

DISSERTATION

ACHIEVEMENTS AND CHALLENGES OF UNDERGRADUATES IN SCIENCE,
TECHNOLOGY, ENGINEERING, AND MATHEMATICS FIELDS IN THE RONALD
E. MCNAIR PROGRAM

Submitted by

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In partial fulfillment of the requirements
For the Degree of Doctor of Philosophy
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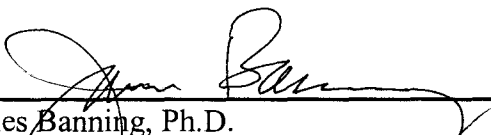
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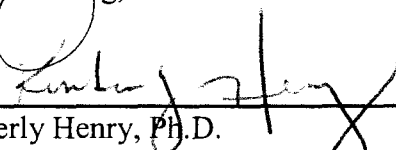
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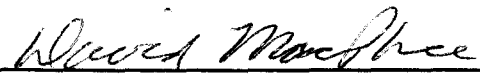
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ABSTRACT OF DISSERTATION

ACHIEVEMENTS AND CHALLENGES OF UNDERGRADUATES IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS FIELDS IN THE RONALD E. MCNAIR PROGRAM

This dissertation is comprised of two studies and is about understanding the challenges, choices, aspirations, and perceptions of successful, underrepresented undergraduates in STEM fields. Study 1 compared self-perceptions of academic ability and academic performance of female and male undergraduate science and engineering students from underrepresented ethnic and socioeconomic groups, upon admission in (Time 1) and graduation from (Time 2) the McNair Mentorship Program. Female and male students were similar in regard to academic performance. However, at Time 1, women were significantly more likely than their male peers to describe themselves as academically weaker. Upon graduation from the McNair Program, women's perceptions of their academic skills were on par with those of men. Students with double minority status (i.e. by sex, ethnicity, generation in college, or income) had more negative self-perceptions of academic skills, as well as lower performance on standardized tests. Overall, these findings suggest that one barrier for women in STEM education is lower confidence. However, over time female McNair students in STEM increased their self-perception of academic competence. This study's findings also indicate that multiple minority status may have a cumulative negative impact on academic self-perceptions and academic performance. Study 2 focused on the experiences of high-achieving, female undergraduates from disadvantaged backgrounds who are majoring in engineering,

physical, or life science. Interviews about educational choices and career aspirations were collected in written form upon admission to (Time 1) and graduation from (Time2) the McNair Mentorship Program. Students' timing of educational and career decisions, motivations, parental expectations and involvement in educational and career planning, career exploration, and career aspirations were qualitatively analyzed longitudinally and across disciplines. Insights about educational choices and career aspirations are shared and recommendations are given for future research to improve career counseling to support disadvantaged women in STEM fields.

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I would like to dedicate this dissertation to my mother, Ms. Milmary Mathews Farro, whose curiosity about the world and love of learning has continued to inspire me throughout my life. Mom, you are a symbol of strength, love, and compassion – thank you for all you have taught me and passed on to me. You will continue to live in the legacy of my work in this world.

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Achievements and Challenges of Undergraduates in Science, Technology, Engineering,
and Mathematics Fields in the Ronald E. McNair Program

This dissertation focuses on gaining a more in-depth understanding of the education challenges, choices, aspirations, and perceptions of under-represented students (e.g., women and some ethnic minorities) in undergraduate education in science, technology, engineering, and mathematics (STEM) fields. In subsequent sections, I will first review theories and findings on educational disparities in STEM, then will review the two primary explanations for educational disparities in STEM, and finally will articulate the rationale and purpose of the specific studies that are a part of this dissertation.

Educational Disparities in STEM Disciplines

STEM disciplines are among the fastest growing and well-paid occupational fields in the United States (Xie & Shauman, 2003). Despite the economic opportunities they offer, STEM education and careers engage few women and ethnic minorities relative to other groups (Babco & Bell, 2004; Baum, 1990; Knapp et al., 2005; Xie & Shauman). STEM fields have persisted as “stubborn exceptions” to fields such as medicine and law and to the general trend of increasing numbers of women entering higher education overall (Ceci, Williams, & Barnett, 2009; Xie & Shauman). For example, a National Science Foundation (NSF, 2009) report indicates that women in 2006 earned only 20% of undergraduate degrees in engineering, 21% of undergraduate degrees in computer sciences, 42% of undergraduate degrees in physical science, and 44% of undergraduate

degrees in mathematics. Additionally, the percentage of women earning undergraduate degrees in computer sciences and mathematics has been decreasing since 1998.

The 2009 NSF report also reveals that some ethnic minority involvement in STEM disciplines is also quite low, particularly for African-American, Hispanic/Latina(o), and Native-American/Pacific Islander citizens and permanent residents in the U.S. In fact, “White” U.S. citizens and permanent residents in 2006 earned the majority of undergraduate degrees in computer sciences, engineering, physical science, and mathematics (NSF, 2009). Comprising 13% of the U.S. population (U.S. Census, 2000), however, African American U.S. citizens and permanent residents earned only 5% of undergraduate degrees in engineering, 6% of undergraduate degrees in mathematics, 7% of undergraduate degrees in physical science, and 12% of undergraduate degrees in computer science in 2006 (NSF, 2009). Hispanic/Latina(o) U.S. citizens and permanent residents also comprise 13% of the U.S. population but received only 6% of undergraduate degrees in mathematics and physical science, 7% of undergraduate degrees in computer science, and 8% of undergraduate degrees in engineering. In 2006, Native-American/Pacific Islander students received only 0.4% of undergraduate degrees in mathematics, 0.6% of undergraduate degrees in engineering and computer science, and 0.7% of undergraduate degrees in physical science despite comprising 1.8% of the U.S. total population.

The predominance of “White” and male students completing STEM degrees is problematic for several reasons. One problem is that women and some ethnic minority groups are not benefitting from the high status and economically advantageous careers that STEM education can offer. STEM disciplines are prestigious and have a high social

standing in U.S. culture. Another problem is that STEM disciplines are not benefitting from the scientific talents and creative contributions women and all ethnic minorities have to offer. The contributions of women and all ethnic minorities are especially important right now because a predicted shortage of scientists in the U.S. has raised concerns about the U.S.'s ability to meet the demands of technological advances and continue being competitive in a global market (Atkinson, 1990). To keep pace with advances in technology and science, the U.S. needs an abundant and innovative science-educated labor force (Xie & Shauman, 2003). Women and some ethnic minorities stand out as a conspicuous and untapped resource in the U.S. (NSF, 1999).

Biological and Contextual Explanations for STEM Disparities

Why are women and some ethnic minorities underrepresented in STEM fields? Many factors have been suggested with two main explanations emerging from the literature. One explanation is that differences in participation in STEM education and careers originates from innate, biological differences in ability (Benbow & Stanley, 1980; 1983; Geary, 1996; 1998; 2007; Kimura, 1999; 2007; Lubinski & Benbow, 2007). Another explanation is that differences in participation primarily result from variation in culture and socialization (Ceci et al., 2009; De Jean et al., 1999; Hess & Miuri, 1985; Milburn et al., 2001; Sheldon, 2004).

According to the biological perspective underrepresentation in STEM fields is the result of innate differences in ability. Data from industrialized countries indicates that males outperform females on mathematical word problems and geometry. These data have been interpreted as evidence of fixed sex differences in science and math related neuro-cognitive systems (Geary, 1996; 1998; 2007; Kimura, 1999; 2007). Additionally,

sex differences in middle school students' mean scores on the Scholastic Aptitude Tests (SAT) in math have also been interpreted to support the biological factors theory. The SAT data have been interpreted as evidence that men tend to have greater innate mathematical ability than women (Benbow & Stanley, 1980; 1983; Lubinski & Benbow, 2007). The SAT data have also been interpreted as evidence that the greater variability of mathematical aptitude among men accounts for men's high prevalence among the most talented scientists (Benbow & Stanley; Lubinski & Benbow).

According to the environmental perspective, underrepresentation in STEM fields is the result of variations in context such as culture and socialization. Arguments based on nurture question biological theories by highlighting data on at least four contextual factors including: historical time period, country of origin, the measure used to demonstrate aptitude, and negative group stereotypes in testing situations. It is noteworthy that in past historical periods, fields such as biological sciences, veterinary medicine, and medical sciences were deemed appropriate only for men due to women's assumed inferior innate cognitive abilities. Despite such biased beliefs in earlier times, evidence today demonstrates that women comprise half or more of those attaining degrees in those same fields (Babco & Bell, 2004; NSF, 2004; 2009). This evidence weakens an argument that attributes underrepresentation in STEM education and vocations to biologically based inferiorities.

The biological perspective is further weakened when data are considered that demonstrates women's participation and aptitude in science varies significantly from one country to another (Hersh, 2000; Oakes, 1990; Valian, 2007). For example, in several studies, scores on mathematical tests indicated that boys scored slightly higher than girls

in both Japan and the United States (Lumis & Stevenson, 1990; Valian, 2007). However, this same study also found that the scores of Japanese girls were much higher than those of U.S. boys (Lumis & Stevenson; Valian). The pattern whereby foreign girls outperform U.S. boys was also found for Singapore and the United States (Valian). These data undermine the assertion that biologically based sex differences in math ability account for women's low participation in STEM. Instead, challenges to the theory of biological sex differences assert that females and males exhibit equal intrinsic aptitude for math and science (Spelke, 2005). Differences in participation of women and men in science technology and engineering fields are shown to be influenced by cultural beliefs, socialization, and environmental factors (De Jean et al., 1999; Hess & Miuri, 1985; Milburn et al., 2001; Sheldon, 2004).

Aptitude in science and math can also vary according to the measure used to assess ability, with different measures yielding inconsistent results. For example, when standardized test scores such as the Scholastic Assessment Test (SAT) are used, boys appear to have greater aptitude in math and science (Spelke & Grace, 2007; Willingham & Cole, 1997). However, girls are shown to have greater aptitude when grade point averages of math and science classes are used (Spelke & Grace; Willingham, & Cole). Therefore, differences in aptitudes for science and math between females and males are not definitive or consistent across various methods of measurement.

