JOURNAL OF RESEARCH IN SCIENCE TEACHING VOL. 42, NO. 6, PP. 691–715 (2005)

# Traveling the Road to Success: A Discourse on Persistence Throughout the Science Pipeline With African American Students at a Predominantly White Institution

Melody L. Russell,[1] Mary M. Atwater[2]

[1]*Department of Curriculum and Teaching, Auburn University, 5004 Haley Center, Auburn University, Alabama 36849*

[2]*Department of Mathematics and Science Education, University of Georgia, Athens, Georgia*

*Received 27 October 2002; Accepted 15 November 2004*

Abstract: This study focuses on 11 African American undergraduate seniors in a biology degree program at a predominantly white research institution in the southeastern United States. These 11 respondents shared their journeys throughout the high school and college science pipeline. Participants described similar precollege factors and experiences that contributed to their academic success and persistence at a predominantly white institution. One of the most critical factors in their academic persistence was participation in advanced science and mathematics courses as part of their high school college preparatory program. Additional factors that had a significant impact on their persistence and academic success were family support, teacher encouragement, intrinsic motivation, and perseverance.
 J Res Sci Teach 42: 691–715, 2005

Although there are increasing numbers of African Americans enrolling in predominantly white institutions (PWIs) of higher learning, the issues of retention and high attrition rates are still of great concern to universities across the country. In addition, African American students who do attend PWIs are consistently underrepresented in the more quantitative science-related degree programs. Despite their increased attendance at PWIs, African American students leave these institutions in disproportionate numbers without completing their baccalaureate degree programs (Green, 2001; Jones, 2001). This is often a result of various social and institutional barriers, which impact African American students' dreams and aspirations in the sciences.

Increased participation in science-related careers (i.e., medicine, dentistry, and engineering) can offer African American students opportunities for both social and economic mobility, especially as many of these students are disenfranchised, oppressed, and marginalized as a large part of this nation's lower class. In the field of science education few studies have investigated

*Correspondence to*: M.L. Russell; E-mail: russeml@auburn.edu
DOI 10.1002/tea.20068
Published online 25 April 2005 in Wiley InterScience (www.interscience.wiley.com).

factors that impact the persistence of African American students in more quantitative science-related degree programs (Lewis, 2003), especially in relation to PWIs. The purpose of this study is to give voice to African American students who experienced success in high school science and mathematics and persisted in the college science pipeline at a PWI.

## Review of Related Literature

### *African American Students and Science Career Development*

Historically, science and science-related careers were viewed as privileges for the elite (AAAS, 1998). Consequently, students of color fail to achieve in science and are significantly underrepresented in science courses and related careers (AAAS, 1998). Unfortunately, despite the principles of equity, equal opportunity, and fairness that are rooted in American culture, certain groups of people are more likely to gain access to valuable scientific knowledge (AAAS, 1998). Although, in the last few decades, African Americans have made significant strides in science and mathematics (Oakes, 1990a, 1990b), their increased participation in the sciences has been miniscule compared with whites. Small percentages of African American students actually become scientists, mathematicians, and engineers, and others select careers as science technicians and engineering technologists (Atwater, 2000).

Research by the National Science Foundation (NSF) reveals that people of color make up only 17% of the nation's scientists and engineers (NSF, 2000). According to the National Science Board (2000), within the next decade, the number of science- and engineering-related jobs in the USA will increase by almost 50%. Competence in science and mathematics at the precollege level is essential if African American students are to persist and achieve in science careers (Butler-Kahle, 1982; Hall & Post-Kammer, 1987; Hrabowski, 2003; Smith & Hausfaus, 1998), especially as enrollment of African Americans at PWIs has increased over the past few decades (DeSousa, 2001; Green, 2001; Jones, 2001). Currently, more researchers have begun to investigate factors that impact the academic persistence of African American students in the fields of science, engineering, and mathematics (SEM) (Hrabowski & Maton, 1995; Hrabowski, Maton, & Grief, 1998; Smith & Hausfaus, 1998). However, a recent review of existing literature on the persistence of African Americans in science degree programs and related topics (Lewis, 2003) indicated that there is still a lack of recent scholarly inquiry on the pervasiveness of the underrepresentation of African American students in science and science-related careers. More specifically, Lewis (2003) asserted that African American representation in science and science-related careers may be even more adversely impacted by the lack of scholarly inquiry in this area, which could provide insight into developing and implementing policies and institutional programs to support their participation and retention.

### *Precollege Factors That Impact Academic Achievement*

Recent attention has been focused on closing the vast academic achievement gap between African American and Latino/a students and their white counterparts, especially as these two groups make up the largest population of people of color and lag substantially behind whites in academic achievement (Hrabowski, 2003). According to the College Board (1999), the achievement gap between African American and white students is especially pronounced in science and mathematics courses. African American students are grossly underrepresented in the more advanced level science and mathematics courses, and their high school course-taking patterns can have a significant impact on career choices and academic achievement in the sciences.

Currently, there are few studies that focus on the direct correlation between African American students' underrepresentation in science-related careers and their science and math course-taking patterns (Connell & Lewis, 2003). Research by Powell (1990), however, suggests that inadequate career guidance during adolescence contributes to the underrepresentation of African American students (both male and female) in science and mathematics courses. This inadequate preparation in math and science during the course of students' precollege years has a significant impact on choice of college major and career selection.

The continual lack of attention and research regarding the matter of increasing the participation of African Americans in challenging, rigorous math and science curricula during their precollege years can only have dire consequences, particularly when researchers such as Ellis (1993) suggest a need for students to increase the number of science and mathematics courses during precollege years. Moreover, students that participate in higher level or advanced ''track'' courses in science and mathematics feel they are more prepared academically to pursue degree programs in quantitative science majors at the college level (Brown, 2000). More specifically, enrollment during secondary education in more mathematics and language courses, primarily at the advanced level with regard to track placement, is paramount (Carnoy, 1994). Students exposed to higher level, more advanced science and mathematics classes are more likely to perform higher on tests in that specific subject area, even if they did not do well in the class as a whole (Carnoy, 1994). Parham & Austin (1994) suggested that individuals are more likely to pursue careers based on how well they feel they can adapt and be successful in a particular career. Increasing the numbers and levels of science and mathematics courses for African American students can only enhance their interest and level of competence in these areas, which better prepares them for science-related degree programs and careers.

In addition to the curriculum and course-taking patterns, teachers play a significant role in student academic achievement and attitudes toward science. Their inexperience can have a profound effect on student motivation, attitude, and interest in continuing in the scientific pipeline. Students in the more advanced-level courses have higher levels of expectations from teachers and their peers, which can ultimately impact students' perspective and motivation toward higher academic achievement and persistence in challenging courses (Oakes, 1985, 1990a, 1990b). The most highly qualified and competent teachers are assigned to teach an enriched curriculum to typically more ''privileged'' students (Darling-Hammond, 1995), or students that participate in the more advanced levels of a curricular track program. Researchers have suggested that teachers of higher level and advanced placement classes also have more positive interactions with students than teachers of lower level classes (Oakes, 1985, 1990a, 1990b; Wheelock, 1992). Based on the literature, African American students that experience acceptance, encouragement, and understanding from their teachers are more likely to have positive relationships with their teachers (Irvine, 1990).

Positive relationships and teacher–student interactions enhance teachers' expectations and students' achievement motivation (Irvine, 1990). Therefore, it is important to note that the quality of student–teacher interaction is particularly important to the success and achievement of African American students (Ford & Harris, 1995). In addition, whether or not they realize it, teachers have the ability to explicitly or implicitly continue to perpetuate the ideology that science and mathematics are ''white, male'' subjects. As a result of negative stereotypes African American students may internalize feelings of intellectual incompetence, especially in content areas that are not perceived as the norm (e.g., engineering, science, and mathematics) (Howard & Hammond, 1985; Steele, 1997). Furthermore, as a result of ''stereotype threat'' (Steele, 1997), African American students often encounter lowered expectations, fewer opportunities for exposure to science and mathematics role models, and less encouragement toward enrollment in advanced

mathematics and science courses, as well as college preparatory tracks, in general (Catsambis, 1995).

