prevalence of obesity in urban neighborhoods in the United States. I did not explicitly ask the instructor why she chose these two particular topics, or if she used them in the regular biology classes. As noted above, the teacher did not survey students to understand their interests and motivations for pursuing science and medicine so her choices were either based on things she previously covered in her teaching or they were based on what she presupposed would be interesting and relevant to students.

Whatever the reason for these choices, it is notable that both topics portrayed people of color in less than positive ways. In the Kuru example, the cause of the disease turned out to be the Fore tribe's custom of eating the brains of deceased members. The brain tissue contained a prion that caused Kuru, which is a fatal degenerative neurological disease similar to Mad Cow Disease. In the obesity example, urban neighborhoods were characterized as places with a lot of less-educated, low-income people on food stamps. Both of these examples positioned people of color as needing help from more knowledgeable Whites. While it was not likely a deliberate or conscious decision on the part of the teacher, these examples perpetuate the notion that Tuck (2009) describes as "damage-centered research" where communities of color are shown as places of pain, loss, and damage and needing help from others. Several of the students found these topics to be problematic and Sean was troubled by the portrayal of the people in the Kuru example: "When you show Black people mostly naked and talk about them like cannibals of course that makes them look bad." While the teacher may have thought these examples might be relevant and interesting to most students, she likely did not think about how these might be regarded by these students.

Students also had the opportunity to work in groups and select a "pseudoscience" popular media article pertaining to some kind of scientific claim. The articles they could choose from were about whether artificial sweeteners cause cancer, the effectiveness of diet drugs, and the value of various nutritional supplements. According to the teacher, the purpose of this activity was "to help you learn to think scientifically and to see the relevance of science in your lives." Again her comments implied that the students were not able to do either of these things. The activity was also supposed to help students use the language of scientific arguments including claims and evidence. The plan was to have students find academic articles related to the popular media articles and then write a critique of the claims and evidence in the media articles. However each group ended up dividing the work among students so no one student had to go through the whole process of reading, researching, analyzing and writing. Alana commented about a similar activity she had done in high school: "I had to do something like this and analyze the evidence that was being used. It was a lot of work, but really helpful to have to do the writing by myself and it helped me learned how to read those kinds of things." This is consistent with the research on the value of using writing to help students learn the language of scientific arguments and of different science genres (Brisk, 2014; McNeill & Krajcik, 2012). However, in the case of the McNair class this value was diluted because the activity was not structured so that that each student could experience the process.

Challenges of the Biology Class

During the first two months of the semester many of the other students were struggling to keep up with the amount of work in the class and to do well on the exams. Most students did well on the first biology exam which primarily covered the "thinking like a scientist" work that students had done with the articles and a section on water molecules. Alana noted, "I already know most of that stuff so the exam wasn't so bad." However on the second exam, several of the students were disappointed with the scores they received given the amount of time they had spent studying and especially given that they had followed the teacher's advice on how to learn the material and prepare for the exam by focusing on questions related to the different Bloom's levels.

During several of the interviews, the biology teacher expressed a strong belief in Blooms taxonomy and the idea that active and engaged learning helped students better learn scientific concepts. As noted earlier, the teacher had attended a teaching workshop at the Howard Hughes Medical Institute where the emphasis was on Bloom's taxonomy of knowledge types (1956). In the workshop instructors were encouraged to do more than just teach and assess factual information that students have memorized. The intent of the approach was to help students synthesize and apply higher levels of science knowledge rather than just memorize factual information (Crowe, Dirks, & Wenderoth, 2008; Handelsman, Miller, & Pfund, 2007).

The teacher often gave students examples of these different Bloom's levels so students could recognize the different levels on an exam. In addition, she provided them with homework exercises from a source called The Molecular Workbench .[15] The online interactive exercises from The Molecular Workbench were meant to give students practice applying what they were learning at these higher Blooms levels. Before the second exam students felt the exercises were helpful in learning the material and they were confident going into the exam. However, after they took the exam they felt that the Molecular Workbench exercises and the Bloom's levels did not relate very closely to the exam questions and that the exam included material that had not been covered in class. Juan noted, "I spent a lot of time doing the different problems and I made sure I could do the different application questions. But there was stuff on the exam that was never talked about in the class and I didn't do very good."

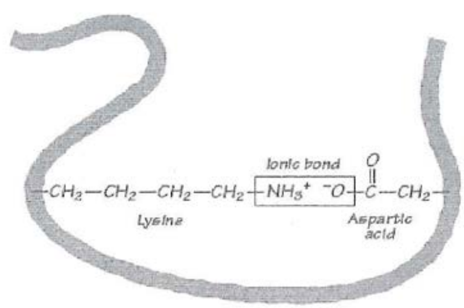
The bigger exam challenge for six of the eight students was the time allotted for the exam. They had trouble completing the exam and in particular reading the questions and making sure they understood what was being asked. In reviewing the exam with Biju, he pointed out the following question as an example of how difficult it was to figure out what was being asked:

[15] http://workbench.concord.org/database/

7.) Experiment 2: Drawn below is part of the tertiary structure of a protein showing the positions of two amino acids (aspartic acid and lysine). Replacing lysine with another amino acid may change the shape and function of the protein. Replacing lysine with which type(s) of amino acid(s) would lead to the least amount of change in the tertiary structure of this protein? (Refer to amino acids in the table above as necessary.)

7a.) Which amino acid(s) could replace lysine with minimal disruption to the tertiary structure of the protein?

7b.) Explain your answer to (a).



He noted that in particular he had a hard time with the sentence: *Replacing lysine with which type(s) of amino acid(s) would lead to the least amount of change in the tertiary structure of this protein?* "At first I didn't even realize it was a question, but when I saw the question mark I realized I was supposed to do something with it. Then I saw the 7a) part and wondered if it was the same or different question. …So many of the questions were like that and it just took me so long. I knew the material, but I just didn't have enough time to read everything and figure it out." Biju, like the several other students had only been learning English for the past four years. The other students also felt the difficult language of the exams was the main reason they did not have enough time to complete everything.

When I met with the instructor to get her perspective on the exam outcomes, she had various explanations. She noted that many of the students had done poorly and she was especially concerned about Biju. “He didn’t do well at all, but I’m not sure why.” In trying to understand students’ overall exam performance, she took some responsibility for including material on the exam that she had not fully covered in class. “I did include some things that I hadn’t directly covered, but I assumed they would have read those things in the [text] book since that was on the exam review sheet I gave them.” On the exam review sheet she had included the following instructions:

> **Chapter 2**, begin with section 2.4 and continue to end of chapter.
>
> **Chapter 3**, read sections 3.2, 3.3 and 3.4. SKIP section “Could polymerization occur in the energy-rich environment of early earth”

She noted that many of the students had not answered the questions related to those sections of the text. However, of all the explanations, she had little sense that the language on the exam might be part of what was contributing to students’ difficulties. As Biju’s comment suggests, it may have been an issue of not having enough time to read and answer all the questions.

In my own analysis of the content on the second exam approximately 25 percent of the questions covered items that were not directly covered in class with the inquiry-based group activities that the teacher built the course around. A lot of these questions asked about factual information at the lower levels of Blooms Taxonomy. In addition, because I had access to the instructor’s exams from an earlier cell biology course, I was able to compare the old and new exams. While there were new and different questions on the McNair biology exam there were also many factual type questions that were carried forward to the new exam. While more analysis would be necessary to deeply understand the complex connections between the classroom pedagogy, exam construction and students studying and exam taking, it seems possible that while the teacher's goal was to change her teaching approach, what was covered in the exam was not fully consistent with that new approach and she was asking more factual and memorization type questions despite the kinds of things she had covered in class. This would not be surprising given that she has been part of and is the product of a science education system that operates from a banking approach where science knowledge is fixed.

While some of the students in the study were struggling, Sharon had done very well on the first two exams. In spite of doing well, Sharon disliked the biology and chemistry curriculum. In one of our interviews in early November, Sharon sat down and quickly said to me, "I love my sociology class because it is about issues I care about, but I'm dropping pre-med because it is not really what I thought it would be—it doesn't have anything to do with health issues really and there is nothing creative and challenging—just way too much really hard stuff and not very interesting." She went on to explain that while she loved her middle school science classes in Jamaica, the college biology and chemistry classes were nothing like her earlier experiences. But she attributed some of her success in the McNair class to her middle school science courses in Jamaica. She had attended a private Catholic school where science was taught integrated with art. In class they spent a lot of time visualizing and drawing various cellular and chemical structures. "This really helped me learn the science material in a different way and I can still visualize what I learned then."

Despite doing well in the college science classes, Sharon just could not see continuing with a major where the material was so unappealing. She had talked to the biology teacher, who had been serving as the teaching assistant in the fall McNair biology class, about her plans to finish the semester and then switch to sociology. According to Sharon, the teacher responded by saying: “Well biology is just not for everyone. If you don’t love it, then maybe it’s just not for you. When I started college, I loved my science classes from the start and that was how I knew it was for me.” Based on the teacher’s response, Sharon was reassured that she was making the right decision to leave the pre-medical program despite her long standing interest in science, medicine and public health.

The teacher’s response to Sharon was something I have heard repeated in various forms from students who had consulted with faculty or administrators to decide if they should continue with science. From one perspective, getting students to see their decision to leave science as a matter of finding something that better matches their interest seems rather innocuous. It is a better option than having students conclude they are just not good at science or they are not smart enough to do science—conclusions that some students reach when they decide to leave the science major. However, this explanation from the teacher obscures other possible explanations as to why students like Sharon find the sciences courses and content so unappealing. It may be that formal academic science content and the pedagogy of the science class is what Sharon finds so unappealing and not science as a whole.

The explanation by the teacher also obscures science knowledge as a system that is made more “natural” to some not because of individual preferences and traits but because of systemic structures related to income levels and cultural practices that in turn socially reproduce inequity. As Lareau (2003) noted, the concerted cultivation in science that more well-off students receive at home and school makes school science seem more accessible and natural to them. In addition the notion of science as fixed and unchangeable rather than permeable and based on a set of theories creates a hierarchy that positions students higher or lower relative to their comfort and mastery of that knowledge. This is perhaps one place were Critical Race Theory can inform ways to transform the dominant model of the school science curriculum as one fixed hierarchy of knowledge. Legal scholar Montoya (2006) suggests that Critical Race Theory "can help create race-conscious and culture-specific curricula and pedagogy that can keep students of color in school, engage their families in education and public policy debates, and improve their chances of navigating through the system" (p. 1310) .

This differential valuing of forms of scientific knowledge is also consistent with Bernstein's (1990) work on the structuring of the academic curriculum where knowledge at the higher abstract level is what counts as important. When Sharon's experience is seen through the lens of Bernstein's hierarchies of knowledge, the academic content in the science class is seen as the higher and more valued level of knowledge and Sharon's knowledge gained through experience and the art classes is seen as something less worthy of attention or acknowledgement in a college science course. When the teacher told Sharon that she loved science from the beginning, the teacher may have been speaking to an adeptness and affiliation for the formal academic science of college classes. Further, the teacher's explanation made this an individual issue that seemingly only pertained to Sharon and collapsed what is a larger systemic issue to an individual student.

In my experiences as a teacher and advisor at the university, one difference I have noticed between the students in this study and the more privileged White students who are successful in the courses is that the White students rarely have an expectation that the first-year science courses will be interesting. They see the courses as a kind of obstacle that they have to get through and they expect it to be unpleasant. Often these students have family members who are doctors and they will mention that have been warned about the nature of the courses. One student's father said to her "Don't worry too much about the [first-year] chemistry. Those things you learn in chemistry have nothing to do with being a doctor. You just have to prove yourself by passing the course." In a sense, these parents are conferring a type of knowledge or capital to their children (Bourdieu, 1986) about the nature of pre-medical and medical education that a student like Sharon does not have. The biology teacher that Sharon consulted could have conferred this type of knowledge but instead she made it more about an individual affinity for science. Of all the students in the study, LeeAnn, was the only one who had this lowered expectation for the science classes. Similar to what the White students were told by their parents, her uncle, a doctor, had advised her to, "…just get through the pre-med classes because medical school was nothing like those classes."

Challenges of the Chemistry Class

The more significant difficulties arose for students in the chemistry course. Unlike the small biology course that was attended only by the McNair students, the chemistry course was a large lecture class where the McNair students were just 28 of 150 students. The chemistry instructor had a reputation as being the hardest teacher in the department and students tried to avoid his class if at all possible. However, the McNair students did not have a choice to enroll with another teacher since taking his class was a requirement of the program. This particular teacher's reputation stemmed from his reluctance to give any students an A or A- in the course and because his exams were known to be very challenging. I had heard from many of my previous students that the teacher routinely told students that 50 percent of an exam would be fairly straightforward, but that the rest would be very challenging problems that many of them would not be able to answer. Tran also conveyed that he has also made that point to the class. The other thing that made students anxious about the grading policy was that the instructor curved the final course grade, but the specifics of that were not determined until the end of the semester so students never really knew how they were doing in the course. According to Tran, "He also told us that if we did well in his course, we would be better prepared for other chemistry courses and for the challenge of medical school." The teacher's comments, were similar to the previously mentioned comment from the pre-medical advisor about the reason for taking so many science classes at once. These comments suggests a belief among the science faculty that they need to prepare students for the competitive and bullying atmosphere of medical school which researchers confirm is still a significant mode of teaching in medical schools and residency programs (Fried, Vermillion, Parker, & Uijtdehaage, 2012). While the faculty members' concerns about medical school might be valid, it seems there would be other ways to prepare students for that environment and perhaps even help change and challenge the atmosphere of medical school.

Most of the students in this study did poorly on the first chemistry exam of the course. Three students (Juan, Sharon, Sean) received failing grades of less than 40 percent. Three students (Fatima, Tran, and Alana) received barely passing grades of around 60 percent. Only two of the students received what they thought were good grades. Biju received a 75 percent and LeeAnn an 80 percent. Biju and LeeAnn were the only two in the group who had taken Advanced Placement chemistry in high school—Biju at a suburban public school and LeeAnn at an affluent private school. Biju had also been able to take a college level chemistry course at a local college during his senior year in high school.

Even before the first exam, of the eight students who were part of this study, six reported feeling intimidated by the instructor and the class. According to both Fatima and Alana, the teacher would frequently say things like, "I'm sure you know this, so I won't spend any time on it." However, the six students who had not taken any advanced chemistry courses in high school had not learned the content the teacher was skipping over. Even worse, he did not provide any guidance on how students could go about learning the material. The course had a required textbook, but students used it mostly for problem sets and as a reference in class when the teacher asked them look at certain pages. The class did have a discussion section, but it was devoted to helping students with the problem sets and neither the teacher nor the teaching assistant in the discussion section offered any advice on how students should use the textbook or otherwise go about learning material they did not know or did not understand.