Lastly, academic performance can vary by testing situation due to a phenomenon called stereotype threat (Osborne, 2001; Spencer & Castano, 2007; Steele, 1992; 1997; Steele, Spencer, & Aronson, 2002). Negative in-group stereotypes are found to undermine academic and intellectual performance and increase performance related

anxiety for women and ethnic minority students independent of ability, preparation, or talent.

Variability in the participation and representation of women and some ethnic minority students in STEM education and occupations is a complex and multifaceted phenomenon. Fortunately, some female and ethnic minority students pursue and are successful in STEM education despite the environmental factors that may act to dissuade their participation. Focusing on understanding this select group of students is one strategy for gaining insight into developing more effective supports and interventions that increase participation of women and all ethnic minorities in STEM.

Purpose

This dissertation is focused on gaining a more in-depth understanding of the challenges, choices, aspirations, and perceptions of successful, underrepresented undergraduates in STEM fields. It is comprised of two studies of undergraduates in STEM. Both studies examine data at admission (Time 1) to and graduation (Time 2) from the McNair Mentorship Program. Study 1 focuses on academic self-perceptions and performance of high-achieving, undergraduate STEM students from underrepresented gender, ethnic, and socio-economic groups. Study 2 focuses on the educational and career choices, aspirations, and perceptions over time for high-achieving, female undergraduates who are predominately from underrepresented ethnic and socio-economic groups and are majoring in engineering, physical science, or life science.

STUDY 1

Academic Self-perceptions and Performance of Gifted Science and Engineering

Undergraduates

Academic self-perceptions and performance of science and engineering undergraduates from underrepresented groups were compared, at admission (Time 1) and graduation (Time 2) of the McNair Program. Females and males demonstrated similar academic performance. At Time 1, women were more likely to perceive themselves as academically weak. At Time 2, women's academic perceptions were on par with men. Students with double minority status had more negative self-perceptions of academic skills and lower performance on standardized tests. One barrier for women in STEM education may be lower confidence. However, female McNair students increased their academic self-perceptions over time. This study's findings also indicate that multiple minority status may have a cumulative negative impact on academic self-perceptions and academic performance.

U.S. women and some ethnic minorities such as African-Americans, Hispanics/Latinas(os), and Native Americans/Pacific Islanders are underrepresented in science, technology, engineering, and mathematics (STEM) education and careers (Babco & Bell, 2004; Baum, 1990; Ceci, Williams, & Barnett, 2009; Dweck, 2007; Knapp, et al., 2005; Lupart, Cannon, & Telfer, 2004; NSF, 2009; Wentling & Camacho, 2008; Xie & Shauman, 2003). The limited participation of women and some ethnic minorities in STEM fields has gained more attention recently due to projected shortages in the U.S. science, technology, and engineering labor force (Wentling & Camacho). Concern about these labor shortages has sparked a growing commitment to understanding factors that may help attract and retain a diversity of students in STEM fields (Wentling & Camacho), especially those who are currently underrepresented in STEM such as female, African-American, Hispanic/Latina(o), and Native American/Pacific Islander students (NSF).

It is crucial to examine barriers to the entrance and persistence in STEM fields for underrepresented groups. Potential barriers include actual and perceived academic competence. This study examined actual and self-perceived academic skills of high-achieving STEM undergraduate students from underrepresented groups (e.g., by sex, ethnicity, family income, and/or generation in college) upon admission and graduation from the McNair Program.

Academic Performance Related to STEM Participation and Persistence

Academic performance and self-perceptions of academic ability are two factors associated with participation and persistence in STEM education, especially for underrepresented groups such as women and ethnic minorities (Betz, 2005; Dweck, 2007; Lupart et al., 2004). In one 2008 study, high school and freshman year grade point average (GPA) have the highest importance for predicting the persistence of female and male students majoring in science or engineering (Mendez, Buskirk, Lohr, & Haag, 2008). Other studies show a positive relationship between women's persistence in "nontraditional" majors and careers and indicators of performance. For example, academic performance as measured by standardized test scores and GPA is related to persistence whereby people who achieve higher scores and grades persist longer (Fassinger, 1985; 1990). Additionally, a 2002 study of women in engineering programs found that, on average, women who persisted in engineering had significantly higher grades (Goodman et al., 2002). Women's ability is also related to a high level of career aspirations whereby women with greater ability (as measured by a combination of ACT/SAT scores and cumulative GPA) have aspirations of more advanced positions in mathematics, science, and engineering (Nauta, Epperson, & Kahn, 1998).

Self-Perception of Academic Ability in Relation to STEM Participation and Persistence

Self-perception of ability is another factor related to attraction to and retention in STEM fields. Female and males have been found to differ in their self-perceptions of STEM-related abilities and their attributions regarding a success or failure (Chrisler, 1998; Dweck, 2007; Lupart et al.). For example, in one study, boys demonstrated greater endorsement of statements such as “I am good at science/math,” “If I were to rank the students in my science/math class from the lowest to the highest, I would put myself in the highest group,” and “I would be successful in a career that required science/math ability” as compared to girls (Lupart et al.). In the same study, girls consistently held the perception of having to work harder at science as compared to boys with greater endorsement of statements such as “I have to work hard to get good grades in science.”

In addition, a review of several studies indicates that adult women who are most likely to struggle with math or decide not to pursue math coursework are those who view mathematical ability as a gift or talent, rather than a skill that is developed with training (Dweck, 2007). Interventions that imply that math skills are *developed* result in female students performing at an equal level to male students but interventions implying that math skills are a *gift* result in significantly reduced performance by females compared to males (Dweck). The perceptions students hold regarding their own ability is critical because self-perceptions are the foundation by which decisions are made related to persistence in science and mathematics education and career choices are made (Dweck).

A different study compared women in engineering to women who had dropped out and found that women who persisted in engineering were more likely to hold self-enhancing perceptions related to performance in math, science, and engineering (Nauta,

Epperson, & Waggoner, 1999). Women's self-perceptions that their success is due to unstable factors such as luck are exaggerated even more when the success is within a context or activity that is viewed as stereotypically masculine (Chrisler, 1998). Similar patterns have also been found regarding the importance of self-perceptions on career development for ethnic minority students. Specifically, experiences of stereotyping and discrimination undermine ethnic minority students' pursuit of some occupations and can lead to the development of diminished vocational self-perceptions (Leung, 1995). The development of negative vocational self-perceptions limits the attraction to and retention of women and ethnic minorities in high status disciplines such as STEM fields.

In conclusion, academic performance and self-perceptions of ability are important influences in attraction to and persistence in STEM disciplines for underrepresented students. Therefore, understanding how to enhance performance and foster positive self-perceptions of competence is a key element in addressing the low representation of women and ethnic minority students in STEM fields as well as addressing the concern of U.S. labor shortages in STEM fields. Gaining insight into these two important factors can aid educators and policy makers by illuminating strategies for recruiting and retaining students from underrepresented groups in STEM fields.

The Current Study

The current study examined academic performance and academic self-perceptions of women and ethnic minority students who, despite barriers, are high-achieving or have strong academic potential in STEM fields. Participants were undergraduate students who are enrolled in the Ronald E. McNair Mentorship Program (the McNair Program). This study builds on previous research by using broader measures of academic ability that

include standardized test scores and grade point average as well as a critical thinking skills measure.

The McNair Mentorship Program is one of six federal TRIO Programs offered by the U.S. Department of Education to motivate and support high achieving undergraduate students from disadvantaged backgrounds (U.S. Department of Education, 2002, 2008). It is designed to prepare college students from at-risk backgrounds for doctoral studies through mentorship and involvement in research and other scholarly activities. In order to be eligible for the program, students must be from one or more underrepresented group in the STEM disciplines including female, ethnic minority, first generation, or low-income family status. Additionally, students in the Program are required to have a 3.00 GPA or higher, or show the potential for achieving that criterion by graduation.

The McNair Program increases the motivation and opportunity of disadvantaged students to pursue graduate studies (Ishiyama & Hopkins, 2003; Lam, Ugweje, Mawasha, & Srivatsan, 2003). However, despite indicators of general success, it is unclear if the McNair Program specifically improves students' performance and self-perceived ability in STEM fields. The following study examines performance and self-perceptions of ability of McNair students by asking several research questions.

Hypotheses

The first research question is, do differences exist in self-perceptions of ability or performance between high-achieving, underrepresented female and male students enrolled in the McNair Program? It is hypothesized that differences exist in self-perceptions of ability, in the direction that women will have less confidence in their ability as compared to men (Betz, 2005; Chrisler, 1998; Dweck, 2007; Lupart, et al.,

2004). However, based on past literature, it is hypothesized that differences are not evident in academic performance between female and male students. For example, in a review of multiple studies, Spelke and Grace (2007) concluded that females and males “are equally systematic in their thinking, they are equally endowed with the core cognitive abilities that support mathematical learning and reasoning, and they master new mathematical material equally well, both on average and in highly selected samples.”

Next, this study asked, do self-perceptions of ability and performance change from Time 1 to Time 2 for high-achieving, underrepresented students? Confusion is a common experience of students learning new material in STEM education because it often involves completely new skills and concepts (Dweck, 2007). This feeling of confusion can often lower self-confidence and increase defeating self-perceptions for underrepresented students (Dweck; Nauta, Epperson, & Waggoner, 1999). Though the challenges of STEM education often discourage underrepresented students in STEM, the students in the current study were enrolled in a program specifically aimed at fostering support for their educational endeavors. The McNair Program has demonstrated positive overall success for supporting disadvantaged students (Ishiyama & Hopkins, 2003; Lam, et al., 2003). Thus, it is hypothesized that a change will occur such that disadvantaged students’ academic self-perceptions of ability will be enhanced and academic performance maintained from Time 1 to Time 2.