Last, one of the most critical precollege factors often having an impact on academic achievement of African American students is the degree of parental involvement, as well as the level of parental expectations they encounter in the home environment (Edwards & Polite, 1992; Fisher & Padmawidjaja, 1999; Ford, 1993; Hrabowski & Maton, 1995; Hrabowski et al., 1998; Steinberg, Dornbusch, & Brown, 1992). Although there are few empirical studies on the impact of African American parents on their children's academic success in science, some studies have identified parental support as a key factor (Hrabowski & Maton, 1995; Hrabowski et al., 1998; Taylor, Hinton, & Wilson, 1995). Furthermore, results from studies conducted on white, middle-class populations have often been applied to students from different racial/ethnic backgrounds (Fisher & Padmawidjaja, 1999). These studies demonstrated a number of parental factors that were instrumental to career development, including: (a) concern and encouragement (Blustein, Walbridge, Friedlander, & Pallidino, 1991; Fisher & Griggs, 1995); (b) positive reinforcement and attitudes (Grotevant & Cooper, 1988); (c) expectations (Young, 1994); (d) interest and aspiration (Astone & McLanahan, 1991); and (e) role model influence (Fisher & Griggs, 1995).

### *African American Students at PWIs*

There is a significant amount of literature addressing the development of models to predict African American students' achievement, although until recently (DeSousa, 2001; Green, 2001; Jones, 2001; Moore, 2001) rarely has the experience of African Americans at predominantly white 4-year colleges or institutions been closely examined (Oliver, Smith, & Wilson, 1989). Recently, PWIs have begun to devote more effort toward increasing both the enrollment and retention of African American students (Davis, 1998; Davis et al., 2004; Tidwell & Berry, 1993; Townsend, 1994), and some researchers have begun to investigate factors of persistence and retention relative to African American students' participation in higher education (Green, 2001; Jones, 2001). Although the enrollment of African American students at colleges and universities has increased in recent decades (DeSousa, 2001; Jones, 2001, Love, 1993), the major issue of retention poses a significant barrier to their success (Green, 2001; Moore, 2001). Moreover, their participation and enrollment in higher education is still disproportionate relative to their representation within the total population in various geographic locations across the country (DeSousa, 2001; Jones, 2001). African Americans are less likely to attend 4-year colleges and institutions of higher learning than their white counterparts, and are more likely not to complete their degree programs (Carnoy, 1995; Jones, 2001; Love, 1993; Sailes, 1993; Steele, 1992). The attrition rate for African American students at PWIs is five to eight times higher than the attrition rate for white students (McCauley, 1998). Based on these statistics, it would seem that opportunities for success and attainment of degrees at PWIs are rarely realized by African American students.

Furthermore, a disproportionate number of African American students who attend and persist in college shift to careers in the social sciences as opposed to the ''hard'' or more quantitative sciences (Hilliard, 1994). This shift to careers in the social sciences is often a result of the fact that many African American students are often unprepared for the pressures and demands of institutions of higher learning (Cuyjet, 1997). Moreover, African American students who attend large, PWIs as freshman encounter classroom formats that consist of large numbers of students and teaching styles that are typically lecture-based, fast-paced, impersonal (Wineke & Certain, 1990 as cited in Maton, Hrabowski, & Schmitt, 2000), and often incongruent with their learning styles. Consequently, these classes early in a students' program are often considered ''weeding-

out'' courses and limit access to degrees in science, engineering, and mathematics (SEM) (Massey, 1992; Seymour & Hewitt, 1997).

### *African Americans and Social Adjustment at PWIs*

The vast majority of African American students that attend college have spent the primary part of their lives in communities or cultures that were racially isolated or homogeneous (Brown, 2001; Carter, 2000). The prior socialization of African American students can impact their ability to successfully adjust to a new, predominantly white environment and may deter their academic progress (Brown, 2001; Carter, 2000; Cureton, 2003). Research demonstrates that many African American students have negative experiences at PWIs, which can impact their achievement and attrition rates (Allen, Epps, & Haniff, 1991; Nettles, 1988). African American students experience stressors that impact their adjustment at PWIs different from their white counterparts (Anderson, 1988; Edmunds, 1984; Henderson, 1988; Moore, 2001). These stressors typically include racial discrimination and feelings of alienation and isolation, often a result of racial exclusion (Anderson, 1988; Delphin & Rollock, 1995; Edmunds, 1984; Henderson, 1988; Neville, Heppner, & Wang, 1997; Neville, Heppner, Ji, & Thye, 2004; Schwitzer, Griffin, Ancis, & Thomas, 1999; Sedlacek, 1987).

In addition, African American students often encounter a campus climate that is hostile and uninviting (Love, 1993) and many experience feelings of isolation and distrust and adjustment problems (Fordham & Ogbu, 1986; Moore, 2001; Watson et al., 2002). From an historical perspective, PWIs were developed to serve the needs and values of the white, middle-class culture (Love, 1993). Moreover, Hughes (1987) described in a phenomenological study how African American students tend to defer their cultural, personal, and social development throughout their college years when at PWIs. Research has also examined the impact of social integration and adjustment to the social milieu on the persistence and success of African American students at PWIs (Oliver, Smith, & Wilson, 1989; Tinto, 1975). African American students attending PWIs also often experience what can be called ''culture shock'' or difficulty adjusting socially.

African American students, as well as other students from underrepresented groups are expected to assimilate and be successful in an environment that lacks diversity, may be hostile or uninviting, and often lacks formal institutional policies and programs that encourage diversity or positive crosscultural relationships. Based on the aforementioned review of the literature, the primary factors that promote African American students' success in high school science, and motivate their achievement and persistence in the college science pipeline despite various institutional and social barriers, include: (a) family support and expectations; (b) high school teacher expectations; (c) high school college preparatory program/advanced science and mathematics courses; and (d) coping strategies, which often facilitate students when they experience cultural dissonance with the social milieu on predominantly white campuses. In addition, positive attitudes toward science, especially when faced with challenging coursework, are critical (Moody, 1997).

This study was designed to shed light on these factors through the voices of African American college students who persisted in the high school science pipeline and pursued a quantitative degree (e.g., biology) at a predominantly white institution.

## Significance of the Study

This research was initiated in hopes of gaining a better understanding for teachers and teacher educators regarding how African American students experience high school science and the

impact of precollege experiences on their pursuit of a biology degree at a predominantly white institution. Furthermore, this article highlights the commonalities of many of the participants' experiences and gives voice to these experiences in their own words. We have designed this study to shed light onto the factors that successful African American students described as primary reasons for their persistence and perseverance in the science pipeline from a phenomenological perspective. Conversing with 11 African American college students at a predominantly white institution, who have ''traveled the road to success'' in high school science and pursued degrees in science, can provide insight into ways of promoting success for other African American students in similar settings. Our primary goal was to identify factors that contributed to the participants' persistence and success in the science pipeline. More specifically, we sought to determine how precollege experiences impacted students' persistence in the science pipeline at a predominantly white institution. Research questions driving this investigation were:

1. What factors from African American college students' precollege experiences impacted their persistence in a biology degree program at a predominantly white institution?
2. How do precollege factors affect the African American college students' experiences in a biology degree program at a predominantly white institution?

## Methods

The methods of qualitative research offer advantages and insights that are more difficult to capture with quantitative research methods. Qualitative research is designed to answer questions about lived or social experiences and gives meaning to these experiences (Denzin & Lincoln, 1994). The phenomenology research strategy was used to examine the experiences of these 11 African American undergraduate seniors in biology degree programs at a predominantly white institution. Similar to research by Watson et al. (2002) and Davis et al. (2004), African American college students' experiences are described through the lens of phenomenological methods. Moreover, patterns of various experiences through the voices of the African American students attending a predominantly white institution were identified.

The phenomenon of the participants' experiences in the high school and college science pipeline was used as a framework to provide insight and understanding into the individual experiences as well as investigate the underlying meaning behind participants' experiences (Watson et al., 2002). This research strategy was most appropriate for examining factors that impact students attending colleges or universities (Lincoln & Guba, 1985; Patton, 1990). Moreover, from a qualitative perspective, it is much more appropriate to understand the experiences of students through words as opposed to quantitative measures (Kuh & Andreas, 1991). The intent is not to generalize to all African American students, but to provide insight into how the African American students that participated in this research experienced science on the precollege level, and how this ultimately impacted their college experience at a predominantly white institution.