The other intimidating element of the chemistry class that the McNair students noted was how prepared all the other—mostly White—students seemed. Sharon commented, "They all seem to know what the teacher was talking about and they don't really want to help any students who don't get it. Maybe they're worried it will raise the curve." Sharon's comments about the behavior of the other students reflected the competitive atmosphere and the grading practices at the university, especially in the science classes. The McNair students were happy to have each other in the course so they could at least work together to figure out problems and study, but as Sharon noted "If none of us know how to solve a problem we aren't much help to each other." In an interview with Fatima and Sean after the first exam, they discussed how the class made them feel about their own academic abilities. Fatima said "The other students all seem so prepared and confident and I never felt so dumb in my whole life." When Sean heard this, his comment was, "Great, at least you passed the exam. If you feel that way, there is no hope for me in the class." The other four students who had done poorly on the first exam expressed similar feelings about their abilities.

Most of the students in the study talked to each other about their grades so they all knew who had done well and who had not. LeeAnn, who had the highest grade on the exam, speculated that the other students were not putting in enough effort: "If they don't understand the material, they should read the book—that's what I did." However, LeeAnn had a lot of experience in her private high school with reading textbooks and she was unaware that the students who had attended urban public schools did not regularly use textbooks in their classes.

Other Challenges at the University

Intimidation by instructors. While the chemistry course presented an intimidating environment for many of the students this was not the only course where students had this experience. Tran was taking a philosophy class and was having difficulty with the exams. She would go in prepared, but when she looked at the exam, she had no idea what the instructor was asking with some of the questions. After the exam was returned, another student in the class asked if all the exams would have questions like the ones on the first exam. According to Tran, the teacher's response was "When I put together an exam, I hope you spend the first five minutes wanting to commit suicide. That tells me I am really making you think." When Tran told me about this, I was very surprised that a teacher would say something like this to students, given the reality of suicide on college campuses. However, some months after Tran told me this, another student (not in the study) told me the same story about the teacher. While this example is not meant to be representative, it does point to the competitive nature of some university classes and the atmosphere of intimidation.

Racial microaggressions. In one of her non-science courses, Sharon also endured a painful experience that shows the impact racial micro aggressions can have on students in a university environment. Building on the work of Chester Pierce (1974), Kohli and Solórzano (2012) describe racial microaggressions as "subtle daily insults that, as a form of racism, support a racial and cultural hierarchy of minority inferiority" (p. 1). This definition captures what happened to Sharon over the course of the fall semester in a research course where she was one of two Black students.

As part of the coursework, students did weekly community service in the urban neighborhoods near the university. Sharon happened to be from one of those neighborhoods and loved being able to go back there to work. However, the White students in class were always complaining about the neighborhood and how dirty and dangerous it was and how depressing it was to work with the people there. One student commented that "Black people from [the neighborhood] never do seem to do anything with their lives." Sharon felt personally offended and felt this was insulting to the people in the neighborhood. Comments like these were a regular occurrence in the course and as the semester went on she tried different ways to challenge the other students. However, after a while she got tired of being the only person who spoke up about some of the comments and assumptions. She also said that the teacher never backed her up in these situations and in fact the teacher did not even seem be aware of how offensive some of the students' comments were. This was not only a problem for Sharon, but also for those students whose stereotyped views of urban neighborhoods were being perpetuated without a challenge from the teacher.

The class was a year-long course and students were supposed to stay with the same teacher all year. Sharon was dismayed to think she would be with this same teacher and set of students all year and she wanted to transfer to another section of the course. In addition her family was having financial difficulties so she had taken a job at a local supermarket. The hours at the job conflicted with the time the course was held. Sharon went and talked to the head of the department giving the job schedule conflict as the reason she wanted to change teachers. She was told that only students with "legitimate campus jobs or other university sanctioned activities such as sports schedules" could change sections of the class. The department head told her she would "just have to tough it out." She was hesitant to articulate the real reason for wanting to change sections because she had told another teacher about the issues in class and the teacher's response was, "Maybe you are making too much out of this." Sharon's experience was not unusual as I had heard similar stories from students of color about their experiences with students and teachers (De Rosa, Guerrero, Pacheco, Sterling, 2013) in classes similar to Sharon's.

This situation that Sharon faced was particularly painful for me to hear about. She had been my student in the summer course and during the summer she had been outgoing, confident, and generally happy to be at the university. She had been accepted to one of the top ranked historically Black universities, but as noted earlier had chosen University on a Hill based on the recommendation of her high school teacher who had attended the university and loved it and her counselor. During the summer I remember thinking to myself that with her self-confidence and willingness to speak up and diplomatically challenge others Sharon would be able to weather the challenges that students of color faced at the university. However, the experiences in the service learning class wore Sharon down and by mid-November she was more quiet, withdrawn, and unhappy being at the university. Her experiences reflected what Kohli and Solórzano (2012) have said about the impact of microaggressions: "Cumulative insults/assaults ... take their toll on People of Color. In isolation, racial microaggressions may not have much meaning or impact; however, as repeated slights, the effect can be profound" (p. 7). After seeing the impact on Sharon, I wondered if she wished she had made the choice to attend the historically Black university where she had been accepted.

Taking Stock: The End of the First Semester

Course outcomes. At the end of the first semester, the students had a range of experiences in the program and they made different decisions on whether they would continue in the McNair pre-medical program. Seven of the eight students in the study completed the McNair biology course and achieved passing grades. However only three of the students (Fatima, Biju, and LeeAnn) completed the chemistry course in the fall. Juan was the first to drop the chemistry class in October after failing two quizzes and the first exam. He planned to continue in biology only so he did not fall below full-time status and risk his financial aid. However, he eventually dropped the biology class after failing the second and third exams. He planned to switch to some other major, but was unsure of a direction. He was very demoralized about the whole experience and was worried about telling his family that he did not make it in the program. It was difficult because his older brother had attended the university and had the same difficulties in the pre-medical program.

Sean and Sharon both dropped chemistry in late October after barely passing the first exam. They had gotten to know each other over the summer and relied on each other for advice and making decisions about the program. They were terrified of the chemistry teacher and did not consult with him before dropping the course, but they did talk to the teaching assistant in the discussion section. The teaching assistant told them that the grades were curved at the end of the semester and that they would likely do better, but it was hard to say whether they would pass the course. Both students had been putting in a significant amount of time studying for both biology and chemistry and felt discouraged about their prospects. They did not think they could put any more time and they both felt unprepared for the expectations of the chemistry teacher. Every time the teacher said something like, “I know you know this so I won’t go into detail.” they realized they did not know that particular content. I asked them why they did not talk to one of the program advisors in the biology department. Sean’s response was, “They will just tell us to better manage our time, work harder and go to the office hours. They just don’t seem to get what our high schools were like and what we don’t know. We can’t change what we didn’t learn.” Both students felt that the only way they could pass biology and their other classes was to drop the chemistry class. This did seem to help these two students as they both improved their grades in biology and in their other classes.

Sean planned to continue in the McNair biology class in the spring, but to wait until the next year to try chemistry again. He asked one of the biology advisors if this would work to only one of the McNair courses and was told it was fine. Sharon went back and forth with her plans. As noted earlier, she intensely disliked the way the science classes were taught and talked about switching to sociology. However, she did not want to give up so easily on her dream to go into medicine and public health. She wanted to take the McNair biology class, but a different instructor for chemistry. However she was told that unless she took both classes, she could not take the McNair biology class. In the end she opted to take the regular cell biology class in the spring and no spring chemistry class.

It is not clear why the program administrators allowed Sean to only take the McNair biology class without chemistry while they prevented Sharon from following a similar path. However, since the two of them frequently talked to each other Sharon was aware of and angry about this discrepancy and felt it was "because I'm too quick to open my mouth and [Sean] is nice and polite." Sharon's explanation could be valid, but it is also possible that the program advisors have unclear policies and a lack of clear communication between all the people involved in this new program.

Tran and Alana stayed in the chemistry class most of the semester and were passing the exams. However on the last regular exam of the semester at the end of November they both did poorly. Tran failed the exam and Alana barely passed. Tran dropped the class right after that and continued with biology, but because she had been dividing her time between biology and chemistry all semester, her grade in biology and her other classes suffered. When I talked to Tran at the end of the semester, she was very angry about the whole program and the rigid way everything was structured. She wished she knew she did not have to take biology and chemistry right away. She also wished she knew that she could major in something else and still be pre-med. She noted that "White rich students know this, but students in the McNair program have no one to tell this to us." She felt that the McNair program biology advisors should be helping students with this kind of thing, but since they were in the biology department, she felt "they could not imagine any other kind way to get to medical school except a biology major."

Alana did not drop the chemistry class right away and thought she might be able to pass the course so she kept doing the coursework and stayed enrolled. However the day before the exam she talked separately to the chemistry teacher and the teaching assistant. "I wanted advice and help, but they both made me think it was likely I would fail the class." Even though it was past the official date to drop the class, she went and met with the dean who allowed her to drop the chemistry course. At first she was relieved to avoid a low grade in the course, but later she regretted her decision because she had invested so much time and effort in the course that she would have to repeat if she wanted to continue in the pre-medical track.

Only three of the eight students—LeeAnn, Biju and Fatima—stayed in both biology and chemistry for the entire fall semester. LeeAnn did relatively well in both classes receiving a B in chemistry and a B+ in biology. Of all the eight students in the study she seemed best positioned to continue in the program in the way the program's creators had envisioned. However, she was unhappy with the whole program and the way they were “treated like children.” She also thought the chemistry teacher’s intimidating treatment of students was “out of line and uncalled for.” She noted “I don’t let him bother me, but I know it upsets some of the students. Everyone says he is a good teacher because he is so demanding, but there is no reason to be make students feel stupid.” At the end of the semester, LeeAnn made the decision to leave the McNair program however she continued in the regular biology and chemistry courses.

Some of the other students also echoed the views and frustrations that they were not treated like capable young adults. However, they did not have the same confidence to just walk away from the program. Of the eight students in the program, LeeAnn was the only one who had attended a private school. Her family had little money, but she had received a full scholarship to a private day school where almost all of her friends were White and wealthy. Of the eight students in the study, LeeAnn was also the only student who looked more phenotypically White. The level of confidence that she carried herself with, her style of dress, and mode of interacting with other students and faculty was more typical of the White wealthy students at the university. In other words, her habitus (Bourdieu, 1986) was more consistent with the predominantly White student populations at her private high school and let her move comfortably and unnoticed in the university environment. In contrast many of the other students in the program, because of their skin color and mannerisms were marked as different to both faculty and other students. LeeAnn’s high school had also conferred on her other academic and cultural capital (Bourdieu, 1986). In conversations with her, she noted that going to a private “mostly White” high school” helped her know what to do at the university. She knew how to approach teachers, advocate for herself and through her work with other students to figure out the best study approaches and short cuts. While some of the students were trying to carefully read everything in the textbook, LeeAnn instead first read the study guide, listened to the lectures and only used the textbook to review content that she still did not understand. In short, while her family was not able to confer the social and cultural capital valued in elite school settings, her high school had served this role.

Language and textbook challenges. Biju had done especially well in the chemistry course and received a B. However, he had not done as well in the biology course where he received a C-. Biju felt this was due to the language comprehension challenges that he had with the exams and some of the reading materials from the textbook. Biju was also experiencing some of these language challenges in his non-science courses, especially the required first-year writing course. Several times he asked me for assistance and feedback on the papers for his class. During this time we talked a lot about his challenges in learning English when he had come to the United States at age 13. Because his family had settled in a suburban New England town with few immigrants, there was little support at school to help him with his English. He had learned some English in school in Nepal, but his education was interrupted in the refugee camp were his family spent two years. In thinking back to his challenges in high school he commented, "I did better in classes like math and chemistry where I didn't have to read very much. I also didn't have trouble talking with my friends and teachers, but the reading and writing are really hard. It's even harder here [at the university] and I don't know where to go for help."

These challenges with academic language are consistent with Cummins (1981) who found students can acquire interpersonal language skills in two to three years, but they may need five to seven years to become fully proficient in the academic language of school disciplines, especially if they are not provided more explicit instruction within the language of specific disciplines. Several other bilingual students in this study who had immigrated to the United States also found the reading demands of the biology textbook and exams to be a challenge. While there was not a great deal of required textbook reading in the course, the students tried to use the textbook as a reference when they did not understand a particular concept. However, they found it hard to make sense of the information and to determine which parts of the text were relevant. In the literature on school science texts researchers describe the challenges of scientific language that is often abstract, dense, and technically complex with frequent nominalizations and complicated noun groups (Fang & Schleppegrell, 2008; Schleppegrell, 2004). Very often this complex language is part of an explanation genre where a scientific phenomenon is being explained or described. An analysis of the biology textbook used in the course (Freeman, 2010) confirmed the presence of this kind of challenging scientific language. For example, the text contains the following passage describing a metabolic pathway:

> Previous work had shown that organisms synthesize arginine in a series of steps called a metabolic pathway. Compounds called ornithine and citrulline are intermediate products in the metabolic pathway leading to arginine. Specific enzymes are required to synthesize ornithine, convert ornithine to citrulline, and change citrulline to arginine (p. 277).

The primary challenges with this passage are the specialized vocabulary and the complex noun groups. These aspects of the text alone make it quite difficult and assume that the reader has a prior knowledge of all the compounds mentioned.

However, further analysis of the Freemen (2010) textbook reveled an additional, perhaps more significant challenge that has not been noted in the previous literature on college science textbooks. Instead of simply presenting the scientific content in the genre of a scientific explanation as might be expected, the textbook embeds the scientific explanations within historical recounts of how the scientific discoveries were made. In some cases, the text also includes procedural recounts of the experiments that were carried out by the scientists. Analysis of the two other college level biology textbooks revealed a similar pattern of embedding scientific explanations within these other two genres (Belk & Maier, 2010; Shuster, 2012). The following passage from the Freeman (2010) text demonstrates this intertwined set of genres:

> Although biologists of the early twentieth century made tremendous progress in understanding how genes are inherited, an explicit hypothesis explaining what genes do did not appear until 1941. That year George Beadle and Edward Tatum published a series of breakthrough experiments on a bread mold called *Neurospora crassa*. Beadle and Tatum's research was inspired by an idea that was brilliant in its simplicity. As Beadle said: "One ought to be able to discover what genes do by making them defective." The idea was to knock out a gene by damaging it and then infer what the gene does by observing the phenotype of the mutant individual. Today, alleles that do not function at all are called knock-out, null, or loss-of-function alleles. Creating knock-out mutant alleles and analyzing their effects is still one of the most common research strategies in studies of gene function, but Beadle and Tatum were the pioneers.

> To start their work, Beadle and Tatum exposed a large number of N.crassa individuals to radiation. As Chapter 14 indicated, high-energy radiation damages the double-helical structure of DNA—often in a way that makes the affected gene nonfunctional. Their next step was to examine the mutant individuals. Eventually they succeeded in finding mutant N.crassa individuals that could not make specific compounds. For example, one of the mutants could not make pyridoxine, also called vitamin B6, even though normal individuals can. Further, Beadle and Tatum showed that the inability to synthesize pyridoxine was due to a defect in a single gene, and that the inability to synthesize other molecules was due to defects in other genes (p. 277).