Lastly, do differences exist in self-perceptions of ability or performance between underrepresented students with single versus multiple risk factors of first-generation or low-income status and ethnic minority status? It is hypothesized that differences will be found in self-perceptions of ability and performance between students with single versus

multiple risk factors such that students with multiple risk factors will have lower self-perceptions of ability and performance. This is based on the stereotype threat research that indicates negative stereotypes of ethnic minority and low-socioeconomic students affect both performance and confidence (Osborne, 2001; Spencer & Castano, 2007; Steele, 1992; 1997; Steele et al., 2002).

Method

Procedure

Two recruitment strategies were employed. The primary strategy involved recruiting participants from the main campus of a large Western university, through mailings targeted at juniors or seniors who met at least one of the selection criteria as an underrepresented student in STEM. In the McNair Program, underrepresented students were defined as those who are female, ethnic minority, first generation, or have low family income and are majoring in a STEM field. A secondary recruitment strategy involved recruiting participants for the summer research program from nearby colleges and universities in two Western states. Summer participants were in residence at the main campus for 3 months, and then continued to be involved with the McNair Program by means of mentoring and research activities at both their home campus and at the host campus. All McNair participants were matched with a mentor in their field of interest, supervised in research projects, and participated in seminars regarding topics such as graduate admissions process, preparation for the Graduate Record Examination, graduate school culture, funding, and so forth.

For federal reporting and program purposes, McNair students were administered multiple questionnaires at the time of entry to the program, during the program, and at graduation of the program. The current study examined a subset of the information that was collected. Specifically, the measures of academic performance were the Watson-Glaser Critical Thinking Appraisal (WGCTA; Watson & Glaser, 1994), the practice tests for the Graduate Record Examination, and cumulative grade point average at the time of graduation. Self-perceptions of ability were measured using two indicators including the What I Am Like (WIAL; Harter, 1992) scale and a self-reported battery of relevant academic skills.

Sample

Participants in this study were STEM students enrolled in the McNair Program between 1995 and 2006 at a large Mountain West university ($N = 177$). Students met criteria for the McNair program if they were female (61% of the sample), ethnic minority (40% Latino, 8% African American, 13% other minority), first-generation (80%), or had low-income status (80%). On average, participants met three of these four criteria. The participants' modal age was 20 years (range = 15 to 53).

Measures

Critical thinking. The Watson-Glaser Critical Thinking Appraisal (WGCTA; Watson & Glaser, 1994) was administered to students at Time 1 ($n = 122$) and at Time 2 ($n = 34$). It is a widely-used measure that consists of various scenarios that measure five aspects of critical thinking: inferences, recognition of assumptions, deduction, interpretation, and evaluation of arguments. The 40 items on Form S, which yield a total score (range = 0-40), are responded to with a two-alternative, multiple choice format that

may inflate scores (Wagner & Harvey, 2006). WGCTA scores are predictive of academic criteria such as GPA and achievement or cognitive test scores (e.g., McCammon, Golden, & Wuensch, 1988), and it has adequate alpha (.94 in this sample) and retest reliabilities (for a review, see Geisinger, 1994). In this sample, the WGCTA was correlated with undergraduate GPA $r = .25$ ($p = .01$) and with the practice GRE Verbal ($r = .51$) and Analytical ($r = .53$) scores.

Academic skills. Practice tests for the Graduate Record Examination (GRE) were administered from one of the published test preparation books. Although many participants also completed the actual GRE, few ($n = 27$) provided the program with their scores at the long-term follow-up. Given that the practice test scores (Verbal, Quantitative, Analytical) were strongly correlated with the actual scores, $r = .51$ to $.76$, and that more complete data were available for the practice test ($n = 96$), the latter was used in the analyses. Cumulative grade point average (GPA) upon graduation was taken from students' transcripts ($n = 131$).

Academic self-perceptions. The What I Am Like (WIAL; Harter, 1992) scale is a measure of self-concept for adolescents and young adults that was given at Time 1 ($n = 137$) and Time 2 ($n = 46$) in the current study. The WIAL uses a forced-alternative item format, in which students select one of two statements that best describes their beliefs about themselves. Once the most descriptive statement has been chosen, the student decides whether it is "*sort of true of me*" or "*really true of me*." Scores can range from 1 to 4, with higher scores reflecting stronger belief that the person possesses that skill or trait. In addition to the Global Self-Worth scale, five content scales were administered: Friends (including loneliness and ability to make new friends), Acceptance (including

self-perceived social skills), Creativity, Scholastic (i.e., mastery of coursework), and Intelligence. The Scholastic and Intelligence scales were correlated ($r = .73$) in this sample and were thus combined into a single score, Academic Skills. Harter (1992) has documented the reliability of this measure (alphas $> .85$) and developmental self-concept changes that are consistent with other normative changes in cognitive and social functioning.

Self-perceived academic strengths and weaknesses. At entry into the program, a subset of McNair students completed a self-assessment of their academic preparation in terms of academic skills in science and math ($n = 69$) as well as in terms of specific study skills (including organization and time management, note taking, test anxiety, and test taking) ($n = 53$). Students rated themselves as *weak* (1), *average* (2), or *strong* (3). In addition, they ($n = 52$) completed three open-ended questions regarding weaknesses and concerns they had about preparing for graduate school, obstacles to their future success in graduate school, and skills and characteristics that they thought would help them to succeed in graduate school.

Analyses

Two-tailed t -tests were used to examine possible differences for females versus males on measures of academic performance as indicated by scores of critical thinking, GRE practice scores, and in cumulative GPA at graduation. Because of past literature indicating that women have lower self-confidence than men, one-tailed t -tests were used to examine differences between females and males on measures of self-perceived academic skills, intelligence, creativity, social domains, global self worth, test-taking abilities, test anxiety, and academic preparedness. A repeated measures MANOVA was

calculated with sex of participant as the between subjects effect for Academic Skills and Creativity. Finally, a one way ANOVA with Tukey post hoc tests was used to examine whether academic self-perceptions and academic performance may differ by family socioeconomic status (SES) and minority status by using three groups of students: (1) ethnic minority students without family SES risk factors ($n = 25$), (2) ethnic minority students with family SES risk factors ($n = 56$), and (3) White students with family SES risk factors ($n = 49$).

For the self-reported academic strengths and weaknesses data, content analysis (Weber, 1990) was used. Two coders independently identified themes related to weaknesses and to strengths in 20 of the responses and resolved coding discrepancies by consensus. These thematic codes were then used for the remaining responses, with 15 of the responses coded by a different pair of raters in order to determine interrater reliability ($kappa = .86$).

There was a high percentage (approximately 62% for Time 1 and 81% for Time 2) of missing data in the sample. Hence, preliminary analyses were conducted for missing data patterns using Pearson chi square analysis. These analyses revealed a non-random pattern of missing data related to the sex of the participant ($\chi^2 = 5.90, p < .015$) whereby men had significantly more missing data than women. Additionally, data were collected from only one participant who did not meet criteria for first-generation status at Time 2. These non-random patterns are addressed as a limitation of the current study.

Results

Two tailed t -tests were computed to determine if females and males differed on measures of academic performance. Female and male students demonstrated similar

academic performance as indicated by scores that did not differ significantly on critical thinking, GRE practice scores, and cumulative GPA at graduation (see Table 1).

Based on past literature suggesting that females have lower self-perceptions than males regarding their skills and abilities in science and engineering, one-tailed *t*-tests were performed. Prior to the Bonferroni correction for multiple *t*-tests, results indicated that female students were significantly more likely to have lower self-perceptions on Academic Skills, Test-Taking Skill, Test Anxiety, and Creativity than their male counterparts (see Table 1). However, with the correction for multiple tests, only the female-male difference in self-perceived creativity levels remained significant. Females and males exhibited similar self-perceptions in Social Domains (comprised of Acceptance and Friends) as well as on measures of Global Self-Worth and Academic Preparedness.

Table 1
Mean Differences in Academic Performance and Self-Perceptions by Sex of Participant

	Females	Males	<i>t</i> (134)
Academic Assessments			
Critical Thinking (WGCT)	34.13 (13.31)	31.61 (8.55)	n.s.
GRE – Verbal	451 (79)	441 (79)	n.s.
GRE – Quantitative	521 (107)	538 (117)	n.s.
GRE – Analytical	462 (127)	459 (167)	n.s.
Cumulative GPA	3.22 (.50)	3.30 (.47)	n.s.
Self-Perceptions			
WIAL: Academic Skills	3.11 (.59)	3.35 (.52)	-2.47**
WIAL: Acceptance	3.03 (.70)	2.97 (.67)	n.s.
WIAL: Friends	3.24.73	3.14 (.81)	n.s.
WIAL: Creativity	2.85.59	3.19 (.64)	-3.11***
WIAL: Global Self Worth	3.31.52	3.30 (.52)	n.s.
Academic Skills: Science	2.69 (.47)	2.74 (.45)	n.s.
Academic Skills: Math	2.24 (.63)	2.21 (.71)	n.s.
Study Skills: Organization	2.62 (.59)	2.38 (.51)	n.s.
Study Skills: Note Taking	2.54 (.60)	2.31 (.63)	n.s.
Study Skills: Time Management	2.38 (.67)	2.54 (.66)	n.s.
Study Skills: Test Anxiety	2.10 (.64)	2.46 (.52)	-1.83**

Study Skills: Test Taking

2.18 (.60)

2.54 (.66)

-1.82**

Note: WGCT = Watson Glazer Critical Thinking scale; GRE = Graduate Record Examination practice test; WIAL = What I Am Like scale

* $p < .05$ ** $p < .01$ *** $p < .001$

The obstacles and strengths female and male students identified for their pursuit of graduate education were examined. Female and male students shared similar concerns related to pursuing graduate education, most frequently identifying finances (56%) and competitive admissions (29%) as obstacles to graduate school. Two obstacles, academic skills and time/stress management, showed a trend toward female-male differences ($\chi^2 = 3.26, p < .07$; $\chi^2 = 3.11, p < .08$) whereby women more frequently identified academic skills, 33% vs. 8%, as an obstacle for pursuing graduate school than men. However, more men identified time/stress management, 38% vs. 15%, as an obstacle to graduate school relative to women. Both female and male students were equally likely to identify determination and hard work (82%) as a personal strength related to pursuing graduate school in the future.