Furthermore, insight into their journeys, experiences, and perspectives can better provide information on how to facilitate and enhance student interest and motivation for success in the science pipeline at both the precollege level and beyond. According to Merriam et al. (2002), all qualitative research is in some aspect phenomenological, because research from the qualitative paradigm focuses on the individual's experience. Moreover, a phenomenological study is designed to gain an understanding of the essence of the experience under investigation (Merriam et al., 2002). Participants shared the same precollege and college experiences in their journeys toward success in a science degree program at a predominantly white institution.

*Participants*

The most appropriate sampling strategy was purposeful sampling. This strategy consists of selecting a population that will provide ''information-rich'' cases, in an effort to learn the most about the issues important to the purpose of the research (Patton, 1990). The participants consisted of eight African American females and three African American males classified as graduating seniors based on credit hours, and majoring in biology and planning to obtain a bachelor's of science degree. The biology major is a liberal arts degree with a concentration in the biological sciences. The biology program at the research institution where this study was conducted is in the College of Arts and Sciences and not a pre-professional degree, but it does prepare students for pre-professional programs in veterinary medicine, dentistry, medicine, and pharmacy, as well as for advanced degrees in the biological sciences.

Participants were selected from a list of students that fit the study criteria (e.g., African American students, undergraduate seniors, biology majors) obtained from the Minority Services Office, which provides programs for students of color. All participants in the study were between 18 and 25 years of age. The Office of Admissions provided the Minority Services Office with a list of African American seniors majoring in biology degree programs, and 30 students fit the criteria for the study. From this sample 11 of the graduating seniors demonstrated an interest and willingness to participate in the study. Similar to research by Davis et al. (2004), African American undergraduate seniors were chosen because they were able to give a better description of their journey through the college science pipeline as graduating seniors.

*Demographic Questionnaire*

All of the students were in college preparatory classes throughout high school and 10 of the 11 participants at some point during high school participated in courses designated advanced placement (AP), advanced, or accelerated for science and/or mathematics. The questionnaire addressed race, major, gender, citizenship, and grade level, as well as several open-ended questions about students' high school demographics, home-life/community, and high school course-level placement (see Appendix A). This open-ended questionnaire was designed to provide insight into the science and mathematics courses that participants had taken during high school. According to the demographic questionnaire, participants listed the following mathematics courses from high school: (a) Algebra I; (b) Geometry; and (c) Algebra II. Furthermore, participants completed other mathematics courses in addition to these core courses. Participants also listed the following science course-taking patterns: (a) Biology; (b) Physics or Physical Science; and (c) Chemistry. Moreover, some students took Human Physiology, Anatomy, and Chemistry II (see Appendix B). Participants completed the demographic questionnaire prior to the interviews. The data for this qualitative study were drawn primarily from open-ended, semi-structured interviews of 11 African American undergraduate seniors attending a predominantly white research institution in the southeastern United States.

*Interviews*

Interviews provided the greatest insight into the perspectives and experiences of the participants. Participants were asked open-ended questions and allowed to elaborate in detail regarding their experiences. Qualitatively speaking, the purposes of open-ended questions in qualitative research are to enable the researcher to both ''understand'' and ''capture'' the viewpoints and perspectives of the participants (Patton, 1990). Davis et al. (2004) suggested that

this research strategy allows the voices of participants to emerge and reiterates the depth, as well as the richness, that emerges from using the open-ended interview method. All participants met with the primary researcher for two interviews scheduled at the convenience of the participants.

Open-ended, semistructured interviews were conducted to allow the researcher to access the perspective of the participants on the factors students thought influenced their success (Patton, 1990). The interviews entailed face-to-face verbal interchanges between the researcher and the participant (Denzin & Lincoln, 1994), and lasted 1–2 hours each. All interviews were audiotaped and transcribed verbatim. Follow-up interviews and member checks were also conducted to serve as validity checks to ensure ''trustworthiness'' of data (LeCompte & Priessle, 1993). Interview questions focused primarily on the following: (1) participants perceptions of what determined their high school science and mathematics course-taking patterns; (2) reasons why participants pursued degrees in science; (3) strategies for persistence in high school and college science; (4) future goals and aspirations in science; (5) pivotal issues that influenced their decision to pursue a degree program in science and their college experiences; and (6) who or what contributed to their success in science during high school.

### *Data Analysis*

Based on responses to interview questions and questionnaire data significant units of interviews were analyzed and placed into various categories and themes. Data were organized in the following manner. First, the demographic questionnaire data were analyzed to determine the students' precollege science and mathematics experiences and course-taking patterns, as well as additional demographic information. Second, students' responses to open-ended, semistructured interview questions were analyzed to gain insight into the participants' experience in the college science pipeline and the precollege factors that impacted their college experience. Based on tentative interpretations, various statements and common patterns across transcripts were used to develop themes.

More specifically, interview data were analyzed to identify basic themes and categories. According to Strauss and Corbin (1990a, 1990b), data categories are defined as units of information that involve various events or occurrences. The themes were organized based on commonalities between participants' experiences regarding family, school, and academic preparation. Findings in a study of this nature are considered valid based on evidence provided in the textual evidence and the extent to which the data bring new light to the research based on information that provides the reader with a new understanding of the experiences of the participants (Davis et al., 2004).

In addition, thematic analysis was used to further develop categories and themes to better understand the phenomenon behind the participants' experiences from both the precollege and college science pipeline. Although the students' stories are not shared in their entirety, the study provides a snapshot into the experiences of African American students who have persisted in the high school science pipeline and college science pipeline at a predominantly white institution. Moreover, quotations from interview data provide richness and depth to the participants' experiences and feelings (Watson et al., 2002). Although the terms validity, reliability, and generalizability are considered misnomers in the realm of qualitative research, this study addressed these constructs through extensive peer reviews as well as member checks of data collected via interviews. Generalizing research from a purposeful or criterion-based sample is not wise in qualitative research. Furthermore, findings for this study are particularistic for this specific group of participants. However, it is important to note that the researcher was more interested in perspectives of each individual participant and whether there was a link between the experiences of the participants, as opposed to generalizability.

## Research Findings

Four primary themes emerged based on the interpretative analysis of the interviews and questionnaire data. These were categorized and identified according to the primary issues addressed throughout the transcripts after analysis of responses to open-ended questions. The four themes are:

1. Parental influence.
2. Teacher influence.
3. Precollege experiences in science.
4. College science pipeline experience.

### *Parental Influence*

Often students encounter different ''messages'' from home regarding the importance of education. Moreover, family relationships and expectations have a significant impact on the persistence of African American students in the science pipeline, as well as their educational preparation, achievement, and ultimate success in school (Hrabowski, Maton, & Grief, 1998). Students were asked who impacted their pursuit of degrees in more quantitative science degree programs. Based on responses, students had a shared experience of similar ''messages'' on the importance of education from their family as well as high expectations. Results between participants were consistent relative to the positive influence on family expectations on their persistence in the science pipeline. According to the participants in this study high expectations from the parents and/or grandparents were expressed as ''messages'' that emphasized the importance of a good education.

All 11 participants expressed that it was either ''understood,'' or an expectation within the household, that they would attend college. One student discussed the reason he selected the college preparatory track:

> That's just always been my desire and my dream to go to college. Both of my parents were educators and that (education) was really understood in my household. You were going to go to school, and I had no bones about that.

In the following statement this student also discussed the role his parents played in his educational pursuits:

> My father was the counselor at my high school and my mother was the head of the program for mentally retarded and handicapped children. They (parents) have been in the school system and on the Board of Education throughout my whole life. It was kind of strange because I spent ninth through twelfth grade around my parents 24 hours a day, which was somewhat of a task, but it was good. They always stressed that education was first. We did other things outside classes, but that was always the first (priority), that you had to have a solid education to get anywhere in life. So they really stressed that.

Students shared their views on how their parents impacted their persistence in science explicitly through verbal messages:

> I guess growing up in my house my mom made a big thing out of what subject you were best in because she is an educator. So she was like, you know you are the science person. So I felt like, okay, I'm the science person. And ever since I was little I was always the one,

> you know how little kids are always like I want to be a fireman, or a lawyer? Well, I was always like I just want to be a doctor.

One student gave a similar account of the influence his family had on his educational pursuits and discussed the importance of making his parents proud of him. Neither of his parents had attended college and both worked minimum wage jobs. He pursued the college preparatory diploma because, ''It was just one thing about growing up. You were just told to go to school, high school, and college. You never thought about technical school or any other thing.'' When asked to elaborate on who ''told'' him this, he replied, ''I guess it was just something that was an unwritten rule from elementary school. You know, this is your life and what you do until you graduate from college.''