The two dominant genres in the above passage are a historical recount of how two scientists discovered how genes work and a procedural recount of the experiment they conducted as part of that work. Embedded within this is a partial explanation of "how genes work." However to fully understand the phenomenon of how genes work, a student must continue reading the historical recount that leads to the present day discovery of RNA. Not only must students make sense of challenging scientific language, they must also untangle the relevant science explanation from the other genres. While this content does show that science is a process and set of theories, this benefit of including the historical recount is far outweighed by the reading comprehension difficulties the mixed genres create for students.

The challenges these students faced with the textbook and exams were largely invisible to the instructor. She did not have any sense that the students had only been in the United States for three or four years and were still learning to work with academic language. She noted that in her conversations with them, their English seemed fine. In the summer before the program began she asked my advice on a textbook for the course. I shared with her my analysis of the textbook and the mixing of the genres and suggested that a more straightforward text might be more helpful to the students. Instead she decided to use the same textbook, but not require much reading from it. While this seemed like a logical approach to minimize student's difficulties with the reading, it was problematic because they still needed to rely on the book, but they did not receive any guidance on how they should go about distilling only the relevant content. Nor were there any other resources or supports in the university to help students with academic reading challenges. Sean went to the university tutoring center to get help with the textbook, but the student tutor was only trained to help students with the subject matter content, not how to use the textbook. This set of practices and omissions around the use of the textbook in the course had the net impact of systemically disadvantaging these students.

Students' Overall Assessment of the Fall Biology Course

While only three of the eight students completed the chemistry course, seven of the eight students completed the biology course with passing grades. In spite of passing the course, their assessments about the value and the quality of course ranged from neutral to negative. Several of the students said they would have dropped the course, but because they were no longer taking chemistry, dropping biology would put them below full-time student status and would have endangered their financial aid. Sean who did drop both biology and chemistry early in the semester was not aware of the consequences and he was in danger of losing his federal financial aid. He eventually worked with the freshman dean who somehow was able to prevent this from happening.

One end of semester assessment that all the students shared about the biology course was that it seemed more like a middle school course rather than—as Tran said—a "real college course." Very quickly into the semester the students learned from other students that their McNair biology course was quite different compared to the regular cell biology that other students in the pre-medical program were taking. They were not aware that one of the teacher's goals was to make science more inquiry-based and interesting compared to the regular cell biology course. Their sense was that they were being treated differently because they were not as capable and they resented that they were segregated into a different course. Most of the students liked some of the course activities such as the physical molecule models, but they felt that they had not learned much beyond their high school biology courses and they were less, not more interested in pursuing science. They were also frustrated that, despite "not being very challenging" they often did not do well on the exams.

When asked if they felt the course had prepared them for the regular cell biology course in the spring most did not think it would since the course was so different compared to the regular cell biology course. They noted that there was little explicit discussion in the fall course about how the content would link to content in the spring course. My observations in the class were consistent with the students' in that I rarely heard the instructor talk about the regular cell biology course. However, when I asked students directly how they knew the fall course would not prepare them for the spring course, the students did acknowledge that would have to wait until spring to find that out. Alana stated that "I guess we'll have to see. I hope it does, but I have my doubts." Sharon commented “My roommate was in the regular class and I can’t see how it will help, but I am taking the regular [non-McNair] class next semester. You can check in with me to see.”

The value of a peer community. While, the students had less than positive reviews of the course and the program overall, in their classmates they had a community of peers who were engaged in the same endeavor. When they had trouble with homework or, more frequently, an exam they could discuss it with classmates and come to an understanding of the cause of the difficulty. Usually the explanations they would come to with their peers were some combination of needing to prepare differently, strategies to approach the exam, gaps between what was covered in the course and what was asked on the exam or gaps in what they had learned in high school. For example Fatima noted that “We all compared which questions we missed on the exam and a lot were the same and we tried to remember when [the teacher] talked about something. When nobody could remember we know it wasn’t us.” Even in cases where students had done very poorly, they did not come out of the experience concluding that they were not good at science or did not work hard enough. This collaborative construction of these more complex explanations stood in contrast to what I had observed from pre-medical students of color in my past experience.

In the past and outside of the McNair program, the typical pattern for students is to take biology, chemistry and calculus along with two other core requirement courses in the humanities or social sciences. However, for most students of color that I have worked with, this combination of biology, chemistry and calculus is too much and they often drop one of the three courses. They struggle with the other two courses often receiving low grades in the D- to C- range. By the end of the semester, they have given up on the pre-medical program and they grapple with trying to make sense of why they have done so poorly. Without a community of peers to talk with, they often conclude that they are just “not good at science” or sometimes that they are just not smart enough. They feel defeated and leave the program not because they want to, but because staying will put them in danger of being placed on academic probation. In contrast, the students in the McNair program in addition to having a somewhat higher GPA, could decide or not for themselves whether to leave the program. Even those who decided to leave, did so with their self-esteem intact and the most frequent reason given for leaving was a disconnect between their own interests and motivations to pursue medicine and the nature of the course work. Juan, the first student to leave the program was initially upset that he was not going to fulfill his family’s expectations, but he realized that he had better options. “I ended up really loving my political science class and I can see myself doing that and maybe getting into politics. In high school I had no idea that kind of major even existed.” His comment also points out that immigrant students may not have family members who can help them navigate the choices they face in the transition to college.

A missed opportunity to understand students. The fall biology teacher had made little effort to understand the students’ backgrounds, prior knowledge and experience, and reasons for pursuing medicine. Given the entrenched way that the science curriculum is structured and taught at the university with the teacher as the expert and keeper of a fixed set of concepts and students as a blank slates it is not surprising that the teacher would do little to inquire into students backgrounds. Further if she took on the goal of connecting to students’ backgrounds and contexts it would have meant changing the course curriculum to connect with students' backgrounds thus exposing science as fluid and not a collection of absolute facts.

However, there was another venue in the McNair pre-medical program where the students' knowledge and experiences could have been shared and affirmed. Every week the students met in an hour long advising class with two faculty members from biology. I did not observe these class sessions, but according to Tran "We don't do much. We talk about how things are going with the classes. Sometimes we watch films about science issues in the news. We also complain a lot about chemistry, but [the teachers] don't really have any helpful advice." Fatima described the sessions as "sort of helpful" but she noted that "I would rather spend the time studying." Biju was very disappointed about the advising class and he wished "We could do more to talk our own science interests and questions." During the summer he and I had spent some time discussing the book *The Immortal Life of Henrietta Lacks* and he had told me the book was one of the things that got him interested in medicine. "I think the weekly advising meetings should be used to discuss issues brought up in books like this or to talk about health internships and careers." At the time he was in the process of applying for a summer health internship and had asked for, but not received help and advice for his application from the science teachers.

In an interview with one of the faculty members who helped run the advising sessions she noted that there had not been a clear sense from the administrators running the program as to the purpose of the weekly sessions. Without a lot of guidance, she and the other faculty member decided how they would use the meetings: "We decided to use the classes to build community and help the students with any issues as they came up."

This faculty member said the sessions were helping her get to know the students, however that “getting to know students” did not seems to include any sense that the students might have valuable knowledge and experiences that they brought to the program. While she seemed to feel the weekly classes were helpful the contrast to the students’ assessment of the sessions was notable. Whether the teacher did not ask or whether the students felt reluctant to openly critique the class, there was clearly a disconnect on the value of the advising component of the program.

On the surface this aspect of the program seems like it would be helpful in terms of providing students with a faculty advisor and a space to collectively problem solve. However, this did little to change the systemic issues at the university nor did it alter the 13 years of inequitable education that many of these students experienced. The same is true of the fall instructor’s approach to teach science in a more engaging, inquiry-based manner. She knew that the way science was normally taught at the university was problematic and she wanted to make substantive changes, however, the changes were being implemented without sensitivity to the other university structures and practices that students would encounter. She also had little curiosity or sensitivity to the students’ experiences and backgrounds including both the knowledge they brought with them and the areas where they needed extra help. However, what was still unknown was how students’ experiences in the fall class would link to and support them in the spring biology class.

CHAPTER SEVEN: The Spring Biology Course

My original intent was to conclude the data collection at the end of the fall semester. Given that one goal of the fall biology course was to prepare students for the required cell biology course that all pre-medical students must take, it seemed important to continue to follow the students who remained in the program to assess the connections between the fall biology course and the spring cell biology course. Four of the students (Biju, Fatima, Sean and Alana) would be continuing in the smaller McNair section of cell biology and two of the students (Sharon and LeeAnn) would be taking the regular, larger cell biology course. Unlike the fall semester when several students dropped the chemistry class and one student dropped both biology and chemistry, the six remaining students would go on to complete all the spring classes in which they enrolled.

The following table summarizes the different courses and course outcomes for each of the eight students in the study for both the fall and spring semesters:

Table 4: Fall and Spring Course Outcomes for Students in Study

Student	Fall Biology	Fall Chemistry	Spring Biology McNair(M) or Regular(R)	Spring Chemistry McNair or Regular
Biju	Completed	Completed	Completed (M)	Completed (M)
Fatima	Completed	Completed	Completed (M)	Completed (M)
LeeAnn	Completed	Completed	Completed (R)	Completed (R)
Sean	Completed	Dropped	Completed (M)	Did not take
Alana	Completed	Dropped	Completed (M)	Did not take
Sharon	Completed	Dropped	Completed (R)	Did not take
Tran	Completed	Dropped	Did not take	Did not take
Juan	Dropped	Dropped	Did not take	Did not take

A continuation of the study through the spring semester helped illuminate the connections between the fall McNair class and the two different sections of cell biology. In addition it provided additional student perspectives on their experiences and decisions on whether to continue in the pre-medical program. The teacher in the spring McNair course agreed to class observations once or twice a week and to several interviews. All the students, including the two students no longer enrolled in any pre-medical classes (Tran and Juan) agreed to participate in several additional interviews throughout the semester. I did not observe the non-McNair section of the cell biology course and the instructor for that course was not involved in the McNair program. However, I had observed that particular instructor several times during the pilot study (De Rosa, 2013) and I was familiar with her teaching approaches which consisted mainly of PowerPoint lecture materials that had been provided by the textbook publisher.

In the following sections I first describe some of the similarities and differences between the fall and spring McNair biology courses and highlight some of the notable events and issues that arose for both the teacher and students during the spring course. I conclude with some of the student perspectives on the program and the year.

Spring Course Structure and Instructor

The instructor for the spring course had been at the university for several years and normally taught the cell biology course. More significantly the teacher had acted as a teaching assistant in the fall biology course so she was familiar with the course material and the inquiry-based teaching approach used by the other instructor. The fall McNair biology course had an enrollment of 32 students but by the spring semester only 21 students were enrolled. Despite the small class size, the spring course was held in a large, 150-student lecture auditorium. The students sat scattered around the room and there was far less interaction between students than there had been the previous semester. In every class that I observed during the semester (28 out of 42 total classes) the teacher stood at the front of the room with a podium and computer from which she controlled the lecture slides. In some ways the instructional approach procedure looked much like the other large lecture-based university courses and the physical setup of the room reinforced the notion of the instructor being the holder of knowledge. However, in contrast to the formal and imposing presence of the lecture hall, the teacher was warm and friendly and addressed the students by name given that she had worked with the students during the fall biology course.

On the first day of class the instructor reviewed the syllabus and overall focus of the class. She described the course as follows: “The course is a foundation for all your other biology courses. We will look at molecular and cellular structures, genes, cell mutations and genetics.” She emphasized the different ways students could receive help including her office hours and review sessions. They could also consult the Teaching Assistant who would attend class each day. Also notable was what she did not talk about. Even though she had first-hand knowledge of the fall biology course, she did not talk about the connections between the fall and spring biology courses nor did she talk about the overall McNair program.

Teacher’s perspective on the McNair program and students. The fall instructor was in her third year teaching at the university and in prior years she mainly taught the large lecture and textbook-based sections of cell biology. In contrast to the fall teacher, the spring instructor was specifically interested in working with the McNair students whereas the fall teacher was primarily interested in implementing inquiry-based science teaching approaches advocated by the National Science Foundation. In one of our early interviews, she said she did not know a lot about the experiences of students of color at University on a Hill, but she noted "I think I was hired in part because I was interested in working with these kinds of students." She stated that she was aware of how few students of color continued in biology and the sciences at the university and she thought it was important that more be done to retain these students. She noted that her husband worked at one of the large public high schools in the city where the university was located. "He talks about how tough it is for those kids to really learn in a consistent way because so there is so much turmoil and many teachers come and go. He said this is especially true when it comes to science classes. It is hard to get good science teachers and once you do, they turn around and leave." It turned out that her husband worked at the same high school that Sean, the student who had grown up in St. John, had attended. When I mentioned that common school connection, her response was "That's helpful. I can see now the kind of challenges he is facing."

While she was interested in this information about Sean, the teacher did not do anything to systemically ascertain students' backgrounds and reasons for pursuing science, such as a beginning of semester survey. Like the fall teacher she explained she did not want to have lower expectations for the McNair students "I don't want to see them as being different than other [university] students in terms of what I should expect." These views, while well meaning, are akin to the color-blind ideology embraced by many liberals in a post-Civil Rights environment. Bonilla-Silva (2003) suggests that this ideology functions as a subtle form of racism as it prevents well-meaning whites from acknowledging the long history of racism and the entrenched inequities that limit educational opportunities for students of color and secure opportunities for White students. In the case of both of the McNair teachers, it was a sense that if they knew too much about student's backgrounds they would not treat them as equal to other students. However, without the knowledge of the challenges these students faced in high school along with any interrogation of the prevailing constructs of racism there was little reason for the teachers to modify and improve the instruction to both address gaps in the students' education and to leverage the knowledge they brought to the course.

When asked about her assessment of the McNair program she had the following to say: "Well, I think overall the program is a good idea, but the way the planning and implementation happened seemed a little rushed and disorganized. I am also wondering how the program will be evaluated and how the university will know if it is successful." She conveyed that at the start of the year, the members of the biology department were told that one of the researchers in the university's education school would be following student progress in the chemistry class. However, for some reason that evaluation never happened. She wondered, "How will they improve the program if there is no analysis of what worked and what didn't? We were told that funding will continue for at least three years, but I don't know what will really happen if there are not some positive results, which I assume means more of these first-gen, low-income students continuing in science." It is notable that she and others connected to the program rarely referred to students' racial backgrounds even though there was only one White student in the program. As noted earlier, this framing of the problem as relating to students' income level and parental education level serves to obscure the role that institutionalized racism at the university or earlier educational settings plays in disadvantaging these students.

In the context of this concern about the program evaluation, in one of the interviews, she shared that, “the student feedback for the fall course had been really terrible.” Based on the student course evaluations, the lead faculty member from the biology department and the McNair administrators had decided that the pre-cell biology course would not be offered the next year. Instead students would go directly into a smaller McNair section of the cell biology course similar to the one she was teaching. She noted that “I think this decision is a little premature, but [the faculty member in the biology department who was leading the effort] does not want students to get a negative view of science just when they are being introduced to it.” This comment from another biology faculty member further illustrated the perspective that students were bringing with them little scientific interest and knowledge to the university, a dominant perspective about students in this program and in policy groups concerned about the low number of students of color in the science fields.