A one-way ANOVA with Tukey post hoc tests was used to examine how self-perceived ability and academic performance may differ by family socioeconomic status (SES) and ethnic minority status (see Table 2). Family SES was comprised of two variables that were related to one another, first-generation status and low family income status ($\chi^2 = 48.46, p < .00$). Ethnic minority status was also found to be somewhat related to both family SES factors (first generation: $\Phi = .41, p < .00$; low family income: $\Phi = .47, p < .00$). Because all three variables could not be considered simultaneously, three groups of students were created: (1) ethnic minority students without family SES risk

factors ($n = 17$), (2) ethnic minority students with family SES risk factors ($n = 63$), and (3) White students with family SES risk factors ($n = 56$).

All three groups were found to have similar self-perceived abilities on Academic Skills, Social Domains, Creativity, Global Self-Worth, Science and Math Skills, and Study Skills. The group that was doubly at-risk – ethnic minority and low SES – perceived themselves to be less academically competent in their test-taking skills whereas White, low-income students were most confident (see Table 2). Differences in performance were also found on the WGCT assessment with ethnic minority, high-SES students performing highest followed by White, low-SES and ethnic minority, low-SES students respectively (see Table 2). On the GRE practice tests, results indicated that White, low-SES students received higher scores than either ethnic minority group for the GRE Verbal section. On the GRE Analytic section, White, low-SES students showed higher scores relative only to the group that was doubly at risk – ethnic minority and low-SES status. For the GRE Quantitative test, scores showed a trend toward significant differences ($p = .06$) with White, low-SES students having higher scores than ethnic minority, low-SES students.

Table 2
Mean (*SD*) Differences in Self-Perceptions and Performance by Family SES and Ethnic Minority Status

	Family SES and Ethnic Minority			
	Min/High SES	Min/Low SES	White/Low SES	
Academic Assessments				$F(2,118)$
Critical Thinking (WGCT)	44.55 _a (20.67)	31.40 _b (11.60)	32.72 _c (7.81)	6.34**
GRE – Verbal	395 _a (79)	432 _a (82)	473 _b (66)	4.78*
GRE – Quantitative	507 (132)	505 _a (112)	559 _b (102)	n.s.
GRE – Analytical	465 (119)	417 _a (141)	513 _b (138)	5.36**
Cumulative GPA	3.28 (.38)	3.18 (.50)	3.33 (.49)	$F(2,128)$ n.s.

Self-Perceptions				<i>F</i> (2,133)
WIAL: Academic Skills	3.27 (.54)	3.09 (.58)	3.31 (.58)	n.s.
WIAL: Acceptance	3.06 (.87)	3.08 (.74)	2.92 (.58)	n.s.
WIAL: Friends	3.21 (.80)	3.23 (.77)	3.18 (.75)	n.s.
WIAL Creativity	3.13 (.59)	2.96 (.66)	2.98 (.63)	n.s.
WIAL: Global Self Worth	3.39 (.47)	3.28 (.54)	3.32 (.51)	n.s.
				<i>F</i> (2,65)
Academic Skills: Science	2.71 (.49)	2.72 (.46)	2.69 (.47)	n.s.
Academic Skills: Math	2.00 (.58)	2.25 (.62)	2.28 (.70)	n.s.
				<i>F</i> (2,49)
Study Skills: Organization	2.83 (.41)	2.42 (.65)	2.64 (.49)	n.s.
Study Skills: Note Taking	2.83 (.41)	2.29 (.69)	2.59 (.50)	n.s.
Study Skills: Time Management	2.50 (.84)	2.25 (.68)	2.59 (.59)	n.s.
Study Skills: Test Anxiety	2.00 (.63)	2.04 (.62)	2.41 (.59)	n.s.
Study Skills: Test Taking	2.33 (.82)	2.04 _a (.62)	2.50 _b (.51)	3.36*

Note: WGCT = Watson Glazer Critical Thinking scale; GRE = Graduate Record Examination practice test; WIAL = What I Am Like scale

* $p < .05$ ** $p < .01$ *** $p < .001$

In order to examine if academic self-perceptions and performance changed from Time 1 to Time 2 for students in the McNair Program, a repeated measures ANOVA was used with sex of participant as the between subjects effect. A significant main effect for time was found, $F(1,43) = 10.47, p = .02$. This effect was qualified by a time by sex of participant interaction effect, $F(1,43) = 5.81, p = .002$, for self-perceived academic skills. Women's perception of academic skills increased by .60 *SDs* by graduation while their male counterparts remained stable. Self-perceived creativity also improved over the course of the program, $F(1,43) = 14.85, p = .0001$, as did Global-Self worth, $F(1,43) = 5.92, p = .019$, but the rate of change was similar for both female and male participants such that the interaction term was not significant. None of the other outcomes changed with time.

Discussion

Based on the research hypotheses, several prominent findings emerged from this study and are reviewed below. Women did not significantly differ from men with regard to cumulative GPA, practice GRE scores, and critical thinking. However, women were

significantly more likely to have lower self-perceptions of academic skills and creativity than men. Women's academic self-perceptions scores increased significantly from admission to graduation in the McNair Program, while men's scores remained stable. Low-income, ethnic minority students had lower GRE scores and more negative self-perceptions of their test-taking skills than low income, White students. Both low-income ethnic minority and White students had lower critical thinking scores than high-income ethnic minority students.

Similar Ability, Less Confidence for Women in STEM

The first hypothesis, that female McNair students would show less confidence in their academic abilities as compared to males, was supported. Female students reported lower confidence at Time 1 compared to their male counterparts for creativity, academic skills, test-taking skills, and test anxiety levels. Additionally, results showed that the female students were less confident than the males despite equal levels of academic performance. A higher percentage of McNair women than men (33% vs 8%) identified academic skills as a prominent concern related to the pursuit of graduate school. These findings corroborate prior research indicating women have lower confidence and more negative self-perceptions of ability (Betz, 2005; Chrisler, 1998; Dweck, 2007; Lupart, et al., 2004) despite having similar ability (Spelke, 2005; Spelke & Grace, 2007). These findings also extend prior studies by indicating that female versus male differences in academic self-perceptions, despite similar academic performance, are also found for disadvantaged students who are ethnic minority, first generation, or have low family income status.

McNair Students Improve Over Time

The second hypothesis, which asserted that a change would occur over time such that academic self-perceptions would improve and academic performance would be maintained, was supported. Self-perceptions of academic skills improved for female McNair students from the time of enrollment of the Program to be on par with their male counterparts by the time of graduation. Although male McNair students' self-perceptions did not increase from Time 1 to Time 2, they initially reported higher self-perceptions at Time 1 and were able to maintain their confidence over the duration of the McNair program. These findings contradict prior literature that indicates the challenges of learning STEM material deter underrepresented students in STEM over time and increase defeating self-perceptions (Dweck, 2007; Nauta et al., 1999). These findings, however, could be related to the prior literature that demonstrates positive outcomes of the McNair Program for assisting underrepresented students in their educational endeavors (Ishiyama & Hopkins, 2003; Lam, et al., 2003).

Multiple Risk Factors Increase Test Difficulties

The third hypothesis was that differences would exist between students with single versus multiple risk factors (e.g., low socioeconomic status and/or being ethnic minority in STEM) on academic self-perceptions and performance such that students with multiple risk factors would have lower confidence and performance. This hypothesis was supported by results that indicate that students with multiple minority statuses showed significantly less confidence in their test taking abilities and lower performance than students with a single minority status. These findings are consistent with studies that indicate negative stereotypes of ethnic minority and low-socioeconomic students undermine academic performance and confidence (Osborne, 2001; Spencer & Castano,

2007; Steele, 1992; 1997; Steele et al., 2002). Critical thinking performance scores were highest, however, for minority, high-SES students, followed by White, low-SES and minority, low-SES students. Several interpretations can be offered regarding this finding. Rearing practices in the family of origin could be different across SES groups due to access to educationally-related resources that foster critical thinking skills. However, another interpretation is that the WGCTA questions may not reflect culturally familiar critical thinking constructs for low-SES students. The WGCTA manual states that the measure was normed on applicants for a variety of management positions, applicants for sales and marketing positions, bank employees and managers, clergy, railroad dispatchers, nurses, and police officers. Combined data were reported for White and ethnic minority individuals but SES is not reported. Presumably, low-SES individuals were not included in the populations selected for norming the instrument.

Limitations and Future Research

This study has several limitations. Although comparing male and female McNair participants permits some conclusions about how a mentoring program's effects might be moderated by sex, without a comparison group of eligible students who were not enrolled in the McNair Program, the study is unable to conclude that the program was responsible for such changes. It is recommended for future research to expand on the current research by using male and female underrepresented and majority students in science and engineering as a control sample for comparison.

A second limitation of this study is the high percentage of missing data, ranging from 61% to 81%, for the majority of the measures. The two measures that had the highest response rate, the WIAL and the WGCTA scales at Time 1, have a missing data

rate of 23% and 31% respectively. Analyses indicated a pattern of missing data by sex at Time 1 and by first-generation status at Time 2. Because of these non-random patterns, the findings of the current study are suggestive and require replication.

A third limitation is related to the comprehensive nature of the McNair Program. A major component of the McNair Program was the mentorship component. However, the McNair Program is a comprehensive intervention that also provides numerous other services to its students including workshops, research activities, and trainings. While this is a positive quality of the program as an intervention, for future research, it would be helpful to conduct pre- and post-assessment of each separate component in the McNair Program in order to determine specifically which one or combination of components in the McNair Program are most effective for addressing the specific and unique needs of women and students with multiple risk factors.

Implications

Female students' lower academic confidence may act as a barrier for women persisting in STEM fields, even if the women are successful and high-achieving (Goodman et al., 2002; Nauta et al., 1999). Therefore, interventions that focus on addressing women's academic confidence in STEM, not only their academic skills, are critical to meeting their unique educational needs and encouraging their persistence and success in STEM.