Another student discussed how science became a career interest because of her parents' occupations:

> Well my science history extends from my family. My mother is a registered nurse and my sister is a registered nurse [laugh]. My whole family is basically in the medical field. I grew up with my mom coming home describing who died on the table and stuff that happened at work. And I am, like, it's exciting. I always grew up with that interest in science and especially in high school when we did dissecting. So that's basically my foundation and my interest in science.

Participants also discussed how parental involvement impacted their study habits. One student stated, ''At home I was always told that I wasn't allowed to do anything until I did my homework.'' She went on to add how her good study habits in high school were primarily enforced by her father. Parents of participants believed that their children were empowered by attaining higher levels of education, and this message was transmitted to the participants.

One respondent stated that, although he never remembered one specific person encouraging him from his family, it was more of an inherent expectation. He discussed his family's expectations in the following statement:

> I mean everyone (family) knew that you were going to college. No one said it or anything. My parents didn't go to college. My older sister was one of the first in our family to graduate from college. So it was how you pictured your life to be. You go to elementary school, then high school, and then college. It was just something implanted in your mind growing up.

Another student described how all of his siblings had pursued degrees in higher education and encountered the same high levels of expectations and similar ''messages'' for postsecondary degrees that he received from parents:

> My oldest brother has a master's degree. My second oldest brother has a master's degree and a PhD. My third oldest brother has a master's and is working on his PhD. My fourth oldest brother is currently completing his PhD. I'm finishing my undergraduate, and then I will go to get my master's, then to medical school. My sister is in junior college back home. So it's kind of like this is what we have to do. But they (my siblings) have all had the same desire to do well and strive well in life and school. Because they (my siblings) know that my parents sacrificed so much during their lives and they (my parents) omitted lots of things they probably wanted to do to see that we did well. And it's kind of a way of giving back to them.

In a similar statement a student shared how his parents' sacrifices motivated him to achieve academic success. He stated:

> My mother and grandmother all worked so hard to get me through middle school, so I decided to take a high-paying job. The first high-paying job that came to mind was a doctor or scientist. . ..You could have a low-paying, middle-paying, or high-paying job, and one thing I always wanted to do was help my family.

Findings from this research suggest that African American students may internalize parental expectations for their own achievement and motivation. The internalization of high parental expectation served as a tremendous motivator for success in high school science and mathematics for the students in this study. Parental influence encompasses a number of factors that motivate students to persist in the high school science pipeline based on the students' responses. Based on interview data, participants encountered high expectations and experienced a home environment that valued education. Furthermore, participants addressed the impact of family role modeling on career choices in science. Overall, the degree of support that students encountered in their ''home'' environment seemed to be an impetus for their persistence throughout the high school science pipeline and subsequent pursuit of degrees in science.

### *Teacher Influence*

This theme was based on participants' descriptions of teachers who were influential in their lives and motivated them to persist or select careers in science. Based on participants' responses both the school environment and exposure to college preparatory curriculum (specifically, more advanced-level courses), as well as more science and mathematics courses, impacted students' career aspirations and their pursuit of biology degrees during high school and college science. The majority of participants seemed to receive a significant amount of encouragement and motivation to succeed from teachers, and in one case a participant was motivated to persevere because a teacher did not believe she was capable of being successful. Participants' descriptions of the influence of teachers reiterate the critical impact that expectations to succeed can have on persistence in the science pipeline. One participant discussed how much she enjoyed her advanced biology class and loved her teacher (who she mentioned was Italian):

> I knew it was my Advanced Biology course, and I liked when we worked in the lab. I really didn't have an interest in the chemistry part. I didn't really care for that or the physics part. So I think it was my Advanced Biology teacher. I loved my teacher. She also went here (university), and she kind of helped push me over here. She was also my track coach so we talked a lot. There was one year where I just didn't know what I wanted to do with my life and she told me, well you are good in science, maybe you should think about that. I started thinking that I really did like the biology, but I wasn't sure. I don't know if it was also instilled in my head since I was a little girl that you're supposed to be a doctor. That's what I'm supposed to do. So I think besides the teacher thing, I just think it was always there. There was nothing else.

One student discussed the ''caring'' ethic that many of her teachers exhibited. She stated:

> Well, they were just caring. They not only cared that you did good in the class, they cared that you loved the class and enjoyed it. I mean we had nice field trips and you actually just saw that they really cared.

Students also described the instruction they encountered in their high school science courses. When asked to elaborate on why she described her teachers in science as ''better'' than other teachers, she stated:

> I mean better as in patience and instruction, everything. They were just better. I mean if I could just go back and do it all over again I would have them teach me eighth and ninth grade when I was beginning my accelerated classes versus the eleventh and twelfth.

Some students discussed how teachers that took a personal interest in their success impacted their persistence:

> Well, in my science classes I always had teachers that basically looked out for you. They made sure that you knew what was going on before they went ahead with anything. I still talk to three of my science teachers from high school today. So it was like they want you to succeed.

Another student added depth to the importance of teacher expectations by recalling a similar experience:

> It started back when I was in elementary school. I thank my teachers from the time when I was younger. They instilled in me along with my parents, grandparents, and aunts that you do your work, pay attention, and you go to college. When I got to high school it was simple for me to just listen to what I had been told. Do your work, pay attention, and go on. I had some good teachers in high school also, but I feel that the teachers who set the base for me were in elementary and middle school, mainly elementary. Those are the teachers I would probably give the most credit to.

On the other hand, another participant discussed the impact that a negative experience with her chemistry teacher had on her motivation to apply for an honor's science program. She was particularly fond of her physics/human physiology teacher who took a personal interest in her success. This science teacher encouraged her to apply for various programs in science. One incident in particular stuck out in her mind:

> I would say one of my teachers. She taught me physics and human physiology. She was always the one pushing me and telling me to enter this or that. I actually had one chemistry teacher in high school and when I told her I was going to apply for a science program she actually said to me, well you know that's for really smart students. And I was like well, what do you think I am? Am I just dumb or something? The chemistry teacher recommended someone else for the program to go up against me. I ended up getting it over this girl so I was really happy about that. I wanted to go back to her and be like, see!

The degree of support that students encountered in the classroom from their teachers seemed to be an impetus for persistence and subsequent pursuit of degrees in science. Collectively, the home environment (i.e., parental expectations) and school environment (i.e., teacher expectations and curriculum) indicate that students encountered similar messages and encouragement to persist in science. Furthermore, the messages many of these students received from both home and school enabled them to understand the requirements for pursuit of biology postsecondary degrees, and to make wise choices about the necessary course-taking patterns. Participants took more science and mathematics courses than needed for the typical core requirements for most high school programs and opted for more of the advanced placement courses when offered during their high school years.

*Precollege Experiences in Science*

Based on analysis of transcripts, participants described factors critical toward their positive attitudes, interest, and persistence in science. Participants voiced their perspectives on the impact of their precollege experiences (which also included various classes) on their interest in continuing their education. One participant discussed the learning environment in their classes as far back as elementary school. He described his elementary school environment as ''home away from home.'' Another student described the environment fostered by the magnet program in her school as: ''Everybody was smart, and you didn't want to look like the idiot in the group.'' Basically, students in the magnet program were motivated and encouraged to be successful. She added that students worked together and encouraged each other to be successful, ''No one was going to let somebody else do badly.'' The magnet program encouraged students to keep high grade point averages, because, ''We all wanted to be in the top 10%. We wanted to get college money.''

A number of different experiences both in and out of the science classroom encourage students' pursuit of a degree in science. Many respondents asserted that science fairs and other science-related activities influenced their interest in science. For example, one participant said:

> I guess it would be around the seventh grade in my first biology course. It was just so much fun for me to go to that class and that's the only class I actually had fun in. So that's when I decided that science would probably be the thing for me. Through high school I took all the sciences courses and participated in difference science activities, science fairs, and activities like that.

Other students participated in various science programs to cultivate their interest in science. According to one participant:

> I guess the first thing that struck me was the fifth grade when I had surgery. I had to have a part of my thyroid gland removed because I had a cyst on my thyroid gland. Ever since then I've had a burning desire to be interested in medicine. I've volunteered numerous amounts of hours at the hospital and I've [participated] in the SEEP program (Student Education Enrichment Program at the Medical College). This program targeted minorities who were interested in the Allied Sciences and I've spent two summers there.