The biology department administrator’s concerns about the program evaluations were not surprising given the context of how faculty and courses are evaluated at the university. The decision to discontinue the course so soon after it got started hints at the “students as consumers” mentality that is pervasive at the university and nationwide with the privatization of education where education is treated as a product with students as the consumers (Fabricant & Fine, 2012; Picciano & Spring, 2013, Ravitch, 2014). At the university, course evaluations are made available to students and decisions about faculty or course continuation are in-part based on course evaluations which measure whether students are happy with the teacher and course content rather than measuring student learning. Certainly this kind of overly simplistic course evaluation in the context of the McNair program does little to measure whether the program is working to increase opportunity and disrupt the systemic inequities in the science program for students of color. As Britzman (1992, 2003) argues it is not enough to have good intentions and a progressive curriculum, educators must acknowledge the complexity of the ways that students and teachers are historically constructed within an inequitable system. Any kind of genuine evaluation of the fall course must acknowledge these complexities. This decision to so quickly eliminate the fall course also hints at potentially conflicting goals for the program. For example, one possible goal is to demonstrate that the university is making an effort to help students of color in the sciences. However this goal is different than the goal of understanding and addressing the underlying causes for the inequitable science outcomes for students of color.

Teaching approach: First half of semester. Early in the spring semester, the instructor's approach to teaching was, according to her, "not really different than any of the other cell biology classes I have taught or any different than other biology faculty." My observations of her classes confirmed that she relied on whole class lectures with PowerPoint slides drawn primarily from those provided by the textbook publisher. This is also what I had observed in two other instructors' sections of cell biology offered in earlier semesters (De Rosa, 2014). The teacher would start out each class with a quick review of the previous class and give an overview of what would be covered. There was little interaction between the instructor and the students in terms of discussion or questions and answers. Occasionally she would ask things like "Does that make sense?"

or “I will assume you understand unless you let me know.” There was little reference to content that had been covered in the fall class, but occasionally she would say things like “I think you covered this with [the fall biology teacher].”

In contrast to the fall McNair biology class where the teacher did more to engage students in group activities, the spring instructional approach was teacher centric with limited effort to engage students or to provide any interaction between students. However, the students all expressed that they much preferred the spring class to their fall experience. They had comments like “Finally I’m in a real biology class” or “Last semester was more like a middle school class.” It did not matter to them that a more interactive instructional approach might be a better way to learn and keep them engaged with the material. What seemed to matter was that they were now in the same kind of biology class as other students in the university. Alana even commented, “Now I can finally use the textbook that I bought last semester.”

This reaction from students of finally being in a “real biology class” illustrates the complexity of efforts to introduce new teaching approaches and a reason why the larger context of the university and particular students’ experiences in that context must be considered. From a pedagogical perspective, breaking from the lecture approach made sense to the fall biology teacher and while the program directors believed they were providing students with extra resources and more interactive teaching, the students saw this as being segregated and not treated as other college students. The students knew from the chemistry course and from other students that most college science classes are taught using this lecture approach. They wanted to be treated as capable learners and be prepared for the reality of the teaching and classes they would encounter. Biju, normally not one to explicitly critique the program, noted that "We were smart enough to get into [the university], they should realize that we are smart enough to figure out how things work."

Biju's reaction echoes LeeAnn's comment at the beginning of the year when she expressed concern that they might be seen as "dumber than other students." Their concerns call to mind Steele's (1997) work on stereotype threat which Steele defines as "the threat that others' judgments or their own actions will negatively stereotype them in the domain" (p. 613). Because of how the program was framed and how students were segregated, both LeeAnn and Biju were concerned they had been negatively stereotyped as not being as capable as the students in the regular pre-medical courses. Steele's research also documented that disrupting the stereotypes that students of color have internalized can lead to better achievement. As noted earlier, the Meyerhoff science program at the University of Maryland for students of color in the sciences is structured in a way that avoids some of this negative stereotyping of students of color. The program has a competitive admissions process and students are educated about the need for and value of having people of color in the health professions. When students are admitted to the program they see it as an achievement, not a punishment, to be provided with extra help and resources (Hrabowski & Maton, 1995; Maton, Hrabowski & Schmitt, 2000). This type of structure and framing for the program at University on Hill could counter the negative stereotypes of students of color as being academically deficient and instead position them as bringing important capabilities to the medical professions.

While the lecture component of the McNair cell biology class was little different than regular cell biology courses I had observed, the class did have a homework component which drew mainly on the end of chapter questions from the textbook. Students were expected to work on the homework themselves, but they could go to a review session with the Teaching Assistant where they would go through the homework questions. The instructor placed a lot of emphasis on the homework and the role that it played in helping students learn the materials. During one of the early classes she commented: “I will try to use lecture time to give you a clear explanation of the science as I know it. However, my view—a constructivist view of knowledge—is that you create your own knowledge. The real way you learn is by going through the material by yourself. The homework is important for that.” However, what remained unclear to the students was how they should use the course textbook for the homework or what other steps they should take if they had difficulty with the questions.

The first quiz and exam: The challenge of applying knowledge. Two weeks before the first exam, the instructor gave a quiz that covered DNA damage, mutation and repair. The teacher noted in class that, “The quiz will help check your understanding of the material and help prepare you for the kinds of questions that will be on the exam.” The inclusion of a quiz, along with the homework in the course, was another component that differentiated the McNair section of the course from the regular cell biology course where no required homework or quizzes were given. In discussing the relationship between the quiz and the upcoming exam the teacher noted, “If you can do well on this quiz then you should be able to do well on the exam in two weeks.” She went on to advise students that the best way to study for the quiz was to review their homework problems and “be able to apply the concepts rather than just memorize the factual information.”

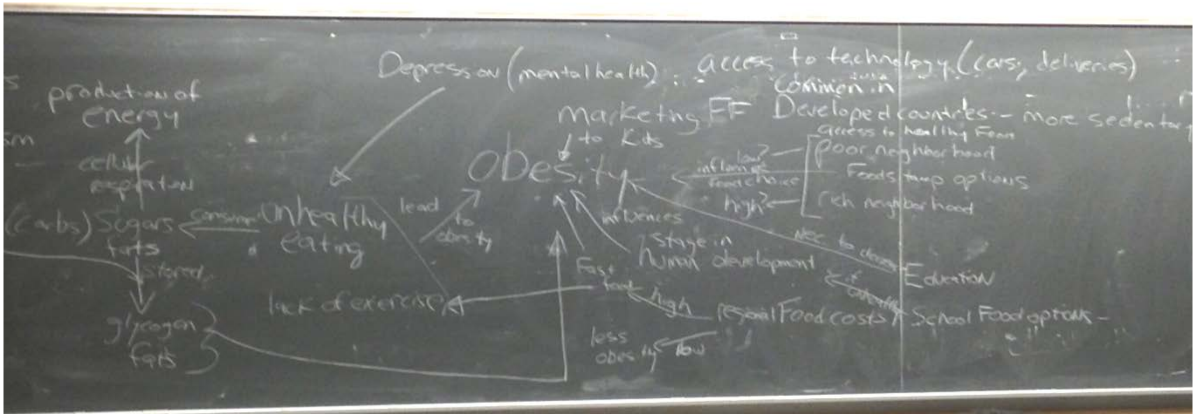
In a brief conversation with Alana after class, I asked her how she planned to study to make sure she could apply the knowledge. She responded "I guess I will review the homework and the slides, but I'm not sure. They always tell us to make sure we can apply things, but last semester I focused so much on applying things that I missed the really easy questions on the exams and I didn't do so great on the application questions either." Alana's comment suggested that she had not quite made the connection between basic factual knowledge and knowledge application and the need to first build a foundation of the factual content.

During my next class visit, the quizzes were being returned to the students and, according to the instructor, the average score was 7.5 out of 10. She went on to convey that "If you got less than 7, you should try to figure out why." She also told students, "It seems like you are trying to just memorize things. I want you to know why something happens rather than just that something happens." However, beyond this comment, there was little guidance provided on how students could become better at knowledge application.

On the quiz the students could identify questions that required an application of knowledge, but often could not put all the knowledge together in the way required to answer the quiz and exam questions. After the class when students got their quizzes back, Biju explained that one of the quiz questions was about some kind of radiation damage to the DNA in a cell and how a particular kind of gene therapy might be able to repair the damage. The teacher had covered both areas of content, but not together. "I knew it was a knowledge application question and I knew the radiation part and the gene stuff, but I still couldn't figure out how to answer the question." Similarly to Alana's comment, Biju also noted that he missed some of the easier knowledge recall questions because he was worried about and focused most of his time studying for the knowledge application questions.

This notion of applying knowledge rather than just memorizing and recalling facts was a frequent refrain in both the fall and spring McNair biology classes and in the regular cell biology courses that I had observed the previous year. In the fall McNair class the teacher emphasized the use of Blooms Taxonomy (1956) and emphasized that students should not just focus on factual details, but be able to apply that information. However, what I never heard articulated for students in any of the classes was the relationship between surface level knowledge and knowledge application. The comments from students like Biju and Alana suggest that they viewed the two types of content as mutually exclusive and focused on applied knowledge because that what was heavily emphasized in class.

However, just telling students that they should focus on knowledge application does not necessarily translate into them being able to apply that understanding. They need to understand the connection between the different types of knowledge and ideally in a way that leverages their own experiences. This is the principle behind culturally responsive teaching (Gay, 2000; Ladson-Billings, 1995; Wlodkowski & Ginsberg, 1995) and perhaps this is what the fall instructor was attempting to do when she used the topic of obesity in urban neighborhoods. In the following concept map that the fall instructor constructed on the board she tried to help students understand how the parts connected to the whole by explaining how the cellular structures of fats and sugars connected to obesity:



However, instead of first finding out if this was a relevant (and welcome) topic for students based on their backgrounds and interests, it seemed to the students that she had made some negative assumptions about where they came from. Further even in that context the instructor did not make explicit to students why they would first need to understand the cell structures, next they would have to understand the cellular process of energy production and finally put together how all that contributes to obesity. Sharon in particular was angry about the example and noted, “It’s not like everyone who is poor and from a city is overweight. Look at me! And anyway how is this supposed to help us with the science.”

At one level this expectation that students should be able to apply content in new contexts seems like a reasonable and an appropriate learning goal. However, this also assumes that students have an opportunity to practice this type of knowledge application and synthesis—something that is difficult to provide in a lecture-based classroom that does not include any kind of complementary lab or activity that requires students to engage in this kind of cognitive process. This expectation of learning to apply knowledge seems akin to having students read about how an automobile works, read about the different ways that a car can be damaged in a car accident and read about how complex it is to repair the damage. After this students would be given a damaged car to repair.

This expectation for knowledge application in their science courses also takes on further significance in light of students' previous education. Six of the eight students in the study attended under-resourced urban schools where lab supplies and experienced science teachers were in short supply. The students also reported that there was a lot of emphasis on memorization and test preparation which is consistent with Tate's (2001) findings about the nature of science education in urban schools. These students' backgrounds are in contrast to those of the White, upper income students who often come to the university from schools with experienced science teachers who provide them with much more lab and applied science experience. Seen in this context, the assumption and expectation by teachers that students come prepared to do knowledge application is one of the teaching practices that ends up disadvantaging students who come to the university without this kind of preparation and experience.

Divergent Explanations of Poor Exam Performance

In discussing the quiz outcomes with the instructor, I asked about her explanation and view of why students were having difficulty with some of the questions. She believed that the homework questions were providing the kind of practice the students needed to be able to apply what they learned. However, she noted, "I don't think they are really doing the homework or taking it seriously. When I talk to [the Teaching Assistant] he says most of them come to the discussion without having tried the homework first. If they were really doing the homework, they should be able to answer the application questions." While her assessment of students effort or lack of effort on the homework may have some validity, it is notable that she located the problem with the students and their lack of effort, rather than examining other possible reasons for the quiz performance including the structure and pedagogy in the course or students' past exposure to and experience with this kind of knowledge application and synthesis.

In talking to students about the homework, they acknowledged that they often did not complete it before the review session with the Teaching Assistant. However, they explained it was because they did not know how to answer some of the questions. They went to the review sessions hoping to get some advice and strategies on how to do the problems. Instead the Teaching Assistant just went through the answers. Fatima summed up the problem with this approach as follows: "If he would just give us some hints of where to start and where to find some of the information we might be able to do this ourselves. But he just goes ahead and does it for us and that is so not helpful."

As the students moved on from the quiz and prepared for the exam they tried to follow the instructor's advice by focusing on higher order questions rather than just memorizing information. In the end, both the students and the instructor were disappointed with exam results, but between the teacher and the students, there were notably divergent explanations for the poor exam performance. On the day the exam was returned the instructor started class by noting that the exam grades were much lower than she was expecting. She spent the first 15 minutes of class discussing how students should think about whether they were putting in enough time studying for the class. Below is a brief excerpt from her comments:

> You need to think about how much you are investing in your own success. All you are responsible for right now is your own success. Later you will have a

> family and other responsibilities, but right now you just have yourself to worry about. If you work hard now, someday you can buy a nice house….. You need to think about how you are studying. This is your major transition to college. The majority of your learning happens outside class. One credit hour means one hour in class plus at least three hours outside of class. For this class you have 4 credit hours. That means just for this class you should spend at least 12 hours each week outside of class studying.

On the surface, this seems fairly straightforward and it is plausible that students do need to put more time into studying. However, when viewed through the lens of Critical Race Theory and theories of capital, this advice from the teacher suggests a view that individual students' hard work and persistence are the key components to doing well in the course. This explanation is what Critical Race Theory scholars term a majoritarian or dominant narrative that embraces claims of meritocracy, which assumes equal opportunity, to explain why one individual does better than another (Ladson-Billings, 1998; Solorzano & Yosso, 2001). The teacher's explanation of the low exam grades locates the problem with the students, instead of examining other factors that might also explain the students' performance on the exam.

In follow-up conversations with Alana, Fatima and Sean, I asked about their views of why they had not done well on the exam. These three students disagreed with the assessment that they did not spend enough time studying. Alana showed me her schedule noting that she routinely spends at least 15 hours per week on the class and the week before the exam, she spent even more time. "I spent so much time that I got behind in my other classes, but it didn't really help me because I still did bad." Several of the students noted that while they managed to dedicate enough time to studying, they were often tired when they did sit down to study due to their jobs. Further conversations with the students revealed that they all have work-study jobs on campus as part of their financial aid packages. Each of them spends at least 10 hours per week working and Sean regularly works 15 hours per week. They explained this was necessary because their families could not provide any financial assistance, including the minimum financial contribution of $2500 required by the university. Fatima was also concerned about her loans. “I already have a lot in loans and I can’t ask my family for help so I have to work more.” Sean, whose mother is disabled, noted that, “Sometimes my mom or brother need some help from me. I feel like I should do what I can so I work more.” These details from the students also contradict the teacher’s assumption that the students had only themselves to worry about as they pursued their college coursework. Their economic circumstances meant their time was divided between coursework and work related pursuits, perhaps compromising their academic work.