One possible solution suggested by this and other studies is the McNair Program, which could provide critical support to disadvantaged students who are underrepresented in STEM education and careers (Ishiyama & Hopkins, 2003; Lam et al., 2003). Women's enhanced academic self-perceptions at Time 2 compared to Time 1 in the McNair

program may be related to the past literature that has found mentoring to be positively associated with academic success of students (Campbell & Campbell, 1997; Ragins & Cotton, 1999). Men can also benefit from mentorship (Ragins & Cotton). In the current study, men's stable high self-perceptions over time may suggest a positive association of mentorship for maintaining men's sense of confidence despite challenges in their STEM education. The positive association between mentorship relationships and educational persistence and success, however, is especially important for women who more often experience isolation in male-dominant disciplines such as STEM. For example, one study found that female college students identified mentors as having a positive influence on their decision to pursue science education (Downing, Crosby & Blake-Beard, 2005). Additionally, in a 2002 report of women in engineering, participation of female engineering students in support activities such as mentorship was associated with positive changes in self-confidence, persistence in engineering, and enhanced perceptions of classroom and department environment in engineering (Goodman et al.). Therefore, mentorship programs, such as the McNair Program, may be a useful intervention for improving women's STEM related self-perceptions and confidence.

A comprehensive mentorship program, such as the McNair Program, may be one possible solution for supporting student with multiple risk factors such as ethnic minority status and low socioeconomic backgrounds. The current study found that students with multiple risk factors may have an even greater chance of being deterred in STEM than students with single risk factors. Thus, students in STEM with multiple risk factors may need broad interventions that focus on fostering confidence, managing stress, and developing academic performance. Numerous studies indicate that factors such as

stereotype threat can undermine the success of ethnic minorities and students from low socioeconomic backgrounds by weakening self-confidence as well as negatively influencing academic performance (Osborne, 2001; Spencer & Castano, 2007; Steele, 1992, 1997; Steele et al., 2002). However, the presence of mentors and positive role models has been found to reduce the negative influence of challenges like stereotype threat (Marx & Roman, 2002; McIntyre, Paulson, & Lord, 2003). In sum, the McNair Program and others like it may offer critical and needed support for talented, underrepresented students in the United States. Supporting the needs of these students is important and could ultimately lead to gains in social capital for society in general and the STEM disciplines in particular.

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STUDY 2

WOMEN IN ENGINEERING, PHYSICAL, AND LIFE SCIENCES EXPLAIN THEIR EDUCATIONAL CHOICES

This study focused on the experiences of high-achieving, female undergraduates from disadvantaged backgrounds who are majoring in engineering, physical, or life science. Interviews about educational choices and career aspirations were collected in written form upon admission to (Time 1) and graduation from (Time2) the McNair Mentorship Program. Students' timing of educational and career decisions, motivations, parental expectations and involvement in educational and career planning, career exploration, and career aspirations were qualitatively analyzed longitudinally and across disciplines. Insights about educational choices and career aspirations are shared and recommendations are given for future research to improve career counseling to support disadvantaged women in STEM fields.

In 2004, the National Science Foundation reported that occupations requiring science and engineering training were growing each year while at the same time the numbers of U.S. citizens who were training to become scientists and engineers was declining. Projected shortages in the U.S. science, technology, engineering, and mathematics (STEM) labor force have contributed to a growing interest in how to encourage students to choose educational and career paths in these fields (NSF, 2009). In particular, the dearth of U.S. women and some ethnic minorities in STEM education and careers stands out as a conspicuous and untapped resource in the U.S. (Babco & Bell, 2004; Baum, 1990; Ceci, Williams, & Barnett, 2009; Dweck, 2007; Knapp, et al., 2005; Lupart, Cannon, & Telfer, 2004; NSF, 1999; 2009; Wentling & Camacho, 2008; Xie & Shauman, 2003). Efforts at universities and in research studies have focused on attracting and supporting the interest of U.S. women and ethnic minorities in STEM (NSF, 2009) because they represent a promising solution to concerns that the U.S. will be unable to meet the demands of technological advances and continue being competitive in a global market (Atkinson, 1990).

Unfortunately, there continues to be low representation in the U.S. of women in science and engineering education, and women drop out of science and engineering majors at a higher rate than that of their male peers. Many barriers have been identified in the literature that may be preventing women from choosing or staying in STEM education. For example, the perception of STEM as a masculine domain, a discouraging academic climate, a lack of support systems, loss of academic self-confidence in a competitive climate, and becoming bored or disappointed with the curriculum have all been related to women not choosing to pursue or dropping out of STEM educational programs (Amenkhienan & Kogan, 2004; Goodman, 2002; Martin, & Wardle, 1999; Rocheleau, 2004; Vogt, Hocesvar, & Hagedorn, 2007). Despite these barriers, there are a select few women who choose and persist in STEM education and successfully graduate with STEM degrees. Studying and understanding the educational choices and experiences of this population of women can provide the opportunity to gain valuable insight into how to facilitate the educational journey of women in STEM. Research on the experiences of female scientists and engineers is needed because it is likely to suggest how to improve attracting further female participants (Moskal, 2000; Wentling & Camacho, 2008). In particular, it is important to consider what aspirations successful women in STEM have as well as when, why, and how educational choices were made to pursue STEM.

Women's Choice to Pursue Education in STEM

The undergraduate degree has particular importance for STEM careers because attainment of the undergraduate degree acts as one gatekeeper to industry in applied settings as well as to pursuing higher education in STEM (Xie & Shauman, 2003). The

undergraduate degree is also considered the necessary minimum requirement for many science and engineering occupations (Betz, 2005) and is often the minimum criterion for inclusion in the scientist/engineer professional community (Xie & Shauman). Several factors are important to consider when understanding women's choice to pursue an undergraduate degree in STEM including timing of decisions, career exploration experiences, parental expectations and involvement, motivations, career goals, and goal commitment.

For STEM fields specifically, the timing of education and career decisions is key to the successful entrance and persistence in undergraduate STEM programs. This is because science- and engineering-focused education at the university level often requires four years of mathematics instruction prior to entering college (Betz, 2005). Thus, making the decision to pursue an undergraduate degree in STEM earlier allows students to more adequately prepare for meeting the prerequisites to majoring in science or engineering once a student enters into a university. This can be a problem, however, for girls and young women who are entering male-dominated careers such as science and engineering. There are concerns that without adequate career exploration opportunities girls and women can experience "an early foreclosure of their career options, which restricts their horizons to female-dominated careers" (Whitmarsh, Brown, Cooper, Hawkins-Rodgers, & Wentworth, 2002, p. 234). In a 2002 study, women in non-female-dominated careers reported making education and career decisions later than women in female-dominated careers (Whitmarsh et al.). Specifically, women in non-female-dominated careers took more time to explore various career options (Whitmarsh et al.). They also reported that they gained new career insights later when they were able to

explore and interact with college and university classmates, professors, mentors, and bosses (Whitmarsh et al.). Thus, the timing of their decisions and the career exploration experiences that occurred for women later may be important in shaping women's educational choice to pursue undergraduate STEM degrees.

Parental expectations and attitudes may also influence women's educational STEM choices and aspirations. For example, female students' perceived ability and their plans to take math courses are substantially influenced by parental expectations and attitudes related to math and science (Bleeker & Jacobs, 2004; Eccles & Jacobs, 1986). Additionally, in a longitudinal study of over 800 elementary children followed for 13 years, parental attitudes were important determinants of children's math performance and their later interests (Davis-Kean et al., 2007). The study also found that girls' interest in math decreased as their fathers' gender stereotypes increased (Davis-Kean et al.). Parental encouragement in math and science is also associated with college women's grades in math and science (Ferry, Fouad, & Smith, 2000). Thus, it is also important to take into account parental expectations and attitudes when exploring educational choices of women in STEM fields.

To understand their educational choices, it is also important to identify motivations women have for choosing to pursue STEM focused education. Evidence suggests that what attracts women to pursue STEM is distinct to women versus men. For example, men report future earning potential as a prominent motivation for choosing to pursue physical science and engineering (LeBold et al., 1983; Wender, 2004). However, women report flexible work hours, satisfying work, having variety in their work assignments, wanting to be challenged, enjoying problem solving, and wanting

independence as prominent motivations (LeBold et al). More recently, Rutherford (2007) found that female engineering students wanted to pursue engineering to help others, work with interesting people, and pursue altruistic goals of changing the world but male engineering students reported an interest in designing and building things, financially supporting a family, and using tools, machines, and “neat” equipment. Eccles (2007, p. 208) also noted that women typically hold more relationally and humanitarian focused motivations when choosing careers and states “if we want to increase the number of females who consider entering physical science and engineering careers, it will be important to help females see that these careers provide opportunities to fulfill their humanistic and people-oriented values and life goals.”

The future aspirations and level of career goal commitment women have is often unique from men and is related to women’s choice to pursue and persist in STEM education. On average, women who select science and engineering focused education are less committed to science and engineering careers and are more likely to be conflicted about career versus family compared to their male peers (Leslie, McClure, & Oaxaca, 1998). Research shows that more women than men forgo career goals in order to prioritize family goals and responsibilities (Ceci, et al., 2009). Additionally, more women aspire to work part time in their careers. Lubinski and his colleagues (2001) found that 31% of female STEM graduate students versus 9% of male STEM graduate students aspired to work part-time for a limited time and 19% of females versus 9% of males aspired to only work part-time in their careers. In short, the choices women make about pursuing STEM education are linked to what future aspirations they have and to the level of their commitment to career goals. For STEM education to be appealing to women, it

may be important for women to believe that they can have STEM careers that accommodate their goals for part-time work and prioritizing family goals.

In sum, to understand women's educational choices and aspirations in STEM, it is important to consider timing of decisions and career exploration experiences, parental expectations and attitudes, motivations, and aspirations and career goal commitment.