Similarly, another student was in a program sponsored by the National Institutes of Health during her senior year of high school. She described this precollege science experience as follows:

> I was in the program here during my senior year in high school for the National Institutes of Health. We did experiments on tumor growths on the mammary glands of rats. Just doing all of the little scientific techniques, [like] working with pipettes, working in the lab, working with live specimens, and watching things actually happen and ways to deter certain things was amazing to me. You know that one day we may be able to do that on humans.

Students also discussed the impact that high school science classes had on their persistence in the science pipeline:

> Taking classes like biology, chemistry, and physical science and stuff like that in high school I always liked it. I liked all the applications and how they applied to my life. So those were like the real big issues I guess that influenced my decision to pursue science.

In a similar statement one student asserted:

> I was influenced by my biology and human anatomy classes. That was the reason I wanted to choose the biology major. I just thought it was interesting which I sort of don't like now (in college). But at the time, it was interesting.

Based on their responses students had opportunities to experience success in science both inside and outside of the classroom. Their experiences with science increased their interest and confidence and self-efficacy toward pursuing degrees and careers in science.

*College Science Pipeline Experience*

The transition to college is often difficult for students and this can be especially challenging for African American students on predominantly white campuses. This theme described how the participants perceived the college science environment at a predominantly white institution. Participants discussed high school preparation and how their precollege science and mathematics experiences impacted their pursuit of a biology degree and college experiences at a predominantly white institution. The majority of participants felt well-prepared in some areas and others did not feel as prepared for the college science pipeline. For example, one student discussed the impact of her high school preparation on her pursuit of a college degree in science: ''I was glad that I took the courses I did because it definitely helped me once I got here to college.''

One student, in particular, described how, because she had attended an all-black high school, she felt more self-confident in her identity at a predominantly white school. This participant described the impact of the precollege environment on the college experience:

> That's another reason why I decided to come to like, you know, the predominantly white school. I was, like, I've been to the black school (high school). I've been there and done that. I've got my motivation; I know who I am, and what I am. Let me just go on out there and do what I go to do and I'm going to graduate.

One student expressed feeling inadequately prepared for the college science pipeline because this student's high school lacked advanced placement science and mathematics courses:

> In the last couple of years I don't think I was prepared as much coming from high school here. I don't think my high school prepared me as much. Like we didn't have AP courses. The only AP course we had was English. So I don't think that I'm really as prepared as a lot of students here right now.

Another student noted that, ''The chemistry we were doing when I was in high school, I got to do in general chemistry here at the university. So I had an upper hand on a lot of things.'' This participant also added, ''My high school science department received a lot of funding and subsequently the school had a lot of stuff to work with. A lot of technology that I'm using again here at the university.''

Another student attributed his success in college science to ''better teachers'' in advanced placement level courses. Participants also suggested decreasing class sizes to facilitate learning and enhance the experience in the college science classroom. One student believed that, as a result of small high school classes, she was more successful:

> Well, because of the smaller classrooms I think the teachers knew me personally. I didn't have a problem going to them and asking them for help or if I didn't understand

> [something]. I thought the teachers taught more so in high school than they do here. I think maybe it's the big classrooms here. My mind wanders and I get lazy, but in high school it was more personal. But, it may have actually been the class size.

Respondents were also able to recognize obstacles to their academic success (i.e., class size, subtle racism through grading) and persevered because they were motivated to succeed. Below participants describe their perceptions of the college science classroom:

> It was big and impersonal, but actually I don't know. The one math class that I really enjoyed was Pre-Calculus and that was because I think our tests were on the computer, and I don't know I guess I just learned better because we had tutorials besides the book. We had tutorials and you actually did things on the computer and learned how to do them. It was hands-on, I guess.

Intrinsic motivation to achieve in both the high school and college science pipeline was also a significant factor for some students. Participants expressed that it was important to ''believe'' that you can do it [science]. One student went on to add, ''Science is not hard. It's basically all written and if you can read the newspaper you can do science. Anybody can do science. You do science everyday. You just don't realize it.'' The power of intrinsic motivation for students to persist in science was also illustrated by a student in the following statement:

> Don't listen to anybody. I mean everybody is not for you. If you are a C student and you feel like, okay, I think I want to practice medicine or I think I want to go into biology/pre-medicine, just because you are a C student in high school does not mean you will not succeed in college. Don't listen to people. Don't become a stereotype. If you want it go after it and you will succeed.

One student's recommendation to African American freshman attending a predominantly white institution was as follows:

> I've been telling a lot of freshman I've talked to when they tell me that their major is biology/pre-medicine or something like that. I tell them it is a very difficult journey, very difficult. You're always going to have someone (I mean this is just personal experiences from the black students I've talked to), you're always going to have someone telling you that's not good enough or you're not going to make it and maybe you need to change your major, and that's just not true. If you stick with it, you can do it. I mean you just have to let comments like that just go in one ear and out the other. Just stay focused on what you need to do. Because I mean I don't want to sound racist or anything, but I mean a lot of white people don't want to see black people in these types of careers. At first, I was like that kind of racism doesn't exist now and I didn't realize it until I became a junior and senior. My freshman year, I didn't really see it that much but now I do. . . now I do.

The issue of subtle racism was also discussed by the participants and summarized by one student in the following statement:

> There were some instances where as far as tests, I would see where a white student and we [black students] would have the same thing and a white student would have a higher grade than the black student. Or we would go back to the teacher and the teacher would give the white student more points back than the black student. Or you would go to your advisor and they would try to pretty much make you change your major to something else.

> You know they did not want you to continue with this or they would say things to discourage you from staying on track with what you really wanted to do.

When asked in follow-up questions on how to persevere in spite of adversity, and negative perceptions of African Americans, one respondent replied:

> I guess it would be from support and friendship from people who were in the same major. And just sticking together, helping each other study and prepare for tests and things like that. Just saying to myself ''It may take me a little longer than someone else to get where I want to go, but it will happen [laugh].''

These students described how intrinsic motivation, precollege academic preparation, and support from family and friends impacted their transition into college at a predominantly white institution. Based on responses to follow-up questions regarding the demographics of their high school science and mathematics courses many participants described that they were either one of few, or the only African American students in their high school advanced science and mathematics courses. The exception was one student who attended a predominantly black high school as part of a magnet program. Prior socialization as the ''minority'' in their science and mathematics classes may have facilitated their adjustment to a predominantly white campus. Furthermore, for the student that attended a predominantly black high school, because she was in the ''majority'' group at her school, it might be inferred that she encountered a sense of positive self-identity and motivation from her high school environment, as a result of the magnet program.

## Discussion

This study gives voice to African American students in the science pipeline at predominantly white institutions. African American students who participated in this study described in great detail their precollege and college science experiences. In addition, many of the issues described by participants show that there was a road they traveled to success in science. This journey is a shared experience and can also be defined as a type of phenomenon characterized by similar precollege factors and the experiences described. The descriptions of the students' precollege and college science experiences help us to understand what it is like to travel the road to success in science for African American students in similar settings. Key factors critical for success in this journey were also identified. Results demonstrate that all the participants' parents and teachers were influential with regard to: (a) high expectations; (b) encouragement; (c) and career guidance.

High expectations and family support for attaining a good education were seemingly among the most salient factors impacting participants' motivation to achieve a college degree. Data from the interviews indicated clearly that the home environment significantly influenced students' persistence and success in the high school science pipeline. This research suggests that parental influence and encouragement provided an additional resource for the African American students who participated in this research and pursued quantitative degrees during postsecondary education. More specifically, parents of participants both implicitly and explicitly fostered high educational expectations for their children based on responses by students. Similar research by Fisher and Padmawidjaja (1999) and Hrabowski and Maton (1995) indicates that parental encouragement and expectations had the most significant impact on participants' decisions regarding careers in science as well as their academic success.

The primary tenets of parental influence identified in this study are:

1. Encouragement: Participants noted they received a significant amount of encouragement from their parents and family. This encouragement was significant in their persistence and success in the high school science pipeline.
2. Acceptance: Participants indicated that their parents accepted and supported their interest in science.
3. Educational expectations: Participants noted that their parents and family expected and motivated them to persist in science throughout high school and to attend college.