These conversations with students reveal some of the systems and policies at the university that put these students at a disadvantage. In this case it is the financial aid practices—which almost always include a work study component and minimum financial contribution from families—that leave these students with less time to study compared to students with more financial resources. In addition the concerns and pressures these students face related to their families’ financial situations do not seem to be taken into account by the university, especially in terms of the university requirement that all families contribute a minimum of $2500 towards a student’s education. So while the university is dedicating extra resources to the McNair program in terms of smaller class sizes, advising sessions and teaching assistants, the program is not addressing the financial burden and time constraints faced by the students in the McNair program.

However, in returning to the question of whether lack of time studying explains the exam performance, the students' comments suggest that the problem is not attributable to inadequate time spent studying. In fact these students seem to be putting in even more time than recommended. Another possible part of the explanation is that the way these students are studying the material is not congruent with the kind of knowledge performance that is expected on the exam. Bourdieu's (1986) theories of capital would suggest that particular kinds of academic capital and academic habitus, including specific ways of studying and taking exams are both privileged and assumed in college science courses.

One study approach that several students noted—and something that they had mentioned earlier— was that they had spent so much time trying to study for the knowledge application questions that they had missed the easier "memorization" questions. This emphasis by teachers on studying for knowledge application vs. content memorization was a recurring theme across both the fall and spring courses as well as the regular cell biology class. Both Sharon and LeeAnn, who were enrolled in the regular section of the cell biology course noted that there was this same emphasis on knowledge application. Sharon told a story similar to the McNair students in that she tried to focus on knowledge application while studying, but had done poorly on the first exam. What Sharon also did, drawing on her earlier science education in Jamaica, was to visualize and draw some of the cell structures that would be covered on the exam. In some ways that approach helped her, but not in the way that was expected on the exam: "Being able to picture the way the cells looked helped me with the questions about structures and stuff, but not for the one about function and the different ways the cells interact."

LeeAnn in contrast had done well on the exam and when asked how she studied her response was "I did what I did in high school. I looked at all the slides to figure out which topics would be emphasized and made sure I knew those. I skimmed through the book to review those things. Besides I knew some of the stuff from high school so the exam was not that hard." When asked if she focused on the knowledge application questions her response was, "I didn't see the point. I know [the teacher] said that, but that was not the what she covered in the lectures." As noted earlier, LeeAnn was the only student in the study who had attended a private high school. In many ways her educational experiences were more like the higher-income White students at the university. All of her high school science classes had a lab component which reinforced the course material and helped students with knowledge application. Through her high school science experiences she seemed to have gained a foundation in the science content valued at the university and she had figured out that the best course of action in studying for the exam was to pay attention to what the teacher focused on during her lectures and use the textbook to supplement that information.

Putting this in terms of Bourdieu's theories of capital, LeeAnn had gained the academic capital and habitus that was rewarded at the university. This does not mean that LeeAnn's approach to studying for this exam was superior to the other students, just that the ways she had learned in high school were congruent with the way things were taught and assessed at the university. An oversimplified conclusion to draw from the example of LeeAnn's success would be to give more students of color access to a private school or to help students acquire the study approaches linked to high exam performance in college. However these approaches would do nothing to address the systemic inequities in the K-12 education system or to prompt more nuanced explorations of the experiences that students of color bring with them to college science.

A Shift in the Teacher's Approach and Perspective

After the first exam, there was a subtle, but discernible difference in how the teacher approached and interacted with the students. Some of these changes suggested that she realized her assumptions about lack of study time did not adequately explain the students' exam performance. As noted above, during the first class after the exam she focused on students needing to spend more time studying. However in the next class session she spoke more explicitly about particular exam questions that a lot of students had missed and pointed to specific slides where that information was covered. She seemed to have spent additional time thinking about why students had not done well. She put up a slide and pointed out that the following three questions were missed by a large number of students:

Q 4. ATP is used to fuel what high energy bond?

Q 8. Originally operons were thought to only exist in the genome of what type of cell? (answer prokaryotes)

Q 17. Where does the energy for DNA replication come from?

For all three questions she then went to the specific slides where students could find answers to the particular questions. She noted to students, "What I am trying to say by going through all this is that—well the information is on the slides. This is where I go to create the exam questions. This is where you should go when you study." It should be noted that all three questions fall into the category of knowledge recall questions, but this was not mentioned by the teacher. While she was still locating the problem with students in terms of their study approach, it is notable that she was going beyond the simple explanation that students were not studying enough and trying to give them more explicit advice on what to do.

The other explicit difference in the instructor's approach after the first exam was that she started asking students more questions during the lectures to check their understanding. Instead of simply telling students they should stop her if they did not understand something, she would ask them to summarize key ideas or ask directed questions to students. When students could not answer fully or correctly she went back and elaborated on or provided further explanation of the content. For example, the following exchange occurred at the start of one class between the instructor and two students:

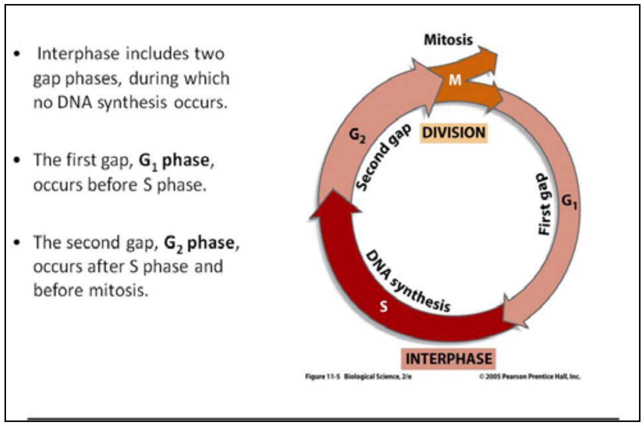
> *Teacher:* We have been talking about the Eukaryotic cell cycle. Who can tell me when DNA replication occurs in the cycle?
>
> *Student 1*: Well, I think it happens during mitosis.
>
> *Teacher:* Well, not quite. The mitotic phase—or the M phase—is when the cell divides and if you remember a dividing cell is not a replicating cell. Replication happens during interphase. But the interphase state is more complicated. Who knows the different interphase states?
>
> *Student 2:* I know there are three stages, and somewhere in the middle the DNA replication happens.
>
> *Teacher* (to Student 2): You are right about the middle part, but can you tell me

more about the three stages and their names?

Student 2: I would have to look at the slides, I can't remember.

Teacher: Ok, so let's look at the slide.

At that point the teacher went to the following slide with the interphase details and spoke in more depth about the three phases and what happens to the DNA during the S phase:



This exchange is notable because it shows students the level of detail they will be expected to recall from the slides. It also points out to the teacher that while the students understood the general concepts related to the cell cycle, they did not know the level of detail that she had assumed.

After this particular class I spoke briefly with Sean who made the comment. "In high school if I got the big idea I was good, but now it seems like there is so much to know and I'm not sure what is important." Sean's comment also suggests a possible explanation of why the students were missing some of the more factual knowledge recall questions. Because there was so much emphasis on knowledge application, students were not spending enough time on the many factual details that were covered in class. They may have made the assumption that it was enough to have a general idea of the concept before going on to the application questions. While there are other possible explanations, this scenario suggests that there is much more room for further investigation into what academic experiences these students are bringing with them to college and how those intersect with the college science expectations.

The teacher's approach of more frequently asking students questions to gauge their understanding also had the effect of keeping students more engaged in the lectures. In earlier class sessions I observed students struggling to stay awake and to follow the slides. Once the instructor started asking questions I saw that the students all had the slides on their computers and were keeping up with her points. In speaking with a few students, they liked that she was interacting with them more and they felt she cared more whether they were getting the material. Alana noted, "She seems nicer and seems to care about how we are doing in the course."

Approximately a month after the first exam, I sat down with the instructor to get her perspective on how things were going with the course. Part of the discussion focused on her experiences teaching the McNair students compared to the students in the regular sections of the cell biology course. She made the following comment about the exam outcomes:

> In [the regular] classes there was always a range of exam grades. Because a good number of students did well it was easy to assume that I had done a good job teaching. For the students who didn't do well, I just assumed they didn't study or pay attention. I didn't think about my teaching or what science background students had. Now with this class, I can't make the same assumptions about students' high school classes. Because most of them did not do well on the exam, there is something else going on. Now I try to review some of the background

> content and make sure they understand things as we go along. I can't assume they have all taken AP bio.

The instructor continued to talk about how she was encouraging students to come to her office more often for help and how she was learning more about what aspects of the material were difficult for them. It was through these direct experiences with students that she started to understand the more complex nature of their challenges and to consider that she might need to change her instructional approach.

It is notable that the instructor was open to a broader understanding of the challenges faced by students and that she was able to consider what role her teaching might play. It is possible that if she had longer to work with these students or had the benefit of a collaborative researcher as a structural element to the course, she might discover more about them. However, she was still approaching the students from a framework that assumed and focused on the gaps or deficits in their backgrounds and the ways that these deficits might be fixed. There was little indication that she was able to see that these students possessed other valuable types of knowledge and experiences that were relevant to the science coursework. The changes to her teaching were intended to help students access the existing curriculum rather than changing the curriculum to leverage their backgrounds and knowledge.

During our interview the instructor was also curious whether I had learned anything from the students that would be helpful to her. I was a little surprised and not prepared for that kind of interest on her part. I had not yet figured out the inconsistency between her study advice about knowledge application and the exam questions requiring knowledge recall or I would have addressed that point. It is possible that if we were able to have that conversation and work more collaboratively over time, it might have led to a better understanding of the issue and she might have worked on ways to address this with students. It was this kind of collaborative program assessment that I had envisioned early in the formulation of this research. However, that kind of approach would require a university program to acknowledge the complexity of the problem and to assume their task is more one of discovery rather than a prescriptive set of actions based on broad assumptions. A collaborative approach would also require a commitment to a longer term multifaceted investigation with input from all those involved with the program.

I did share with the spring instructor some of the issues that students had regarding the language challenges with the exam and textbook. Similar to the fall teacher she was surprised to learn that English was not the first language for many of the students or that some students had trouble with the complexity of the language on the exams. I also shared that most students did not have a lot of experience using science textbooks because of the limited resources at their high schools. Some of the students tried to read the book before lectures while others read it after lectures but neither approach seemed to help students learn the material. I suggested that it might be helpful if she spent some time talking with students about the best way to make use of the book as a resource. I was surprised when she explained that she saw very little value in the textbooks:

> I don't think that the textbooks are very helpful and in fact I usually tell students to not even bother reading the book because there is too much information. If they review and study the slides and pay attentions to the lecture, that should be all they need. I guess I need to talk to the class about this, but I don't know how to advise them. I also don't follow the order of the chapters so the book won't be as

helpful.

While her answer was not what I expected, her view of the textbooks was consistent with the research showing that most college science textbooks are problematic because they cover too many topics, use difficult vocabulary, make no attempt to link to students' background knowledge, and lack logical structures that develop concepts and relate them in a systematic way (Goldman, 2000; Goldman & Bisanz, 2002). The research also shows that even though the textbooks play a central role in college science courses and present many challenges to students, college science instructors are even less likely than high school teachers to provide students with science reading and writing strategies (Goldman & Bisanz, 2002).

At one level the instructor's view that students are best served by ignoring the textbook seems helpful given all the limitations of the textbooks and the challenges the books pose to the students. Students may benefit if the content in her slides is more direct and accessible to students then the content in the textbooks. However by ignoring the textbook, she is limiting students' ability to make use of the book as a resource when they are not sure about particular content covered in the slides. In addition, it is likely that they will be required to use textbooks in future science courses and by not providing assistance, they will be at a disadvantage compared to students whose literacy background provided them with this kind of familiarity.

End of Year: Outcomes and Student Perspectives

During the remaining part of the semester, there was another exam approximately a month and a half after the first exam and then the cumulative end of semester exam. The students did marginally better on second exam and the final exam, but not as well as either the teacher or students had hoped for or expected. In follow-up conversations with the students, they raised similar concerns about how all the effort studying often did not often translate into better exam results. The teacher expressed some level of frustration that even with the changes in her teaching, there had not been more improvement. She did concede that it was complicated: “It is really difficult to figure out the best way to help students with such a wide range of backgrounds.”

All four of the students who started the spring McNair biology class completed and passed the course with at least a C-. Of these four students who had stayed in the McNair biology course only Fatima would continue as a sophomore in the pre-medical program. She got a C+ in biology and a C in the chemistry course. These were not the grades she had hoped for, but she counted them as successes. She assessed her situation with the following comments: “It was so hard at first and I felt so intimidated by the teachers and the other students. But I kept thinking back to the encouragement from my [high school] teachers and my older sister who is studying engineering. [My sister] told me I might not do so well at first, but just to get through the first year of classes. The summer program I did at [the state university] medical school in high school really helped me see that big picture of medicine and science. All the time in the [college] classes I just kept thinking back to that [program] along with the terrible health problems I had seen in Afghanistan. I was always trying to put what I was learning in the context of those things and that really helped me better learn the material.” When I asked her how she knew to do that, she talked about what her high school biology teacher had done. “She was always asking us things about our family and where we were from. She was really interested in my experiences in Afghanistan—I think her husband had been there.

Anyway…during science class she would sometimes make connections to things we knew about such as different diseases. That kept me from getting bored with the material and I guess I just tried to do the same thing here." Fatima's experiences suggest the important role that student's background experiences and knowledge play in student learning. Even though the McNair program instructors did not provide this link, Fatima managed a way on her own to leverage her background knowledge. Her experiences also show that students can learn to use this strategy on their own even when their instructors do not actively do this.

Biju did not think he would continue in the pre-medical program, but he did continue as a Chemistry major. He attributed his difficulties in biology to his language challenges."In biology there is just too much reading and the vocabulary is too much for me. I thought my English was better than it was, but I just couldn't do it—especially getting through all the exam questions." Because Biju continued in a science program, the university might count this outcome as a success, but Biju was disappointed that he was not able to persist in the biology course work. "I would work so hard studying and reading, but when I got to the exams, I was slow reading the questions and I never had time to finish. But I don't want to give up on medical school so maybe I will figure something out."

Alana and Sean both passed the McNair cell biology class with a C and C- respectively. Both decided to leave the pre-medical program, but they did not have many regrets about their decisions or the outcome. Sean had decided to switch to psychology and saw connections between the biology work and psychology. "All of this was helpful in terms of my psych classes and I think it will help later. I wish I got a better grade, but now I have an idea of what I want to do." Alana was not sure what she was going to do, but believed she would figure it out. "I'm not sure. I have a lot of other core [required] classes to take and hopefully I will like something. Maybe I shouldn't have taken [the spring cell biology] class, but now I don't need to take any more science class."

Sean and Alana's reactions were notable in that they left the program with their grades and sense of themselves as students intact. In previous years many of the students I had worked with left the pre-medical program because they were barely passing the classes. Some were left with a terrible sense of failure and a view that they were just not good at science. In addition, their science class grades lowered their GPA which had repercussions through the rest of their time in college because many other opportunities such as study abroad and admission to specialized programs are based on a certain GPA.