Purpose and Research Questions

The purpose of the current study is to further understand the educational choices, aspirations, and experiences of high-achieving undergraduate female students from two groups – those that are majoring in a male-dominated science field (physical science and engineering) and those that are majoring in a science field (life science) where women are equally represented (Eccles, 2007). Of particular importance, the women in this study are also ethnic minority, from low-income families, or are the first-generation of their families to attain a college degree. This study aims to hear from the voice of the women themselves who, despite multiple obstacles, are choosing and persisting in male-dominated STEM fields successfully. Although previous research has been conducted on the underrepresentation of women in STEM, there is a lack of understanding about the experiences of ethnic minority, low income, or first-generation women in STEM. Acknowledging and exploring the experiences of this unique and highly underrepresented population in STEM education can help inform educators, career counselors and policy makers alike of new insight for facilitating the education of women who face multiple barriers to education in general and STEM education in particular.

Interview surveys were analyzed for this study in order to address several research questions. First, when are women choosing to pursue science and engineering focused

education? What role, if any, do parents have in the educational and career decisions of women who choose science and engineering focused education? Do women who choose science and engineering focused education explore other career options? What future aspirations do women who choose science and engineering focused education hold and how committed are they to career goals? And lastly, do differences exist in the career decision making process for women in male-dominated fields such as physical science and engineering compared to women in life science?

Method

Participants

Recruitment. Participants were female undergraduate students enrolled in the McNair program at a Mountain West public university. The McNair program is one of six federal TRIO Programs offered by the U.S. Department of Education to help underrepresented students from disadvantaged backgrounds to prepare for doctoral studies through involvement in research and other scholarly activities (U.S. Department of Education, 2002). To qualify for the McNair program, students must be from one or more underrepresented group in the science, technology, engineering, and mathematical (STEM) disciplines, including being female, ethnic minority, first generation, or low-income family status. Additionally, students also had to demonstrate strong academic potential by having a 3.00 GPA or higher, or by showing the potential for achieving that criterion by graduation (U.S. Department of Education, 2002).

Recruitment for the McNair program was done primarily from the main campus of a large Mountain West public university, through mailings targeted at juniors or seniors who met at least one of the selection criteria as an underrepresented student.

Additional students were recruited for the summer research program from other nearby colleges and universities in two Western states. On average, 12 participants per year were enrolled in the 9-month academic year program, typically for two years, and an additional 4 to 6 participants from other universities enrolled in the summer-only program. As part of the program, participants were matched with a mentor in their field of interest and participated in seminars regarding topics such as graduate admissions process, preparation for the Graduate Record Examination, graduate school culture, and funding.

Sample. The sample for this study consisted of female undergraduate students ($N = 75$) who were majoring in engineering, physical science, or life science and enrolled in the McNair Program between 1996 and 2006. All eligible students participated in this study but, due to incomplete Time 2 data, 53 could not be included in analyses. Of the 22 participants in the final sample with complete Time 1 and Time 2 data, there were 11 women majoring in physical science, 8 in life science, and 3 in engineering. Of the participants in the final sample, 46% identified as Latina, 36% as White, 9% as American Indian or Alaskan Native, and 5% as Asian or multiracial. Participants' average age was 24 years (range = 19 to 42). Additionally, there were 73% who met criteria for low-income status and 82% for first-generation status.

Data Collection

To chart career identity development and educational experiences of the students, all students in the McNair program were administered the vocational section of the Identity Status Interview in written format (Marcia, 1966; 1980). The university's institutional research board approved all data collection procedures. Individual student responses were collected at two times – approximately upon entrance into the McNair

Program (Time 1) and prior to graduation (Time 2). Group data collection was most common. Of the interview reports that were dated ($n = 13$), the average length of time between Time 1 data and Time 2 data was 28 weeks, with a minimum of 8 weeks and a maximum of 56 weeks.

Measure. Participants' written responses to eight questions from The Identity Status Interview (see Appendix A) were analyzed. Questions focused on identifying timing of important decisions ("*When did you decide on your major? On the career you intend to pursue?*"), previous career exploration ("*Did you ever consider other majors and/or careers? Please describe (a) which one(s) and (b) how much you pursued these other goals; read about them, talked to people about them, actually took courses in the area.*"), parental expectations and involvement in career planning ("*Most parents have plans for their children, things they'd like them to go into or do. Did your parents have any plans like that for you? Briefly describe.*" and "*How do your folks feel about your plans now?*"), motivations for pursuing science or engineering focused education ("*What is most attractive about your current major/career?*"), commitment to career goals ("*How willing do you think you'd be to change your plans if something better came along?*"), and identifying career goals and future aspirations ("*What do you plan to do with your major, in the future?*" and "*What might be a better option in your terms?*").

Data Transcription

Original handwritten responses to the Identity Status Interview reports were transcribed into electronic files. Several steps were taken in order to ensure and verify the accuracy of the transcription. First, an audit trail was kept throughout the transcription process that documented issues and outlined the steps taken to resolve them. Most often,

issues in transcription were misspellings, words being cut off from poor copying, illegible writing, or the use of abbreviations. For each issue identified in an interview report, a reviewer was consulted and a consensus was reached regarding appropriate resolution. The majority of issues were easily resolved by referring to the original interviews or by using the context of the interview to determine a questionable word. Interviews that were not easily deciphered were brought to weekly research team meetings where they were discussed and resolved by the team. Once transcribed, interview files from Time 1 and Time 2 were imported into the qualitative data analysis program NVivo where they were coded together. NVivo was used to organize the coding and data analyses as described below.

Ethnographic Content Analysis

Ethnographic content analysis (ECA) was used for analysis of the interview reports (Altheide, Coyle, DeVriese, & Schneider, 2008). ECA is a qualitative strategy that focuses on the discovery of meaning of a phenomenon, in this case the educational choices and experiences of women in science and engineering education (Altheide, 1987; Altheide, et al.; Fetterman, 1989). ECA is an interpretative strategy that highlights the emergence of themes from the data itself (Merriam et al., 2002). ECA emphasizes “discovery and description, including searching for contexts, underlying meanings, patterns, and processes, rather than on mere quantity or numerical relationships between two or more variables” (Altheide, et al.). ECA was chosen for the current study because it is both rigorous and flexible enough to consider data that may be missed using other types of analysis. ECA focuses on thematic trends in communication patterns (Altheide, et al.; Krippendorff, 2004). Because of this its focus, ECA purposefully aims to place the

voice of the participants at the center of the research design. Feminist scholars have highlighted the importance of taking this focus, particularly in research that concerns women, so as to avoid perpetuating oppressive social norms that deny these contributions.

In order to identify emergent themes, several coding steps were taken to describe, document, verify, and understand the meaning of the interview narratives. The open coding phase was the first step in the data analysis. The author examined interview responses to identify single units of information and then attached a coding name to each unit. This open coding phase continued until saturation – the point at which new information no longer provided further knowledge. The use of constant comparison between the interviews and the codes allowed for the addition of codes when indicated by the analysis. Constant comparison refers to the strategy whereby codes are determined by comparing each unit of data to all others, to induce a system of coding. In this process, memos are kept and referred to repeatedly. Constant comparison provides an avenue for the researcher to note ideas and connections between concepts (Pandit, 1996). In this study, multiple rounds of open coding were completed using constant comparison. A total of 581 final open codes were generated to describe each unit of information in all interviews.

The next step in coding, called axial coding, determined conceptual relationships among the codes. For the axial coding phase, the author examined the 581 open codes and arranged them into categories, with broader categories being induced from the more specific open codes. During the axial coding phase, a faculty expert in qualitative research methods and a peer reviewer met with the author for consultation. At

consultation meetings, questions about procedures and issues regarding codes were discussed. After discussions between the primary researcher, faculty expert, and peer reviewer, it was decided that the peer reviewer would examine all levels of axial codes to provide a check. For the peer review session, disagreements in axial codes were identified, discussed, and consensus was reached prior to moving on to the final step in coding. Additionally, once the last round of axial codes was complete, data were separated by major for Time 1 and Time 2 interviews.

The final step in coding was the selective coding phase. In the selective coding phase, the final axial categories were connected within an integrated framework and reported in the results separated by student major and, when relevant, by Time 1 and Time 2. The selective coding phase provides the final thematic structure for this study.

Rigor and Trustworthiness

Rigor and trustworthiness in the qualitative research tradition is comparable to validity and reliability in the quantitative research tradition. The current study followed several protocols to ensure qualitative rigor and trustworthiness based on accepted standards in the field. This includes using reflexivity, consultation, and audit trails.

In line with accepted qualitative practices, reflexivity served as a quality check in the current study. Ethnographic content analysis methods require that a researcher be immersed in the data in order to induce meaning from it. To immerse herself in the data, the author read and reviewed all interviews prior to beginning coding or analysis. However, when a preset coding system is not used, it is also standard practice for the author to reflect on and make explicit her position on the data and to openly address personal positions that may have influenced the interpretations of the data and

conclusions of the study. Throughout the process of coding, the author maintained a reflective journal of notes and memos, which revealed the personal connection the author has as an underrepresented student in a university setting. In order to be explicit about this connection, the author describes the relevant information regarding her background and past experiences prior to reporting the results for this project.

Consultation served as an additional quality check prior to and throughout the duration of the coding phases. Prior to beginning the first coding phase, the author consulted with three advanced doctoral students experienced in qualitative research, a research team experienced in women's issues, two faculty members who study women's career development, and a faculty expert on qualitative methods. Consultations typically consisted of either in-person meetings or phone conversations, and focused on defining project goals, reviewing methods and procedures in qualitative research, and discussing culturally relevant considerations of the project. These initial consultations served to solidify decisions regarding which qualitative method would be most appropriate for the data being analyzed. In addition to consultation, a peer reviewer was also used throughout all of the coding phases in order to provide support and critiques at each stage. According to Creswell (1998), peer review supplies a check on the research process in a way that is similar to interrater reliability in quantitative methods. The peer reviewer in this study was specifically selected due to her familiarity with the data set as well as for her expertise and training in women's career development in sciences and engineering. The author and peer reviewer met at least weekly to collaborate and discuss the data and coding process. Lastly, throughout all phases of coding, the author regularly

communicated with a faculty expert in qualitative methods to discuss and resolve difficulties or questions in the procedures for coding and interpretation of this project.