Similar to research by Steinberg (1992) and Hrabowski et al. (1998), we found that African American students of parents that set high expectations for academic achievement are more likely to have high achievement orientation and academic success.

Participants' responses demonstrate the significant impact that high school course-taking patterns had on career choices and persistence in science. Furthermore, all participants were in high school college preparatory programs and experienced similar classroom expectations from their teachers. Participants took critical ''filter'' courses, such as algebra and geometry, and continued to take higher level mathematics courses beyond the typical core requirements. These course-taking patterns provided a ''gateway'' to facilitate the pursuit of more ''quantitative'' degrees. These findings were consistent with other studies (Hall & Post-Kammer, 1991; Powell, 1990) demonstrating that successful completion of ''gate-keeping'' courses increases the likelihood that students will attend college or pursue post-secondary degrees in science.

In keeping with previous research (Oakes, 1985; Wheelock, 1992), this study has also described the high expectations and enriched classroom experiences participants encountered in the more advanced classes, as well as opportunities to participate in science outside of the classroom. All respondents were in high school college preparatory programs, which also determined their high school science and mathematics course-taking patterns. Participants were characterized as students with the ability to cope with various instructional and institutional barriers encountered in their high school and college science and mathematics courses. Participants seemed to have also kept a positive attitude despite the challenging coursework they encountered, which in turn gave them the determination to persevere in their biology degree programs. Research in mathematics education by Moody (1997) suggested that positive attitudes and determination to succeed resulted in students not switching or dropping out of their science degree programs. Furthermore, based on interview conversations it was evident that participants were determined to reach their goals of attending medical school and pursuing careers in medicine.

Of the 11 participants, 8 described specific teachers that impacted their persistence in the high school science pipeline. The present research compares with work by Ogbu (1990), who delineated how African American students achieve academic success through the support of caring educators and strong parental support systems. The quality of teacher–student interaction is particularly important to the success and achievement of African American students (Ford & Harris, 1995). Teacher expectations, encouragement, and attitudes are often primary factors that lead to negative self-fulfilling prophecies for African American students (Nieto, 1992), and it is notable that participants encountered attitudes that fostered their achievement and self-efficacy in science from their teachers. Teacher encouragement and motivation seemingly increased students' self-concepts and belief that they could ''do'' science, and it is evident that participants' teachers conveyed the message that they ''believed'' their students could achieve.

An inherent motivation to succeed, college preparation, aspirations, and more than likely the continual support from family that they experienced in high school facilitated their persistence in

the college science pipeline at predominantly white institutions. These findings were consistent with literature that asserts various internal factors, such as personal motivation, self-concept, and goals and aspirations, are strong contributors to the academic progress of African American students (Dorsey & Jackson, 1995). Moreover, college preparation and academic aspirations and social adjustment also impact the academic persistence of African American students (Kemp, 1990; Sedlacek & Tracey, 1985). Finally, participants described the college science pipeline at a predominantly white institution. Similar to research findings by Davis et al. (2004), this research reiterates that oftentimes African American students feel a need to ''prove they are worthy'' academically in efforts to overcome perceived stereotypes and misconceptions about their ability to achieve academic success. Overall, this research described and validated some of the factors that have been discussed previously in research regarding African American students' persistence at PWIs, and gave depth to factors that impact persistence in the science pipeline through the voices of African American college students.

## Implications

This research was initiated in hopes that teachers and educators would listen to the ways African American students (who have achieved success in the high school science pipeline) perceived and recounted precollege science and mathematical experiences and their reasons for success in the high school science pipeline. Their views and experiences give an ''insider'' perspective on elements that led to their success in high school science. This is especially important to the recruitment and retention of African American students in science and science-related degree programs. Information may be used to educate teachers on the critical role they play in the persistence and subsequent success of African American students in science and mathematics. Teacher educators need to better prepare teachers on how to foster positive relationships, exhibit positive attitudes through encouragement, and communicate high expectations for their students. Although this is beyond the scope of this research, often students in teacher preparation courses complain that they are not adequately prepared in how to interact and communicate with the students and parents from culturally diverse backgrounds. Positive attitudes, high expectations, and encouragement can transcend cultural borders that often pose barriers to teacher–student interactions.

Results also reiterate the impact of parent and teacher expectations and encouragement. Based on findings from this study, both of these factors were closely intertwined and appear to be the most salient factors when recounting experiences in the high school science pipeline. Parent and teacher support had a lasting impact on students and was pivotal in contributing to their persistence and success in science at predominantly white institutions. Participants described the value of the classes and curriculum encountered in the high school college preparatory track. It is important to note that the feelings and levels of adequacy varied based on their high school science and mathematics classes. When both teachers and parents conveyed the message that they ''believed'' that their students or children can achieve and be successful in science, it motivated the participants to continue with the high school science pipeline and to pursue post-secondary degrees in science.

High parental and teacher expectations, as well as participation in the college preparatory curriculum, are factors that contribute to success in high school science and persistence in the college science pipeline at predominantly white institutions. Offering more opportunities for African American students to participate in not only the college preparatory curriculum, but more a rigorous curriculum within the college preparatory track early in their academic program, may

lead more students to participation in quantitative science careers and degree programs. Moreover, based on student responses, exposure to more challenging classes in high school enhanced their levels of self-efficacy and confidence in pursuing a biology degree in college. Although investigating this issue more in depth is beyond the scope of this study, research demonstrates that self-efficacy and self-concept have an effect on African American students' academic achievement and are important for persistence (Love, 1993).

It is essential for science teacher educators to recognize the significant role they play in educating teachers on the importance of encouraging their students to enroll and persist in science and mathematics. In the area of teacher education, the presence of caring teachers has always been important. It is essential that professional development programs emphasize the importance of this component in the success of African American students in particular. Moreover, this research provides implications for both research and practice in challenging professional development programs to include efforts to raise teacher knowledge and skills so they can effectively teach and encourage African Americans students to persist and achieve in science. It is important that teachers understand and value the individual needs of all students to encourage their participation in more rigorous and challenging curricula.

The findings from this study affirm the significant impact teachers, parents, and course-taking patterns have on the career development of African American students in science. Teachers and counselors should also have a commitment to involve parents in career planning of their children, the earlier the better. Furthermore, results from this investigation help teachers understand the importance of getting parents to participate in their children's education. It is critical that science educators and counselors continue to encourage enrollment in more rigorous high school courses to increase the pool of science applicants. This research challenges educators to develop policies and intervention programs that raise parents' awareness of the importance of both the college preparatory curriculum as well as challenging and rigorous courses in the pursuit of careers and degrees in science.

Career workshops for parents and students are ideal for educating parents on the significant influence they have on their children's career development. Finally, it is important for predominantly white institutions of higher learning to continue to research and develop programs that foster and promote academic achievement of African American students in higher education—more specifically, programs similar to the Meyerhoff Scholars Program at the University of Maryland, Baltimore County (UMBC). This program is successful and was designed to promote achievement of African American students in science, mathematics, and engineering and to increase the participation of underrepresented racial/ethnic groups pursuing graduate and professional degrees in these disciplines (Maton, Hrawbowski, & Schmitt, 2000). It is critical that researchers continue to support these programs and work toward the development and implementation of similar ones.

According to Oliver, Smith, and Wilson (1989), organizational support at predominantly white institutions is critical for social adjustment of African American students. With regard to methods of providing more support for African American students, Love (1993) suggested: (a) developing programs for retention; (b) developing programs to eliminate racism; (c) providing training for institutional leadership; (d) fostering positive faculty–student relationships for African American students; and (e) continuation of research into the success of African American students. Ongoing research in these areas will hopefully provide teacher educators and researchers with strategies to foster and promote the success of African American students in the science pipeline. Teacher educators are charged with the responsibility of ensuring success in students' journeys throughout the high school and college science pipelines.

## Acknowledgments

M.L.R. expresses her gratitude to Dr. Beverly Armento, Dr. Marilyn Strutchens, and Dr. Jared Russell for their encouragement and helpful comments with earlier versions of this article.