For LeeAnn and Sharon, the two students in the regular cell biology class the results were mixed. Sharon barely passed the class with a D-, but LeeAnn did well with a B. LeeAnn had switched to a different chemistry teacher and did well in that class with a B+. She planned to continue in the regular pre-medical program and unlike the others she had no expectations that the science classes would be interesting or engaging. "The classes are hard and boring, but I just need to make it through them. I hope they will get better, but I still do want to be a doctor." LeeAnn was also happy to be out of the McNair program noting that, "I hated how they tried to control everything and made us do all the extra work and made us take certain teachers."

Sharon's experience in the cell biology course was similar to those of the students of color I have worked with in previous years. After receiving a D- in biology, Sharon was very discouraged and doubtful about both her science abilities and her future in a medical career. Of all the students in the study, she had started with the most passion for science and public health issues and it took her a while to regroup and figure out a new direction. At the end of the semester she was too upset to talk about what had happened. In a later conversation I asked if she regretted leaving the McNair section of biology: "Maybe if I had stayed in the [McNair cell biology class] my grade would have been better and I wouldn't feel so dumb when it comes to science. But I don't think I would like the class any better—the way science is taught here sucks. It is hard to say whether I would still be in pre-med….But I will tell you what, my sociology class helped me see that I was confusing service and medicine. I can still do things in a public health area without being a doctor." Like Sharon, many of the previous students of color who left the pre-medical decided to major in sociology. Sharon expressed views that I have heard from many of these students about their affinity for sociology: "[Sociology] just explains so much here [at the university]. It doesn't make it better, and sometimes I hate it here, but at least it's not just me and I can talk about it with people who understand."

The final two students, Tran and Juan, had left the McNair program during the first semester. Juan had dropped both biology and chemistry during the fall. Because of that decision his grades were not impacted by the science courses. When I met with him at the end of the year he had decided to major in political science. He did not regret leaving the pre-medical program, but he did comment on how little he knew about the different fields of study in college: "My high school didn't really help me know things like what kinds of majors I could pick in college. All they talked about was math and science and how we should go those directions. My brother wanted me to do science too. I didn't really know what else I could do and when I got here, nobody really explained anything. I just thought medicine and biology. When I realized I couldn't do science, I didn't know what to do. But I got a mentor who explained it all to me and helped me look at political science."

Tran had dropped the fall chemistry class and finished the fall biology class with a C-. She wanted to continue in the pre-medical program but she did not want to major in biology or chemistry. Not realizing that there were other options, she decided not to continue with the science classes, however towards the end of the year she was angry to learn that she did not have to major in science to fulfill the pre-medical requirements. "I could have been a philosophy major and done the pre-med requirements. I didn't have to take all the science classes at once. I might have done a lot better and not left the program. I wish someone had told me that. Maybe I would have continued. I guess I still can, but I don't know right now. All I heard was how you had to finish all these pre-med classes on track or you can't apply [to medical school]."

Like Juan, Tran would have benefited from more information at the start of college on the different academic paths that are possible both in general and to fulfill the pre-medical requirements. However, the pre-medical advisors at the university often emphasize a path that lets students complete the requirements in three years so they can apply to medical school as seniors. In an interview, one of the administrators who works with many students of color strongly disagreed with this policy: "It is ridiculous that they push them to take so many science and math classes their first year. I always advise pre-med freshman to start with only one science class and not to rush things. I tell them that most people don't apply to medical school as undergrads and there are other ways—like a post-baccalaureate program—to meet the requirements. They will also be more successful if they get some experience after college."

The experiences of these eight students show the complexity of their challenges and the difficulty of identifying a simple set of changes or interventions that could be made to improve the program. The ways their various pre-college backgrounds intersect with the systemic patterns in pedagogy, curriculum, and university practices and context shows the complex and intertwined nature of the problem and raises difficult questions about the chances for students of color in this kind of university context.

CHAPTER EIGHT: Conclusions and Implications

The purpose of this research was to use the lens of Critical Race Theory to examine the experiences of eight student of color during their first year in a new pre-medical program at University on a Hill. As is the case at many large research universities, very few students of color at this university continue in the pre-medical science courses past their first year. The question was what explains why so few of these students of color continue in the pre-medical science courses. Using the lens of Critical Race Theory allowed these experiences to be seen in the larger institutional context of the university where their obstacles are connected to the successes of affluent, US born, White students in these same pre-medical courses. Thus the more significant research focus was to make visible and explain, in order to interrupt, the institutional structures, practices and explanations that advantage some groups and disadvantage others.

Previous Research

As noted in Chapter Two, much of the existing research regarding success in college science courses has focused on discrete reasons why students are not successful in college science and on interventions to address the perceived problems. This research does not usually acknowledge the particular challenges faced by students of color and whether the interventions will improve the outcomes for these students. Some of the key areas of research focus on science interest, high school preparation, the challenges of science language, the nature of college science teaching and the college science classroom atmosphere.

Tai, Liu, Maltese, and Fan (2006) found that eighth grade students who expressed an interest in science and believed they would have a career in science by age 30 were more likely to graduate from college with a science degree. Other research suggests a link between high school course work and college science outcomes. Studies examining students' high school preparation and persistence in college science fields suggest that students who have not taken enough rigorous high school courses in math, science and English will have difficulty with college science course work (Adelman, 1999, 2006; Horn, Kojaku & Carroll, 2001; National Academies, 2007, 2010). Another finding (Sadler & Tai, 2001; Tai, Sadler & Loehr, 2005) is that students are more successful in college when their high school teachers concentrated on fewer concepts and covered less material, but in greater depth. While the research affirms the importance of helping students more deeply understand conceptual ideas, Tate (2001) found that students of color, who are more likely to be concentrated in urban schools, enjoy less quantity and quality of science instruction compared to suburban students because in urban schools deeper conceptual work is limited and much more time is devoted to standardized test preparation.

Other research has focused on the language challenges of science. Halliday and Martin (1993) and Schleppegrell (2004) note the distinctly different nature of science language and text structures and more importantly how that language presents a linguistic challenge to readers whose home or school backgrounds have not privileged this type of language use. Despite this particular challenge involving science and language, there is a lack of acknowledgement by educators regarding the central role that language actually plays in science education and learning (Yore et al., 2003).

Much of the research on college science teaching (Crowe, Dirks, & Wenderoth, 2008; Handelsman et al. 2004; Handelsman, Miller, & Pfund, 2007; Stokstad, 2001) is focused on improving student interest and engagement in courses by the use of active learning and inquiry-based pedagogies. However other researchers (Lawrenz, Huffman & Appeldoorn, 2005) confirm that most introductory college science courses still rely on a knowledge transmission model with the use of lectures and textbooks. Further, an analysis of college science textbooks shows that most texts cover too many topics, use difficult vocabulary, make no attempt to link to students' background knowledge, and lack logical structures that develop concepts and relate them in a systematic way. While these characteristics make the reading comprehension a challenge for all students, the impact on bilingual students is more significant because the cognitive challenges are increased (Gainen, 1995; Goldman & Saul, 1994; Nassaji, 2002).

A small body of research has focus on the challenges faced by students of color in college science courses. Researchers have documented the detrimental impact of impersonal science classroom environments and the valuable role of support structures in science course engagement (Gasiewski et al., 2012). Beasley found that for students of color, stereotype threat (Steele, 1997), or anxiety that their performance might confirm negative stereotypes about Blacks' academic abilities was a significant reason why they left college science programs. While all of these factors are potentially relevant and may contribute to students' challenges, there has been little research that looks at how these and other factors work together in the context of the university environment to systematically privilege one group and disadvantage another group in college science programs.

Research Focus and Purpose

So that these various factors might be examined more systemically, this inquiry used the analytic frameworks of Critical Race Theory and theories of capital to examine how the various individual factors impacting students of color function together to form an interlocking system that disadvantages these students in pre-medical college science classes. The major areas of analytic focus included: Assumptions and dominant narratives about students of color in science, pedagogical approaches employed by instructors in college science classes, including the classroom environment and how those compare to approaches that students of color have experienced in their various high school settings; the role and impact on students of the academic science language in course textbooks and exams; the ways that race, class, language, and immigration status impact students in the science classes and the larger university; and the various ways university structures and practices such as financial aid policies, science course structures, and grading practices impact students of color pursuing pre-medical science courses.

Research Questions and Findings

My primary research question was "What can a Critical Race Theory perspective tell us about a predominantly White research university's program aimed at supporting students of color in pre-medical courses and the experiences of students of color in those courses?" In some sense this is a rhetorical question because in keeping with the principles of Critical Race Theory, the assumed answer is that students' experiences and challenges are complex and not easily understood and addressed though discrete solutions. While the intent is to understand the systemic impact, it is necessary to examine the various parts in order to understand how they function as a whole. To that end I sought to understand and foreground the experiences of eight students of color in the program, but within that context the perspectives of the eight students were compared to and analyzed alongside those of science faculty members who were involved in the program's implementation, and university administrators who support students of color at the university. I also sought to situate these perspectives in the larger university context and the national discourse surrounding students of color both in science programs and in universities. These multiple perspectives provided a broad contextual understanding of the program, the university and the students along with showing how these views, structures and policies play a role in maintaining institutional inequities.

Below are the specific research questions I asked relative to these different aspects of the university environment. For each question, I highlight some of the key findings. Following the findings, I provide the stories of two students, Biju and Sharon to illustrate the ways that these multiple factors interconnect to systematically disadvantage these two students in the pre-medical program.

Discourse on students of color in science. *What are the cultural, economic and sociopolitical narratives and articulated motivations for the creation of college programs designed to retain students of color in pre-medical science programs? What kinds of racialized understandings and assumptions about students are used to formulate these programs?*

Within the public policy discourse, the dominant narrative framing the question of students of color in science is that the country needs more of these students in science careers so the US can remain economically competitive in a global economy (National Academies, 2007, 2010). The concern about students of color is linked to an awareness that people of color are a growing percentage of the population and if they do not pursue science fields the country will not be able to compete with other nations. In this framing of the problem, the focus is primarily to identify students of color interested in science at a younger age and sustain their interest through more inquiry-based and active learning pedagogies (NSF, 2005; Tai, Liu, Maltese, & Fan, 2006). The problematic underlying assumption is that these students have little science interest or awareness of the relevance of science in their lives to begin with. This dominant framing related to students of color in science was reflected in both the discourse and the philosophies underlying the McNair pre-medical program at University on a Hill. Trying to facilitate students' interest in and awareness of the relevance of science was an especially prevalent goal in the design of the program and courses.

Even though medicine is a distinct subfield of science, within the public policy discourse there is little effort to differentiate the framing of the issue in terms of why the country needs students of color in a field like engineering versus why they are needed in the health professions. When the question is framed in this way, students of color are viewed as an important and missing population in the health care professions. In this narrative they are seen as possessing important linguistic, cultural and experiential capital that the profession requires to serve a population that is increasing in cultural and racial diversity. Those advocating for more students of color in health fields have a more complex understanding of why there are so few people of color in the health professions. Grumbach et al., (2003) notes that, "The problem …is the end-result of profound disparities in educational opportunities and support, beginning at the earliest schooling stages. To address … disparities in the health professions means to confront fundamental social inequities in educational and life opportunities in the US" (p. 3). At University on a

Hill there was no mention of the need for and valuable role for students of color in the medical field.

The experiences of students of color in science. *How do students of color in pre-medical college science programs make sense of their experiences, particularly in terms of the language and pedagogical practices employed in the college science courses and how do those practices compare to their earlier K-12 educational experiences?*

In the context of research on students of color in college science, the students' perspectives have been a profoundly missing part of understanding the challenges they encounter on the way to and during their coursework. The students in this study felt they had been pressured into a program they saw as remedial, and overly controlled in terms of their time and the work required, especially in the chemistry class and their required advising class. They believed they had been segregated and were treated as lacking because of their racial and educational backgrounds, a view that was compounded because they had also been required to attend a summer bridge program as a condition of their admittance to the university. In addition, because their fall biology class had a notably different pedagogy than the other pre-medical biology courses this sense that they were being treated differently than other students at the university was intensified.

The students expressed a strong desire to experience the same teaching approaches as other students in the pre-medical program, however they were aware that their K-12 educational background was in many ways not the same as other students at the university. Many noted inexperienced high school science teachers who meant well, but did not prepare them for college science. Within their high school classes they noted a focus on test preparation at the expense of more in-depth conceptual learning and a lack of access to textbooks and lab materials. In the college science courses, they were frequently reminded of these differences in their backgrounds when teachers made comments like "I know you already know this, so I won't spend any time on it." The bilingual students were also aware that many language aspects of the science curriculum posed a barrier to them, particularly the language used on the exams and in the textbook. They wanted instructors to help them learn what they did not already know and they wanted and needed more clarity around the frequently repeated notion of applying knowledge. They also wanted assistance with how they should go about using the textbook as a knowledge resource.

At the same time the students wanted faculty members to recognize that they brought considerable science knowledge and experience with them to the university. Many of the students had attended summer science programs at universities where they were engaged in research. In addition, a large percentage of the students had direct knowledge of the public health issues faced by communities of color. While, not always conscious of how teachers might use their rich backgrounds, a few of the students noted past experiences where teachers were able to link to and leverage their knowledge and experiences and how helpful that was in the learning process.

Science faculty members. *How do science faculty members in these programs make sense of their role and what assumptions and understandings do they have about the students' backgrounds and motivations? How do science faculty members understand the university context, especially in terms of university structures and practices, including language and pedagogical practices that reinforce or disrupt racialized advantages?*

The science faculty members in this study were committed to helping the students succeed in the new pre-medical program. They were recruited to work with the program based on either a desire to work with these students or because of an interest in new teaching approaches. However, they had little knowledge or understanding of the students' motivations for pursuing medicine. Nor were they aware of the students' backgrounds both in terms of the gaps in their educational experiences and the considerable science and health profession related experience and aspirations the students possessed. There was a concern by the teachers that if they knew too much about students' backgrounds they would see them as less capable than other students. This view was somewhat ironic given that the whole model of the program was based on the premise that these students needed extra help to make up for what they did not know.

The instructors primarily saw their role as giving students the academic science knowledge they were lacking and seemed to work from the view that there were core, fixed concepts of science that, for the most part, were unchanging rather than presenting science as a process of both building on and challenging past theories and dogmas. This view of the fixed nature of the science curriculum afforded little room or reason to inquire about students' backgrounds and to in turn shift the curriculum and the pedagogy to leverage that knowledge. While both of the faculty members had conducted their own research and likely understood the theoretical and changing nature of science knowledge, this was not the sense of science that was presented in the course. Perhaps this reflects Bernstein's (1996) notion of knowledge hierarchies where students are not permitted to do "real" science until they make their way through the lower levels of science knowledge.

While the spring biology teacher began to understand the more complex nature of what might explain why students did not do well on the exams, there was a dominant view that students were not working hard enough or were not doing the right things to study. There was little indication that the instructors understood some of the larger systemic factors at work both within the science courses and in the university as a whole. They also had little awareness of how language challenges with the textbook or the exam might play a role in student academic success. Nor did instructors have a broader sense of students' experiences in the university or in their home lives and an understanding that many of the students faced time and financial pressures because of work study and family financial concerns.