In keeping with the qualitative research tradition, audit trails were also kept throughout the coding process in the current project. Audit trails served to document the process of coding, decision making, and interpretation. Most notably in this study, they helped the author to keep a record of questions during coding to bring back to consultation meetings with her peer reviewer and the faculty expert in qualitative methods. They helped the author document her decision-making by detailing explicitly how and why analytical decisions were made. Most often audit trails revealed that the author had technical questions for using the computer program NVivo.

Personal positions. In an effort to be explicit about the author's stance, it is important to note that the author of this project holds the perspective that the underrepresentation of women in some sciences and engineering fields is more influenced by contextual factors rather than by biological sex differences in ability. Additionally, because of the focus of the current project and the sample being examined, it is also relevant to inform the reader of the author's background. Throughout childhood, the author lived in a poor, rural community and has had to overcome financial barriers throughout her pursuit of higher education. Part of the author's interest in this study originates from her own personal experiences in higher education as a student coming from impoverished financial circumstances.

Results

The results reported below are organized by participants' type of major; that is physical science and engineering versus life science. Results from women in physical

science and engineering (WIPSE) are reported first followed by those from women in life science (WILS). This section is organized in this manner rather than longitudinally to best highlight themes related to this study's research questions and because of the overlap in responses from interviews at Time 1 and Time 2. However, longitudinal trend trends are also highlighted when relevant.

Women in Physical Science and Engineering

Below are themes that emerged in both the Time 1 and 2 statements from women majoring in physical science and engineering, arranged according to the four main topics addressed in the questions participants responded to in writing. First, findings related to the timing of significant decisions are reviewed followed by parental expectations and influences in women's career planning. Next, themes on motivations for pursuing physical science and engineering education are reported. Finally, the career development experiences of women in physical science and engineering are described including previous career exploration, future career goals and commitment to career goals, and better alternatives or options for the future.

Timing of decisions. For WIPSE, the timing of significant education and career decisions varied greatly from person to person at the time of the first interview. At this point, WIPSE reported making career decisions from early childhood years through college years. For example, one student reported, "I decided on a career as an astronaut in grade five," in contrast to another who stated that "I decided the career I would lead my sophomore/junior year at [this] university."

At Time 2, however, WIPSE remembered making career decisions slightly differently, stating that these decisions were mostly made during the high school years.

For example, students reported, “around ten years ago when I was in high school” and “I knew earlier on in high school.” Only one statement indicated that a career decision was made during the college years. Additionally, the Time 2 narratives indicated more career indecision for WIPSE about their career than at Time 1. For example, one student reported, “I still haven’t exactly decided on the career I plan to pursue.” Across both times, decisions about a specific major were consistently reported to occur during the late high school and college years only.

Parental expectations and career planning involvement. At both Time 1 and 2, questions about parental expectations and involvement garnered lengthy responses from WIPSE. Additionally, responses were consistent from Time 1 to Time 2 with several themes emerging including that parents felt positively about their daughter’s career plans, daughters perceived their parents to be supportive, parents did not have career expectations for their daughters, and parents were unable to relate to their daughter’s career goals.

Regarding career plans, WIPSE strongly believed that parents were happy, proud, and excited. Respondents wrote that parents “are very excited and proud” and “are happy that I have made it this far.” Additionally, WIPSE generally reported feeling supported by their parents as evidenced by statements such as, “They have always supported me on my own decisions” and “They let me decide what career path to pursue and supported all of my decisions and even my indecisiveness.”

WIPSE, however, did not believe that their parents had any career expectations for them. This was evidenced by statements such as, “I made my own plans,” and “My parents didn’t really have solid plans for me.” Although for WIPSE, parents were viewed

as supportive, the participants' comments also revealed a sense of independence and self-reliance from the women regarding educational choices and career decision-making. Participants did indicate that their parents had other types of expectations for them. For example, they wrote that parental expectations were focused more on having financial stability and independence, seeking personal fulfillment, and maintaining moral values. This was evidenced by statements that parents "just [want me to] be decent." Women also reported that "they just wanted me to do something with my life so that I would have a decent income, since they never had much money," "The only 'plans' my parents had for me was that I find a career which fulfills me and one that is economically stable," and "My mother ... always encouraged me to pursue a career, to be self-supportive, and happy."

The WIPSE also reported feeling that their parents did not fully understand their career or educational plans. This barrier between the participants and their parents was described by one student, who wrote, "I think they find it a little confusing. I think they are proud of me, but don't understand why I want to go to graduate school. I don't think they realize that I want to be a scientist not a millionaire." Some respondents believed that they had to work hard to justify educational plans to others as evidenced by statements like, "I worked very hard at laying the foundation, finding the money, and continually explain to friends and family that this is important."

Motivations for choosing physical science or engineering. At Time 1 and Time 2, WIPSE identified a strong focus on the enjoyment of learning and education as motivations for choosing physical science or engineering focused education. Specifically, WIPSE reported appreciating the experience of research and discovery, using their

intellect, being challenged, and knowing multiple sciences. They made statements like, “I’m enjoying the opportunity to educate myself” and “it is challenging and I will feel a real accomplishment upon completion.”

By Time 2, awareness about the job market emerged as a new motivation. Analyses revealed that at this time WIPSE were also motivated by their desire to be competitive in the job market and to be on the cutting edge in their fields. By Time 2, respondents also mentioned being motivated by having the ability to benefit humanity and improve the quality of others’ lives in their careers.

The next section focuses on the career development experiences of WIPSE. Results about career development experiences were subdivided into four subcategories including women’s previous career exploration, future career goals and commitment to career goals, and better alternatives or options for the future.

Career exploration. At both Time 1 and 2, reports indicate that previous exploration of other career and educational options was a normative experience. Specifically, WIPSE reported commonly of having previously considered disciplines that related to their current choices such as mathematics and other types of engineering. When exploring other career and educational options, WIPSE reported that they researched or read about other majors or careers, talked with people or professionals in other fields, and took course work in other fields. In addition, WIPSE indicated that they had been employed in other fields and toured labs or relevant facilities related to other fields. Personal self-reflection was also a theme associated with their exploration as evidenced by students’ reports of “soul searching” or trying to understand “what fit my needs and likes best.”

Consistent with the reports of exploring other careers, changing majors was also commonly mentioned by WIPSE and was reported at both Time 1 and 2. Participants at Time 1 reported changing between mathematics, engineering, and physical science majors. For example, one woman described changing her major to physical science by sharing, “I had thought about continuing on in chemical engineering, but was kind of turned off by the idea. I wanted to learn something new.”

At Time 1, WIPSE noted that personal exploration and teacher encouragement influenced educational and career decisions. Yet, at Time 2, WIPSE noted that the McNair program was helpful for making career and educational decisions. Also at Time 2, WIPSE elaborated more about why changing majors had occurred for them, revealing that educational plans were modified in order to increase earning potential or expand education to learn new things. One student, however, reported changing her major from engineering after one year of college because of a lack of mathematics skills. She stated, “I felt my math skill was not as strong as it should be.”

Career goals. When asked about current career plans, WIPSE demonstrated more confidence about their vocational plans at Time 1 than at Time 2. There were no responses at Time 1 from these participants indicating that their career was undecided. In fact, Time 1 responses revealed specific organizations for which WIPSE would like to work in the future. For example, one woman stated that she would like to “direct disease eradication programs with the EPA, CDC, or WHO” and other students wrote, “my career goal is to work either for the Center for Disease Control or National Institutes of Health,” and “My ultimate goal is to be an astronaut and/or participate in research onboard the upcoming space station.” By Time 2, WIPSE demonstrated less certainty

about their career plans and more variety when describing plans. This was evidenced by one student who stated she was “not completely sure yet” as to what she would do with her major in the future and that her “career [was] still undecided.”

Despite some ambiguity about career plans, analysis of WIPSE written statements at both Time 1 and 2 from women in physical science and engineering consistently indicated a strong interest in attending graduate school and conducting research in the future. Education was viewed as a priority by these women and was believed to create options and opportunities for the future. Student responses revealed, “I would like to go to grad school and get a PhD,” “I will work towards getting my graduate degree in zoology,” and “I plan to attend graduate school and apply it to the field of immunology/pathology.” Participants also indicated a clear and consistent interest in conducting research as represented by statements such as, “I would like to pursue research in a biomedical field or in reproductive physiology for animals,” “I found out this year that I really love research and hopefully I can incorporate the research aspect into my future plans,” and “I don’t care if I conduct research in academia or private industry or government, but I want to be a researcher.”

Career commitment. Overall, despite any previous changes in career plans or majors, WIPSE were cautious about making drastic career changes and were careful with how they invested time or effort at Time 1. For example, one student stated, “that would depend on how much better that something was, how much I thought I would like it, and how much work was involved.” At Time 1, the importance of balancing effort with potential gain was also a factor as evidenced in this response: “If something better came

along and it didn't require too much extra planning, I might be willing but I'm pretty happy with things now."

At Time 2, reports about willingness to make career changes were more variable from person to person. Some statements indicated that the participants were open to making career changes. This is exemplified by statements such as, "I am very willing to change/adapt my plans to new opportunities" and "I'm always keeping my mind and eyes open for change." However, other statements indicated a strong desire to first complete what they had started. For example, students wrote, "I would want to finish the program that I'm involved in now before making the change" and "I don't see a reason to not follow through."

At Time 2, WIPSE reported having more prerequisites or conditions before they would be willing to making career changes. Similar to Time 1, the wish to balance effort with potential gain was still a focus but at Time 2, WIPSE were also considering how career changes they made would benefit loved ones.

Better alternatives and options. Analyses of the written statements at Time 1 and Time 2 revealed that, overall, WIPSE were very satisfied with their career plans. They shared things like, "I am quite happy with what I am doing." At Time 1, the women did not believe there were better options than their current career goals. This was evidenced by statements such as, "I think there's nothing better" and "This is what I want to do. This is who I want to be." By Time 2, WIPSE were not necessarily aware of better career options but believed that new opportunities would emerge in their future. For example, when asked about better options, participants stated "Not sure, I'm still investigating" and "I'm not sure yet. I have to wait until I'm actually out there." At both Time 1 and 2,

WIPSE were actively seeking additional career information regarding specializations within their chosen fields of study.