## Appendix A

Table 1A
*Participant information*

| Participant | Gender | Transfer Student | Major |
|---|---|---|---|
| 1 | Female | No | Biology/pre-medicine |
| 2 | Female | No | Biology/pre-medicine minor in Psychology |
| 3 | Male | No | Biology/pre-medicine |
| 4 | Male | No | Biology/pre-medicine |
| 5 | Female | Yes | Biology/pre-medicine |
| 6 | Male | No | Biology/pre-medicine |
| 7 | Female | No | Biology/pre-medicine |
| 8 | Female | No | Biology/pre-medicine |
| 9 | Female | No | Biology/pre-medicine |
| 10 | Female | No | Biology/pre-medicine/minor in Health Promotion and Behavior |
| 11 | Female | No | Biology/pre-dentistry |

## Appendix B

Table 1B
*Participants high school science and math course-taking patterns*

| Participant | Science Courses | Mathematics Courses |
|---|---|---|
| 1 | (Above-average level) Biology, Chemistry Physical Science, Human Anatomy | Algebra I, Algebra II, Geometry, Trigonometry |
| 2 | AP Chemistry, AP Biology, Human Anatomy, Physics | Accelerated Algebra I and II Trigonometry, Geometry, Accelerated Pre-Calculus, AP Calculus |
| 3 | Advanced Biology, Chemistry, Advanced Physics, Advanced Physical Science | Advanced Algebra I and II, Geometry, Calculus, |
| 4 | AP Biology, AP Chemistry, AP Chemistry II, AP Physics | Geometry, Algebra II, Trigonometry, AP Calculus |
| 5 | Physical Science, Biology, AP Human Anatomy, AP Physics | Algebra I and II, Geometry |
| 6 | Honors Physical Science, Biology, Honors Chemistry | (Average level) Algebra I, Algebra II, Geometry, Trigonometry |
| 7 | AP Physics, AP Chemistry, AP Biology | Geometry, Algebra II, Trigonometry, Calculus |
| 8 | (School did not have AP science and mathematics courses) Chemistry, Physical Science, Biology, Advanced Biology | Geometry, Algebra I Algebra II, Pre-Calculus Trigonometry |
| 9 | Advanced Biology, Advanced Physics, Advanced Physical Science, Advanced Chemistry, Human Anatomy | Algebra I and II, Trigonometry, Calculus |
| 10 | Advanced Physics, Advanced Biology, Advanced Chemistry | Advanced Algebra I, Advanced Algebra II, Advanced Calculus, Advanced Trigonometry |
| 11 | Honors Biology, Honors Physical Science, Honors Chemistry, Human Physiology, Honors Physics | Algebra I, Geometry, Algebra II, Advanced Trigonometry |

## References

Allen, W., Epps, E.G., & Haniff, N.F. (1991). Colleges in black and white: African American students in predominantly white and in historically black public universities. New York: State University of New York Press.

Allen, W.R. (1992). The color of success: African American college student outcomes at predominantly white and historically black public colleges and universities. Harvard Educational Review, 62, 26–44.

American Association for the Advancement of Science. (1998). Project 2061. Blueprints for reform in science, mathematics, and technology education. Washington, DC: AAAS.

Anderson, T. (1988). Black encounters of racism and elitism in white academe. Journal of Black Studies, 18, 259–272.

Astone, N., & McLanahan, S. (1991). Family structures, parental practices, and high school completion. American Sociological Review, 56, 309–320.

Atwater, M.M. (2000). Equity for black Americans in precollege science. Science Education, 84, 154–179.

Blustein, D.L., Waldbridge, M.M., Friedlander, M.L., & Palladino, D.E. (1991). Contributions of psychological separation and parental attachment to the career process. Journal of Counseling Psychology, 38, 39–50.

Brown, M.L. (2000). Factors that impact the educational pursuits and career aspirations of African American college students. Unpublished dissertation, University of Georgia, Athens, GA.

Brown, T. (2001). Exposure to all black contexts and psychological well being: The benefits of racial concentration. African American Research Perspectives, 7, 157–172.

Butler-Kahle, J. (1982). Can positive minority attitudes lead to achievement gains in science? Analysis of the 1977 National Assessment of Educational Progress toward science. Science Education, 66, 539–546.

Carnoy, M. (1994, Autumn). Why aren't more African Americans going to college? Black Issues in Higher Education 5, 66–69.

Carter, P. (2000). A review: The role of race and culture in the academic and social attainment of African American youth. African American Research Perspectives, 6, 65–73.

Catsambis, S. (1995). Gender, race, ethnicity, and science education in the middle grades. Journal of Research in Science Teaching, 32, 243–257.

College Board. (1999). Reaching the top: A report of the national task force on minority high achievement. New York: College Boards Publications.

Connell, S., & Lewis, B. (2003). An examination of the relationships between African American students' enrollment in advanced science courses and their career consideration. Paper presented at the National Association for Research in Science Teaching, Philadelphia, PA.

Cureton, S.R. (2003). Race-specific college student experiences on a predominantly white campus. Journal of Black Studies, 33, 295–311.

Cuyjet, M.J. (1997). Helping African American men succeed in college: New directions for student services. San Francisco: Jossey-Bass.

Darling-Hammond, L. (1995). Inequality and access to knowledge. In J.A. Banks & C.A.M. Banks (Eds.), Handbook on research on multicultural education (pp. 465–483). New York: Macmillan.

Davis, J.E. (1998). Campus climate, gender, and achievement of African American college students. African American Research Perspectives, 4, 40–46.

Davis, M., Dias-Bowie, Y., Greenberg, K., Klukken, G., Pollio, H.R., Thomas, S.P., & Thompson, C.L. (2004). A fly in the buttermilk: Descriptions of university life by successful black

undergraduate students at a predominantly white southeastern university. The Journal of Higher Education, 75, 420–445.

Delphin, M.E., & Rollock, D. (1995). University alienation and African American ethnic identity as predictors of attitudes toward, knowledge about, and likely use of psychological services. Journal of College Student Development, 36, 337–346.

Denzin, N., & Lincoln, Y.S. (1994). Handbook of qualitative research. Newbury Park, CA: Sage.

DeSousa, J. (2001). Reexamining the educational pipeline for African-American students. In L. Jones (Ed.), Retaining African Americans in higher education: Challenging paradigms for retaining students, faculty, & administrators (pp. 21–44). Sterling, VA: Stylus Publishers.

Dorsey, M., & Jackson, A. (1995). Afro-American students' perceptions of factors affecting academic performance at a predominantly White school. Western Journal of Black Studies, 19, 192.

Edmunds, G.J. (1984). Needs assessment strategy for black students: An examination of stressors and program implications. Journal of Non-White Concerns in Personnel and Guidance, 12, 48–56.

Edwards, A., & Polite, C.K. (1992). Children of the dream: The psychology of black success. New York: Doubleday.

Ellis, R.S. (1993). Impacted the science attitudes of minority high school youth. School Science and Mathematics, 98, 400–407.

Fisher, T.A., & Griggs, M.B. (1995). Factors that influence the career development of African American and Latino youth. Journal of Vocational Education Research, 20, 47–66.

Fisher, T.A., & Padmawidjaja, I. (1999, July). Parental influences on career development perceived by African American and Mexican American college students. Journal of Multicultural Counseling and Development, 136–152.

Ford, D.Y. (1993). Black students' achievement orientation as a function of perceived family achievement orientation and demographic variables. Journal of Counseling and Development, 69, 577–580.

Ford, D.Y., & Harris, J.J. (1995). Underachievement among gifted African American students: Implications for school counselors. School Counselor, 42, 196–203.

Fordham, S., & Ogbu, J. (1986). Black students' school success: Coping with the burden of ''acting white.'' The Urban Review, 19, 176–206.

Green, P.E. (2001). The policies and politics of retention and access of African American students' in public white institutions. In L. Jones (Ed.), Retaining African Americans in higher education: Challenging paradigms for retaining students, faculty, & administrators (pp. 21–44). Sterling, VA: Stylus Publishers.

Grotevant, H.D., & Cooper, H.R. (1988). The role of family experience in career exploration: A lifespan perspective. In P.B. Baltes, D.L. Featherman, & R.M. Lerner (Eds.), Lifespan development and behavior (pp. 231–258). London: Erlbaum.

Hall, E.R., & Post-Kammer, P. (1987). Black mathematics and science majors: Why so few? The Career Development Quarterly, 35, 206–219.

Henderson, P.L. (1988). The invisible minority black students at a southern white university. Journal of College Student Development, 29, 349–355.

Hilliard, A.G. (1994). What good is this thing called intelligence and why bother to measure it? The Journal of Black Psychology, 20, 430–443.