University administrator perspectives. *How do university administrators who work with students of color interested in pursuing science fields make sense of students' backgrounds, motivations, and experiences in the university context? How do these administrators understand the university context in terms of structures and practices that reinforce or disrupt racialized advantages?*

The two administrators interviewed for this study work closely with students of color individually advising them in academic and non-academic concerns. Their level of knowledge about and experience with students of color is quite different from many other university administrators and thus their perspective is not intended to be broadly representative of university administrators. However, these administrators work with students from a range of racial, income, and educational backgrounds. They also both frequently interact with other university administrators and with faculty members and these multifaceted experiences give them a broad view of the university context and how the various university practices and systems impact students of color.

Because both of these administrators spent considerable time working individually with students of color they often come to know their personal stories and reasons for pursuing a medical career. They are aware that some students—including students of color—pursue a pre-medical concentration because of family pressures or because it seems like a financially lucrative profession. However, they also know that most of these students come to the university with a long-standing interest and experience with the health professions either through personal experience or through various summer or after school extra-curricular programs. When asked about why students have difficulty in the science classes, they expressed an understanding of students' experiences in the broader context of the students' past educational experience and the university environment and how those factors, rather than an individual student's efforts were linked to their difficulties. One of the administrators, because her work is more focused on helping students academically, was very aware of how the practice of grading students on a normal distribution in the science classes impacts students who have inadequate high school preparation. She has worked to educate science faculty members on the need for competency-based grading. She also noted the lack of racial diversity among the faculty and how that translated into a lack of awareness of the challenges that students of color face at the university.

The other administrator who works more often with students newly admitted to the university had an awareness of the financial and family challenges that many students of color face as they transition into a college environment. She noted that many students struggle financially and that they often work too many hours in their work study jobs. She had worked with students and the financial aid office on a case by case basis and the office she worked for was able to provide some financial assistance to students. While she was aware of students' challenges, she also knew the richness of knowledge and experience that students brought to the university and did what she could to educate the university community on this perspective. She too was concerned about the lack of racial and class diversity among the science faculty and saw that as a barrier to faculty understanding of both the challenges and strengths students of color brought to the university and to the way they taught those students.

While both administrators are aware of these broader issues and they work to influence the wider university community about these issues, they are also aware of their limited influence to change what are long standing practices at the university and in society. They do everything they can to support students of color in the pre-medical classes, however at a certain point they can see that the best approach may be to advise students to switch to another field of study to preserve the GPA and future study options. One of the administrators when asked what advice she would give to a student of color considering coming to the university for the pre-medical program, said, "I would recommend that they go somewhere else—to a smaller school or to a less competitive public university so they would have a chance to succeed." What this administrator had articulated was a thought that I had struggled with many times during this study. Her comment raised one of the difficult questions about the extent of the challenges at a large research university and what would be required for students to succeed addresses the many ways that students of color are disadvantaged.

The birdcage: Biju and Sharon's stories. In the process of analyzing the many ways that students of color were challenged in the pre-medical program, I endeavored to understand the ways these multiple factors functioned together to systemically disadvantage the students of color in this study. Marilyn Frye's (1983) birdcage analogy of oppression is an apt way to illustrate why these factors must be understood as interconnected and systemic. Frye points out the problem with only examining a single wire in the birdcage: "If you look very closely at just one wire in the cage, you cannot see the other wires. If your conception of what is before you is determined by this myopic focus, you could look at that one wire, up and down the length of it, and be unable to see why a bird would not just fly around the wire any time it wanted to go somewhere" (p. 4). Frye goes on to explain that only by seeing that cage as a whole is it possible to understand the interconnectedness of the wires: "It is only when you step back, stop looking at the wires one by one, microscopically, and take a macroscopic view of the whole cage, that you can see why the bird does not go anywhere; and then you will see it in a moment…. that the bird is surrounded by a network of systematically related barriers" (p. 5).

To illustrate the interlocking nature of these challenges, I draw on the stories of Biju and Sharon, two of the students in the study. The experiences of these students are situated in a university context where students of color are frequently portrayed on the university website as coming from difficult family circumstances and backgrounds such as low-income urban neighborhoods lacking in resources. This characterization is coupled with a dominant narrative, both in the public policy discourse and within the science departments, that students of color are not interested in science and do not understand the relevance of science in their lives. These majoritarian narratives make it seem normal and acceptable for an instructor to use the example of obesity in urban neighborhoods as a way of helping students of color see the relevance of science in their lives.

Within this larger context, each of these students was challenged in particular ways by multiple interconnected factors. I start first with Biju's experiences. After Biju had emigrated from Nepal at age 13, he attended a well-resourced suburban school where he was able to take two years of advanced chemistry courses. He seemed poised to do well in the college science courses and he did do well in the both semesters of the chemistry class. However, Biju struggled in the biology courses because of difficulties with the complex language on the exams and in the textbook. The suburban high school he attended was not accustomed or equipped to help immigrant students with the challenges of learning academic English and he started college without the literacy skills that would have helped him on the biology exams and to make use of the textbook. The college biology teachers were unaware of the challenges posed by complex science language generally and were also not aware of Biju's particular language background. Further, the teachers had not been trained in working with bilingual students and were not able to provide the needed assistance or flexibility in their exam structures to address these language challenges. Biju, perhaps because he was concerned that he had been negatively stereotyped as not being as capable as the students in the regular pre-medical courses, did not talk to the teachers about his difficulties and was not sure of the other ways to seek help or study for the exams. Despite these challenges he put in many hours studying and went into the biology exams with a strong sense of the material. However, he always had difficulty completing the exams because of the time it took him to read and understand the questions. As a result, he received low grades on most of the biology exams. The fall biology teacher noted that she was concerned about Biju's exam grades, however it is unlikely that she had a sense of the complex set of factors that ultimately impacted his exam performance. Biju did continue with chemistry, but the language challenges in biology ultimately led to Biju's decision not to continue with the biology course work and the pre-medical course of study.

Sharon had a somewhat more complex set of interconnected challenges. At age 15 she had moved to the US from Jamaica where she had attended Catholic schools. In Jamaica she gained a strong science background because of the way science and art were taught in an integrated manner where students had to visualize and draw the various scientific structures and processes. Once in the United States, Sharon enrolled in a large urban high school. The school did have advanced science classes, but because she had come from Jamaica and was not able to show that she had taken the pre-requisite course work she was placed in the lower level science classes and was also required to repeat a year of high school. The teachers in her high school science classes were, in Sharon's words, "terrible" but she was able to draw on her science background from Jamaica to get through the classes and do well. Despite her dislike of the science classes, she continued to be interested in issues of equity in medical care and public health because of her experience growing up in Jamaica and her service trip to Nicaragua.

Sharon's first-choice college was one of the top ranked, historically Black universities where she had been accepted. However, she had little assistance and guidance during the college application process and both a high school counselor and teacher urged her to attend University on a Hill over the other school. Sharon also believed that University on a Hill had provided better financial aid than the other school. However, she did not initially understand that her financial aid included loans and work study. Because her family was unable to provide much financial assistance, during her first year at University on a Hill she routinely worked 15 hours a week at her work-study job and at one point also worked off campus at a grocery store.

Sharon's high school had provided her with only the basics of chemistry and she had a difficult time in the college chemistry course where the teacher assumed all the students had taken advanced chemistry courses in high school. Because the teacher used a normal distribution to determine exam grades, Sharon's exam grades were always on the lower end of the curve. She noted how this grading practice contributed to a competitive class environment where students were reluctant to help each other. Sharon did better in the fall biology course where she continued to use the science skills she had acquired in Jamaica. Despite doing well on the exams, she felt the rigid biology curriculum was disconnected from the medical and public health topics she cared about. This sense of alienation from the curriculum was furthered when one of the biology teachers suggested that unless a person loved science from the start, then perhaps it was not the right field. She was also offended by the obesity and Kuru disease examples used in the science class because of their negative racial characterizations. In another university class Sharon had also endured ongoing racial microaggressions when the White students denigrated the people in the urban neighborhood where she had lived during high school. Throughout all of these challenges Sharon found that her sociology courses, unlike the science courses, resonated with her interests and experiences. At the end of the first year she decided to leave the pre-medical program and instead to pursue a major in sociology.

Sharon and Biju's experiences illustrate the interconnected complexity of the "bird cage" where these students and students of color, generally, find themselves trapped and where, in spite of their very hard work, are unable to free themselves. In reviewing the experiences of the eight students, many obstacles—or wires—were evident and are summarized in Table 5.

Table 5: Obstacles Impacting Students in Science Courses.

- Students are seen as lacking in science interest by college instructors
- Prevalence of meritocracy and color blindness narratives at the university
- Immigration status impact on schooling; length of time in the US
- Language status impact on schooling; length of time spent learning English
- Poor advising in high school related to college selection and financial aid
- Limited and inadequate high school science coursework
- Inexperienced high school teachers
- Incongruent schooling practices between high school and college
- Poor advising in college related to the selection of college science courses
- Normal distribution grading practices in college science courses
- Competitive and intimidating college classroom environments
- Incongruent pedagogies between different college science courses
- Program structured as a remedial vs. elite program
- Stereotype threats and racial microaggressions
- Financial constraints leading to long work hours
- Rigid and unappealing science curriculum
- Science course pedagogy focused on knowledge application, but exams focused on knowledge recall
- Complex textbook and exam language; inadequate time to complete exams
- Teachers lack of interest in students' background
- Teachers lack of knowledge about students' high school preparation
- Students experience and knowledge not seen as assets by instructors

For some students there were more bars than for others and the obstructions intersected in particular ways with various individual histories of the students: sometimes language constraints, sometimes time and financial constraints, sometimes alienation from the curriculum. Other bars, such as the science course structures, the grading practices, stereotype threats, and racial microaggressions were obstacles for most all of the students. For all of the students, the obstacles were multiple, interconnected and not easily overcome or addressed and it becomes clearer why so few students of color continue on a science path.

Recommendations for Better Envisioned Programs

The experiences of Biju and Sharon point to one of the difficult implications and questions that comes out of this study: Can a program be implemented at a place like University on Hill where so many factors work against students of color in the pre-medical science courses, especially the structures and practices that normalize the competitiveness and sorting of students so that only a small number are able to continue in the discipline? I do not want to conclude that it is impossible, but this study suggests it is a much more challenging and complex task than the creators of the McNair pre-medical program have assumed. It does seem possible to draw on the findings of this study to make some recommendations for how a large, competitive, research university like University on a Hill might go about informing such a program.

One fundamental requirement is an acknowledgement of the complex and systemic nature of the issue which in turn calls for a program that functions as an interconnected set of supports. Analogous to the birdcage, a program must be envisioned as a supporting web rather than a few discrete elements that end up looking like a tightrope that might enable a few more to cross, but will eliminate most. In discussing why *Brown v. Board of Education* did not bring about lasting change, Guinier (2006) concluded that real and lasting change must be grounded in efforts that involve a broader coalition of proponents who have equal concern about social justice for people of color. For a university to better support students of color the many university constituents must be committed to the same goal. They must come together and work to understand the larger context of structured opportunities and obstacles so that a program might better reckon with these institutional forces. Individual components of the programs are important, but attention must be paid to how all the components work together and how they will impact the students in the program. For example, implementing an inquiry-based pedagogy without considering how other courses are taught or how students in a program will view being segregated and taught differently may undermine any benefit from the teaching approach.

Universities must also assume that many of their practices and structures are a fundamental part of the problem of institutionalized oppression and they must be willing to examine and change these practices. For example, the grading practices at University on Hill along with the corresponding view that pre-medical classes are a boot-camp that eliminates all but a few are contrary to the notion of supporting students. If a university is not able to take on those difficult issues, a few discrete supporting measures will make little difference. While not intended to be an exhaustive list, below are some considerations for universities that endeavor to support students of color in pre-medical science programs. Some of these considerations are not difficult undertakings for universities, but other suggestions challenge the very core of the way traditional science programs function (very efficiently) to narrow down the number and type of students who are able to continue in a pre-medical course of study.

Setup the program as a reward, not a remediation. Instead of persuading students to take part in a special curriculum once they are at a university, creating a series of supports like the Meyerhoff program (Hrabowski & Maton, 1995; Maton, Hrabowski & Schmitt, 2000) where students must apply and are subsequently selected to participate would go a long way in framing the work as an achievement and reward. If the application process starts with the assumption that students have valuable knowledge capital to bring to a pre-medical program, during the process of reviewing and evaluating those applications, the university would gain a sense of the capabilities these students bring and could use those to formulate the curriculum. Correspondingly the program needs to be framed in terms of the capabilities that people of color bring to the health professions. Telling students that they are needed in science for the nation's economic competitiveness or that they are part of a leaky science pipeline does nothing to tap into or affirm their value as capable human beings. The Meyerhof program is also mindful of the other barriers at the university and as providing full financial support to students and faculty mentors of color, when possible, further frames the program in an affirming way.

Gain knowledge about students and structure the curriculum accordingly. While they may not have the same background and experience, students of color must be seen as bringing equal, if not more valuable knowledge and experience to a pre-medical program along with deeply held and legitimate motivations for pursuing a medical career. Many of the students had direct knowledge of the public health issues faced by communities of color and of the inequitable health outcomes for people of color. Some of the students had served as language and cultural translators for relatives in health care settings and they understood the need for health care providers to be more culturally competent.

Because of the challenges these students have faced, the university may see these students as deficient and in need of help, but their backgrounds have given them knowledge not available to those raised in the dominant culture. In discussing what is gained from the margins, Calabrese Barton and Furman (2007) argue that, “Borderlands have special meaning because those who live in the borderlands develop, for the purposes of survival, a kind of critical consciousness that straddles cultures, races, languages, nationalities, sexualities and spiritualities.” (p. 174). When instructors do not work to learn about students’ backgrounds, they miss out on a wide range of student knowledge and expertise.

Programs should be developed with some flexibility in the curriculum in order to leverage and develop the capital that students bring to the university. For example, Biju noted his longstanding interest in book, *The Immortal Life of Henrietta Lacks* (Skloot, 2010) which explores both key cell biology discoveries and several challenging social and ethical issues related to medicine. A course built around that text would provide a different kind of curriculum that may better leverage students’ knowledge and capabilities. This kind of flexibility in the curriculum would also counter the notion that there is a fixed set of science knowledge and would instead show science as evolving and intertwined with larger societal issues.

It was this connection between social issues and medicine that led many of the students to their pre-medical studies. However, they found the college science curriculum rigid and unconnected to the issues they cared about. At the university many of the students of color who start in the pre-medical program ultimately end up majoring in sociology. The sociology department and classes seem to provide a more welcoming environment and students felt those classes validated their own experiences. A partnership with sociology or similar department would allow this kind of perspective to inform and complement the science curriculum. This is also consistent with the new MCAT (Medical College Admissions Test) which will include sections on social sciences, ethics and cross-cultural studies because of the acknowledgment by medical schools that these fields are important in medicine (Rosenthal, 2012). This change in the MCAT and collaborations with the social sciences may also provide a path to transform the pre-medical curriculum over time.

At the same time, a program must recognize that these students are different because of their racialized backgrounds, income level, language background, and schooling experiences. Pretending that they are the same as other students and that they just need to work harder to succeed is problematic because it reinforces the majoritarian meritocracy myth. Well-informed knowledge of both students' strengths and challenges can enable a program to understand what particular supports students will need, but it will also enable the university to identify practices that disadvantage students. The chemistry teacher's frequent comments about students already knowing certain content was something that likely built up the confidence of students who did know the content, but deflated the those students who did not. In addition, the inconsistent use of and guidance in using the textbook significantly disadvantaged the bilingual students and those who had limited access to this resource in high school. The same was true about the overly complex language on the exam.

Carefully select and teach the teachers. The faculty members and administrators who work with these programs should be selected with care. Ideally their racial and social backgrounds would be similar to the students they are teaching so they might offer a greater level of understanding of students' backgrounds and experiences (Carter, 2006). However, given the lack of racial diversity in the science faculty at most large research universities (Nelson, Brammer & Rhodes, 2007) it is likely that instructors will not be people of color and they must be educated so they are knowledgeable about the students and affirming of what the students bring with them. The teachers should care about working with this population of students, but they need more than just the motivation and desire to be part of a program. They need knowledge about the students as complex individuals and a curiosity and desire to learn more about them and to shift the curriculum accordingly. The spring teacher in this study was open to considering that she might need to do something differently and this should be a key trait in teachers who are engaged in these efforts. Faculty members also need an understanding of and willingness to challenge the broader practices in the university that impact these students. Had the spring teacher known that many of the students maintained work study jobs and had real financial pressures related to their families she likely would not have commented that they only had themselves to worry about. I would also like to think that she might have used that knowledge to influence the financial aid awards given to these students so they did not have to work so many hours each week.

The faculty for a program like this must also become more aware of the language challenges of science and how this in particular impacts bilingual students. Neither the fall or spring teacher was aware of how the complexity of the exam language prevented students from fully expressing what they had learned. The same was true for the textbook. While teachers may find the textbook problematic, avoiding it further disadvantages these students.

Challenge the broader science curriculum and grading practices.

Implementing a new science teaching approach in the context of an interconnected science curriculum presents particular challenges for university science departments. While the research might say that science is better learned in a collaborative, interactive way, if that approach is counter to other teaching practices in the science departments, the effect can be two fold. First, if it is only employed with students of color they will certainly feel excluded from the "normal" way of doing things at the university, as was the case with the students in this study. Second, if the students will need to go onto other science classes where that approach is not used, they may be less, not more prepared than students who made it through the "regular" class.

The same dilemma emerges if a more culturally relevant curriculum is implemented. These potential conflicts suggests that universities will need to examine their curriculum and teaching practices more broadly and make systematic changes that present some challenging questions. If all the science courses were modified to align with and leverage the cultural knowledge students of color bring, those students would be advantaged over more well-off White students who do not possess that knowledge. Perhaps this kind of change would be appropriate (and overdue) given the long-time disadvantages the students of color have endured. And these cultural competencies are exactly what medical schools are beginning to acknowledge and seek out in their students (Rosenthal, 2012).

The grading practices employed in the science classes also present a particular challenge in the pre-medical curriculum. At least in this study, they seem to be influenced both by the university's concern about grade inflation, and also by the sense that this is a key way to prepare students for the rigors of medical school and the related entrance and professional exams. Any program with the goal of supporting students who come to the university differently prepared must be willing to examine and address this practice including an assessment of who is helped by this practice and who is disadvantaged. Diversifying the ways in which students are assessed, such as using competency based assessments would be a fairer way to evaluate students and might enable more students to continue in the sciences—and apply to medical school. However this might also mean that the university's medical school acceptance rate would drop, potentially impacting their prestige and rankings—presenting another challenging dilemma for universities.

Use the best resources to formulate the program and continually assess. In this study it became clear that the two administrators who work closely with students of color not only know the students, but they also have a rich understanding of the broader university context and the practices and systems that disadvantage these students. Had they been consulted as part of the program formulation, the program may have been better conceived to support students and particular university practices could be examined and perhaps challenged. Every university is likely to have faculty members and administrators who possess this kind of knowledge and experience. Consulting the views of existing administrators and faculty members as widely as possible would ensure that programs are conceived in a way that not both supports students, but also challenges the university to examine the larger systemic factors that disadvantage these students.

Universities should also assume that they will inevitably get many things wrong with an initial implementation of a program. There must be a robust means to continually assess the program and a commitment to change as necessary. While not required, this kind of program assessment would be an ideal venue for a participatory or collaborative action research project (Herr & Anderson, 2005) where both the program creators and the researchers share the goal of understanding students' complex experiences in the context of a particular university environment and finding ways to support students and challenge the practices that disadvantage them. Many times during this study I was in a position to share the experiences and perspectives of the students with those implementing the program however, as noted earlier, I was not in a position to undertake this kind of participatory research. I do hope the analysis and findings from this study can be used by others who endeavor to formulate and research similar support programs for students of color in science.

Recommendations for Students (and their High School Teachers and Counselors)

Throughout I have tried to bring forward the stories of the students and I wanted to end with an acknowledgment of the agency that students themselves possess in the process of selecting a university and pursuing a pre-medical program of study. Many of the students in this study applied to and enrolled at University on a Hill because of the advice of their high school teachers and counselors. The reputation and name recognition of the university was a primary factor in these students being guided to the university.

While there are benefits to attending a well-regarded university, for students considering a pre-medical path there are other factors more important to consider. The research suggests that students of color have better outcomes in the sciences at small liberal arts colleges and at historically Black universities (Cech, 1999; CIC, 2014; Tobias, 1993) and this is an important factor for students to consider when making decisions about colleges.

Students should also ask certain questions of the universities—and universities should be more transparent and forthcoming with the answers. These include: 1.) What percentage of your successful medical school applicants are students of color and what are their educational backgrounds? 2.) What percentage of the graduates in the life sciences are students of color and what are their educational backgrounds? 3.) What percentage of students who start out in a pre-medical track actually complete that work and what is the breakdown by race? 4.) What is the average class size of your introductory science courses and what percentage of students complete those classes? 5.) How are grades determined in science classes? By a normal distribution or competency-based grading? 6.) What percentage of your faculty in the sciences are people of color? 7.) How does your medical school application process work? 8.) What kinds of supports are provided for students of color in the pre-medical program generally and in regards to financial aid? The answers to these questions are far more important than a general assessment of a university's reputation.

Finally, students of color who aspire to a medical career should recognize the tremendous knowledge and experience that they bring to the field of medicine and the importance of those capabilities. Medical schools, belatedly, are now working to impart that kind of knowledge and perspective to their students through classes on cultural competency and through service learning (Betancourt, 2003; Tervalon, 2003). However those activities are inadequate substitutions for the authentic and deeply held knowledge that the students in this study possess. bell hooks (1993) articulates the potential these students possess because of their life experiences:

> Marginality is much more than a site of deprivation; …it is also the site of radical possibility, a space of resistance…it nourishes one's capacity to resist. It offers to one the possibility of radical perspective from which to see and create, to imagine alternatives, new worlds (p. 341).

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Appendix: Interview Protocols

Below are the interview protocols that have been approved by the IRB and which I have generally followed.

Student Interview Protocols:

<u>Student Interview 1:</u> Student Background and Middle School Science Experiences

Thank you for your willingness to be interviewed for this study. As you know, I am a doctoral student at Boston College and I'm conducting a study about first-generation college student persistence in science coursework. In this first interview I would like to get a sense of your background and your science education experiences in middle school. In the next interview we'll look at your science education experiences in high school and finally in the third interview we'll discuss your college science experiences. You don't need to answer any questions that make you uncomfortable and you can end the interview at any time. Do you have any questions before we get started?

1. Tell me about your family and language background?
   Prompts:
   a. Family structure and circumstances?
   b. Income level?
   c. Immigrant or US native?
   d. Native language and other languages?
   e. Self-perception of language abilities?

2. Tell me about your elementary school experiences?
   Prompts:
   a. Type of school(s)?
   b. Age at start of school in US?
   c. Previous non-US schooling?
   d. Bilingual or English Immersion program?

3. Tell me about your middle school?
   Prompts:
   a. Size?
   b. Diversity of gender, class, race?
   c. Location?
   d. Public, private, religious?
   e. Rigorous?

4. Tell me about your middle school science teachers and classes?
   Prompts:
   a. Which teachers were most effective and why?
   b. What was the difference between 6^{th}, 7^{th}, and 8^{th} grade science classes?

c. What topics/subjects were covered in the science classes? Was it too much or not enough?
d. How were the classes taught? Lectures? Projects? Worksheets? Textbooks? Computers? Labs?
e. Were classes conducted in English? Native language? Combination?
f. Were science study and science reading skills taught?
g. What was fun and interesting in the classes? What was not?
h. What did you like or not like about the teachers/classes?

5. Were you a good science student in middle school? How did you know?

6. What role did your family or others outside of school play in your middle school science experiences?

7. What else do you remember about your middle science experiences either in or out of school?

8. Is there anything else you want to add about your background or middle school science experiences?

<u>Student Interview 2:</u> High School Science Experiences

Thank you for meeting again and your willingness to be interviewed for this study about first-generation college student persistence in science coursework. In this interview we will be discussing your science education experiences in high school. You don't need to answer any questions that make you uncomfortable and you can end the interview at any time. Do you have any questions before we get started?

1. In the last interview we talked about your family background, your elementary school experiences and your middle school science experiences. Is there anything you thought of that you wanted to say more about?

2. Tell me about your high school?
   Prompts
   a. Size?
   b. Diversity of gender, class, race?
   c. Location?
   d. Public, private, religious?
   e. Rigorous?

3. Tell me about your high school science teachers and classes?
   Prompts:
   a. Which teachers were most effective and why?
   b. What was the difference between 9^{th}, 10^{th}, 11^{th} and 12^{th} grade science classes?
   c. What level classes did you take? (AP, Honors, IB)

d. What topics/subjects were covered in the science classes? Was it too much or not enough?
e. How were the classes taught? Lectures? Projects? Worksheets? Textbooks? Computers? Labs? Inquiry Based?
f. Were classes conducted in English? Native language? Combination?
g. How were science study and science reading/writing skills taught? How was science vocabulary taught?
h. Did you use textbooks and how often and how much did you read from them?
i. What was engaging and interesting in the classes?
j. What was challenging and difficult in the classes?
k. What did you like or not like about the teachers/classes?

4. How did your middle school science experiences prepare you (or not) for high school science classes?

5. How did you decide which science classes to take in high school?

6. Were you a good science student in high school? How did you know?

7. What role did your family or others outside of school play in your high school science experiences?

8. What else do you remember about your high school science experiences either in or out of school?

9. Is there anything else you want to add about your or high school science experiences?

<u>Student Interview 3:</u> College Science Experiences

Thank you for meeting again and your willingness to be interviewed for this study about first-generation college student persistence in science coursework. In this interview we will be discussing your science education experiences in college. You don't need to answer any questions that make you uncomfortable and you can end the interview at any time. Do you have any questions before we get started?

1. In the last interview we talked about your high school science experiences. Is there anything you thought of that you wanted to say more about?

2. How and why did you decide to apply to and attend [this college] and how do you feel about your decision?

3. What did you want to study/major in when you first enrolled at [this college] and is that still your focus?

4. What science classes have you taken at college and why did you choose those classes? How well did you do in those classes?

5. What do you think the connection is between your high school science classes and your high school science classes? How did your high school science experiences prepare you (or not) for college science classes?

6. Tell me about your college science teachers and classes?
   Prompts:
   a. Which teachers were most effective and why?
   b. What topics/subjects were covered in the science classes? Was it too much or not enough?
   c. How were the classes taught? Lectures? Projects? Worksheets? Textbooks? Computers? Labs? Inquiry Based?
   d. How were science study and science reading/writing skills taught? How was science vocabulary taught?
   e. Did you use textbooks and how often and how much did you read from them?
   f. What was engaging and interesting in the classes?
   g. What was challenging and difficulty in the courses? (Prompt about language if not mentioned.)
   h. What did you like or not like about the teachers/classes?

7. Will you take additional college science classes?

8. What do you plan to do after you graduate from College and how will your science coursework help you?

9. What role has your family or other adults at [this college] or outside of school played in your college science experiences?

10. Is there anything else you want to add about your college science experiences?

Teacher/Faculty Interview Protocol:

Thank you for your willingness to be interviewed for this study. As you know, I am a doctoral student at Boston College and I'm conducting a study about first-generation college student persistence in science coursework. In the interview I will ask you questions about your approaches to teaching science and other school factors that might be relevant in understanding students' educational experiences. You don't need to answer any questions that make you uncomfortable and you can end the interview at any time. Do you have any questions before we get started?

1. Tell me about your school and the students at the school?

2. Tell me about the science program at your school and the classes and the students that you teach?

3. Tell me about the (AP Biology, 7th Grade Science, Chemistry) class that you have taught/teach at your school?

4. What teaching approaches do you use in your science classes and why do you use those approaches?
   Prompts:
   a. Lectures? Projects? Worksheets? Textbooks? Computers? Labs? Inquiry Based?
   b. How is science vocabulary taught?
   c. How are science reading skills and writing skills taught?

5. What challenges do you face as a science teacher and what successes have you had?

6. What do students need to do to be successful in your science classes and how do you help them achieve that success?

7. What experiences, challenges, and successes have you had teaching science to bilingual students?
   Prompts:
   a. What do you do to help bilingual students?
   b. What do bilingual students need to do to be successful in your classes?

8. What prevents students from doing well in your science classes and what do you do to help them overcome those challenges?

9. What do you think will prepare your students to succeed in science at the next level (high school, college, graduate school, career) of school?

10. Is there anything else you want to convey about science education in your school or other educational contexts?

Administrator Interview Protocol:

Thank you for your willingness to be interviewed for this study. As you know, I am a doctoral student at Boston College and I'm conducting a study about first-generation college student experience in science coursework. In the interview I will ask you questions about your work with students of color at the university and your knowledge of their experiences in science coursework. I will also ask you questions about any programs you have designed to support these students and/or your knowledge about programs at the university. You don't need to answer any questions that make you uncomfortable and you can end the interview at any time. Do you have any questions before we get started?

1. Can you tell me about your department/program and your work with students of color at the university?
2. In your work with students of color what have you noticed about their experiences in science courses?
   Prompts:
   a. Why do students pursue science?
   b. What role does their high school background and preparation play?
3. What is your view on how well the university does/does not support students of color in science coursework?
   a. Support programs?
   b. Level of courses?
   c. Instructor's views of and support for students?
   d. Career and academic advising?
4. Can you tell me about any programs your organization developed to support students of color in science?
   a. Why created?
   b. How created?
   c. Successful? By what criteria?
   d. Students' views of program(s)?
   e. Modifications to program(s)?
5. What other thoughts or perspectives can you share on students of color who are pursuing science courses/careers at this university?
6. Admission practices?
7. Role in the university and has that changed over time?