Howard, J., & Hammond, R. (1985). Rumors of inferiority. The New Republic, 193, 17–21.

Hrabowski, F. (2003, December–January). Raising minority achievement in science and math. Educational Leadership, 44–48.

Hrabowski, F.A., & Maton, K.I. (1995). Enhancing the success of African American students in the sciences: Freshman year outcomes. School Science and Mathematics, 95, 19–27.

Hrabowski, F.A., Maton, K.I., & Grief, G.L. (1998). Beating the odds: Raising academically successful African American males. New York: Oxford University Press.

Hrabowski, F., Maton, K., Grief, J., & Greene, M. (2002). Overcoming the odds: Raising academically successful African American young women. New York: Oxford University Press.

Hughes, M. (1987). Black students' participation in higher education. Journal of College Student Personnel, 28, 532–545.

Irvine, J.J. (1990). Black students and school failure: Policies, practices, and prescriptions. New York: Greenwood Press.

Jones, L. (2001). Creating an affirming culture to retain African American students during the postaffirmative action era in higher education. In L. Jones (Ed.), Retaining African Americans in higher education: Challenging paradigms for retaining students, faculty and administrators (pp. 3–20). Sterling, VA: Stylus Publishers.

Kemp, A.D. (1990). From matriculation to graduation: Focusing beyond minority retention. Journal of Multicultural Counseling and Development, 18, 144–149.

Kuh, G., & Andreas, R.E. (1991). It's about time: Using qualitative methods in student life studies. Journal of College Student Development, 32, 397–405.

LeCompte, M.D., & Priessle, J. (1993). Ethnography and qualitative design in education research. San Diego, CA: Academic Press.

Lewis, B. (2003). The under-representation of African Americans in science: A review of the literature. Paper presented at the National Association of Research in Science Teaching, Philadelphia, PA.

Lincoln, Y., & Guba, E. (1985). Naturalistic inquiry. Newbury Park, CA: Sage.

Love, B.J. (1993). Issues and problems in the retention of black students in predominantly white institutions of higher education. Equity and Excellence in Education, 26, 27–36.

Massey, W.E. (1992). A success story amid decades of disappointment. Science, 258, 1177–1179.

Maton, K.I., Hrabowski, F.A., & Schmitt, C.L. (2000). African American college students excelling in the sciences: College and postcollege outcomes in the Meyerhoff Scholars Program. Journal of Research in Science Teaching, 37, 629–654.

McCauley, D.P. (1988, January). Effects of specific factors on blacks' persistence at a predominantly white university. Journal of College Student Development, 48–51.

Merriam, S.B., et al. (2002). Phenomenological research. In S.B. Merriam (Ed.), Qualitative research in practice: Examples or discussion and analysis (pp. 93–95). San Francisco, CA: Jossey-Bass/John Wiley & Sons.

Moody, V. (1997). Giving voice to African Americans who have been successful with school mathematics. Unpublished doctoral dissertation, University of Georgia, Athens, GA.

Moore, J.L. (2001). Developing academic warriors: Things that parents, administrators, and faculty should know. In L. Jones (Ed.), Retaining African Americans in higher education: Challenging paradigms for retaining students, faculty, & administrators (pp. 77–90). Sterling, VA: Stylus Publishers.

National Center for Education Statistics (NCES). (1992). Historically black colleges and universities: 1976–1990. Washington, DC: NCES.

National Science Foundation (NSF). (2000). Women, minorities, and persons with disabilities in science and engineering 2000 (NSF 00-327). Arlington, VA: NSF.

National Science Board. (2000). Science and engineering indicators 2000 (NSB-00-1). Arlington, VA: NSF.

Natriello, G., Pallas, A.M., & Alexander, K. (1989). On the right track? Curriculum and academic achievement. Sociology of Education, 62, 109–118.

Nettles, T. (1988). Factors related to black and white students' college performance: Toward black undergraduate student equality in American higher education. New York: Green Press.

Neville, H.A., Heppner, P.P., Ji, P., & Thye, R. (2004). The relations among general race-related stressors and psychoeducational adjustment in black students attending predominantly white institutions. Journal of Black Studies, 34, 599–618.

Neville, H.A., Heppner, P.P., & Wang, L. (1997). Relations among racial identity attitudes, perceived stressors, and coping styles in African American college students. Journal of Counseling Development, 75, 303–311.

Nieto, S. (1992). Affirming diversity: The sociopolitical context of multicultural education. New York: Longman.

Oakes, J. (1985). Keeping track: How schools structure inequality. New Haven, CT: Yale University Press.

Oakes, J. (1990a). Lost talent: The underparticipation of women, minorities, and disabled students in science. Santa Monica, CA: The Rand Corporation.

Oakes, J. (1990b). Multiplying inequalities: The effects of race, social class, and tracking on opportunities to learn mathematics and science. Santa Monica, CA: The Rand Corporation.

Ogbu, J.U. (1990). Overcoming racial barriers to equal access. In J.J. Goodlad & P. Keating (Eds.), Access to knowledge: An agenda for our nation's schools. New York: College Entrance Examination Board.

Oliver, M., Smith, A., & Wilson, K. (1989). Supporting successful black students: Personal, organizational, and institutional factors. National Journal of Sociology, 3, 199–221.

Parham, T.A., & Austin, N.L. (1994). Career development and African Americans: A contextual reappraisal using the Nigrescence construct. Journal of Vocational Behavior, 44, 139–154.

Patton, M.Q. (1990). Qualitative evaluation and research methods (2nd ed.). Newbury Park, CA: Sage.

Powell, L. (1990). Factors associated with the underrepresentation of African Americans in mathematics and science. Journal of Negro Education, 59, 292–298.

Sailes, G.A. (1993). An investigation of black student attrition at a large, predominantly white, midwestern university. Western Journal of Black Studies, 17, 179–182.

Schwitzer, A.M., Griffin, O.T., Ancis, J.R., & Thomas, C.R. (1999). Social adjustment experiences of African American college students. Journal of Counseling & Development, 77, 189–197.

Sedlacek, W.E. (1987). Black students on white campuses years of research. Special issues: Blacks in U.S. in higher education. Journal of College Student Personnel, 28, 484–494.

Sedlacek, W., & Tracey, T. (1985). The relationship of non-cognitive variables to academic success: A longitudinal comparison by race. Journal of College Student Personnel, 26, 405–410.

Seymour, E., & Hewitt, N.M. (1997). Talking about leaving: Why undergraduates leave the sciences. Boulder, CO: Westview Press.

Smith, F.M., & Hausfaus, C.O. (1998). Relationship of family support and ethnic minority students' achievement in science and mathematics. Science Education, 82, 111–125.

Steele, C. (1992, April). Stigma: Race and the schooling of black Americans. Atlantic Monthly, 68–78.

Steele, C.M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. American Psychologist, 52, 613–629.

Steinberg, L., Dornbusch, M., & Brown, B. (1992). Ethnic differences in academic achievement: An ecological perspective. American Psychologist, 47, 923–929.

Strauss, A.L., & Corbin, J. (1990a). Grounded theory methodology: An overview. In N.K. Denzin & Y.S. Lincoln (Eds.), Handbook of qualitative research. Thousand Oaks, CA: Sage.

Strauss, A.L., & Corbin, J. (1990b). Basics of qualitative research: Grounded theory procedures and techniques. Newbury Park, CA: Sage.

Taylor, L.C., Hinton, I.D., & Wilson, M.N. (1995). Parental influences on academic performance in African American students. Journal of Child and Family Studies, 4, 293–302.

Tidwell, R., & Berry, G.L. (1993). Higher education and the African American experience: Historical perceptions and the challenge for change. College Student Journal, 27, 465–471.

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. Review of Educational Research, 45, 89–125.

Townsend, L. (1994). How universities successfully retain and graduate black students. Journal of Blacks in Higher Education, 4, 85–89.

Watson, L.W., Terrell, M.C., Wright, D.J., Bonner II, F.A., Cuyjet, M.J., Gold, J.A., Rudy, D.E., & Person, D.R. (2002). How minority students experience college: Implications for planning and policy. Sterling, VA: Stylus Publications.

Wheelock, A. (1992). Crossing the tracks: How ''untracking'' can save America's schools. New York: The New Press.

Young, R.A. (1994). Helping adolescents with career development. The Career Development Quarterly, 42, 195–203.