When better options were identified, the responses at Time 1 were primarily focused on quality of life factors rather than vocation specific options. For example, having peacefulness, happiness, flexibility in life, and less stress were cited as better options. Additionally, having more money was noted as a better option. At Time 2, better options that were identified from women majoring in physical science and engineering were primarily focused on learning or gaining more experience. For example, one student responded that “an experience that could offer me new insight into a science-related field (paid internship, study abroad, etc)” would be a better option for her.

Women in Life Science

Below are themes that emerged in both the Time 1 and 2 written statements from women majoring in life science. Findings are arranged according to the four main topics addressed in the questions participants responded to in writing. First, findings related to the timing of significant decisions are reviewed followed by parental expectations and influences in women’s career planning. Next, themes on motivations for pursuing life science are reported. Finally, the career development experiences of women in life science are described including previous career exploration, future career goals and commitment to career goals, and better alternatives or options for the future.

Timing of decisions. Women in life science (WILS) revealed that decisions about careers were commonly made prior to or during their high school years. This was consistently reported at both Time 1 and Time 2. For example, women’s responses included, “I stated that I was going to be a vet when I was eight years old,” “I decided my

career around the age of sixteen,” and “I always knew that helping protect the environment or species would be the path I take.” One student at Time 2 identified the McNair Program as having helped her make career decisions.

Analysis of responses from WILS also revealed at both Time 1 and 2 that choosing a major in college occurred later, during the high school or college years. This is exemplified by one interview stating, “I decided the general area in high school and the specific major my Freshman year of college.”

Parental expectations and career planning involvement. Analysis revealed consistent responses over Time 1 and 2 from WILS regarding parental involvement and vocational expectations. Respondents consistently indicated that parents were not involved in their educational or vocational planning. For example, one woman stated, “they don’t really care much,” when asked if their parents had career plans for her. Others reported “don’t know” and “I have no idea!” about parents’ career plans. When expectations were identified, responses were less related to careers and more focused on parents wanting their daughter to be happy or to conform to a conventional female role in society. For example, a student wrote, “My parents wanted me to get married and have children.”

Although in this group, parents were not reported to have specific career plans for their daughters, at Time 1 and Time 2, parents were perceived by their daughters as being happy, proud, and supportive. WILS shared that parents were “proud/amazed” and “They think it’s great I’m going on for a PhD.” Parents were also viewed as supportive from their daughter’s perspective. This was conveyed by statements such as, “They support me in every decision I make and they are thrilled that I’ve come this far and keep on

achieving my goals,” “My parents are 100% behind what I want to do especially since I’m putting myself through school,” and “If I decided to go to school or get married and start a family, they would be ok with whatever path I chose.”

At Time 1, WILS who identified as first-generation reported a sense of isolation related to feeling that their parents could not fully relate to their educational goals. For example, students shared, “It was tough being a first-generation student though because there’s only so much support your parents can provide” and “My parents were just expecting me to get married and start a family. Attending college was not an option because we couldn’t afford it and also because no one in my family had ever gone to college.” By Time 2, however, this finding was not present in the narratives of women in life science.

Motivations for choosing life science. Regarding what attracted them to pursue life science, WILS reported enjoyment of learning life science at both Time 1 and 2. For example, a student wrote, “To me, it is most attractive simply because I love the subject matter.” At both Time 1 and 2, the context of the work environment was also important to WILS, who reported choosing their career because of enthusiastic colleagues or because they enjoyed working with people or animals. At Time 1, the desire to learn new and different things, concern about finances or job opportunities, and high stress were related to career decisions of women majoring in life science. By Time 2, being motivated to pursue their current career paths because they enjoyed helping others was related to the education and career choices of WILS. For example, one woman reported, “I’m interested in what I’m learning and I love what I will be able to do for people” and

another shared she liked it because she could “help protect something that can’t protect itself.”

The next section focuses on the career development experiences of WILS. Results about career development experiences were subdivided into four subcategories including women’s previous career exploration, future career goals and commitment to career goals, and better alternatives or options for the future.

Career exploration. Exploration of a wide variety of other career alternatives was normative for respondents in life science. Responses indicated that they had previously explored fields that differed in important ways from their current field. For example, students shared that they had considered “being an EMT or doctor,” “an equine science major for a semester,” doing “interior design,” and “sign language interpreting.” Results indicated that women in life science had explored career alternatives by taking course work, researching or reading about other careers, and by talking to people or professionals about other careers. Although they explored of career alternatives, WILS did not commonly change educational majors.

Career goals. Findings related to career goals indicated that a shift occurred from Time 1 to Time 2 for WILS. At Time 1, WILS had vague ideas for their future careers but lacked concrete or specific plans. For example, one student reported, “I don’t have a definite specific area of interest” while another stated “If I saw something of extreme interest to me, no matter how off base from my major, I’d latch onto it and hang on for the ride.” Results indicated that when goals were identified by women in life science at Time 1, they were less focused on career goals and more on students’ desire to be fulfilled and to use their intellect in the future. For example, one student wrote, “I want to

be involved in a career field that is constantly evolving, rewarding/compassionate, and earns a respectable wage.” The only specific plans that were identified were focused primarily on pursuing graduate school. For example, students reported, “I plan on getting my doctorate,” “I would like to use my animal science major to pursue a master’s in some type of animal genetics,” and wanting to “attend graduate school to receive a PhD.”

By Time 2, WILS were able to identify more specific career goals including job locations and settings as well as organizations they were interested in working with. One woman expressed, “I would like to work in a clinical setting (hospital, clinic, etc). I would like to work either in California or Florida” while another woman shared, “I plan to go to graduate school and then work for the division of wildlife.” Firm and specific plans for pursuing graduate school were still prominent for women in life science at Time 2 as evidenced by statements like, “I plan on furthering my study at Iowa State University...my PhD will be in molecular genetics of livestock animals” and “I plan to go to graduate school.”

Career commitment. At both Time 1 and Time 2, WILS were open to changing or modifying their career plans. For example, women shared that “If I feel passionate about it, then I can change easily,” “I think I know what’s best for me and I’d hope that I’d change my plans accordingly,” and “I am extremely willing to change my plans because I believe that different opportunities present themselves all the time, and I want to leave myself open to all kinds of options.” At Time 1, the willingness to change career plans was expressed in the context of stating that changing plans now would depend on how much better the changes would be, if the changes benefited the student directly, and if the changes were related to more earning money. By Time 2, conditions of changing plans

were focused on ensuring that future changes would be tied to their current career plans or would have to benefit them or their relationships in order to be considered fully.

Better alternatives and options. WILS consistently reported that there were no better career options for them aside from gaining additional education or preparing for graduate school. At both Time 1 and 2, WILS wrote statements such as, “nothing else seem to be a better fit/choice,” “I couldn’t imagine something better,” and “I think my best option at this point is to try to get a master’s degree/PhD through my current job.”

Discussion

The current study explored the educational choices and aspirations of high-achieving women in physical science and engineering, two predominately male fields, and compared them to high-achieving women in life science, a field in which women are more well represented. Several prominent findings related to the research questions emerged from this study.

WIPSE reported making education and career decisions later than WILS. Parents of both WIPSE and WILS were perceived as supportive of, yet uninvolved, in educational or career planning and did not generally expect their daughters to pursue science or engineering. Both WIPSE and WILS reported that the enjoyment of learning their respective subjects is what attracted them most to their fields as well as job opportunities and being able to help humanity and the world. WIPSE and WILS were also similar in that both groups of women reported exploring other education and career options. However, WIPSE’s future aspirations became more undecided or vague from Time 1 to 2, whereas WILS’s future aspirations became more concrete. WIPSE’s commitment to persisting in their current plans was high while WILS were much more

open to changing their plans. WIPSE also identified less stress as a better option for their future.

The first research question of this study addressed the timing of educational choices and career decisions for women in science and engineering focused education. Unique differences emerged regarding the timing of career decisions for women who majored in physical science or engineering and those who majored in life science. WIPSE initially reported making career decisions throughout their lifetime but later wrote that they made decisions during high school or had not made a career decision yet. This was different from WILS, who consistently reported making the career decisions earlier than WIPSE. The findings of this study corroborate earlier studies that indicate women in non-female-dominated careers make education and career decisions later than women in female dominated careers (Whitmarsh et al., 2002). Interaction with college and university classmates, professors, mentors, and bosses are thought to provide valuable career insights for women who enter non-female-dominated careers (Whitmarsh et al.). Contrary to prior research (Betz, 2005), however, the WIPSE in the current study did not report problems of inadequate mathematics instruction from high school as result of making later education and career decisions. This indicates that WIPSE in the current study completed high school prerequisite requirements for university STEM educational program despite waiting to make education and career decisions until later. These findings could also suggest that as long as women are encouraged to attain the right skill set in high school years, the college years may not be too late to use still recruit capable women to pursue STEM focused education and careers.

Another research question addressed in this study focused on parental expectations and involvement in the educational choices and career planning of women in science and engineering education. Both WIPSE and WILS reported similar experiences with parental expectation and involvement. Generally, parents were perceived by all the women in this study as supportive and happy about the career goals of their daughters, although parents reportedly did not relate to or understand their daughters' goals. Participants were unaware of parents having specific career goals for them and most often conveyed a sense of choosing career paths on their own. Feeling that parents could not relate to their educational and career goals persisted for WIPSE over time but did not for WILS. These findings corroborate prior research that parental support and encouragement are important factors in women's confidence, educational choices, and performance in math-related education like science and engineering (Bleeker & Jacobs, 2004; Davis-Kean et al., 2007; Eccles & Jacobs, 1986; Ferry, Fouad, & Smith, 2000). However, these findings also suggest that assisting women with career planning may be particularly important for helping them to pursue science because parents may not be expecting their daughters to pursue these fields. Mentorship is linked with numerous positive outcomes and may offer one potential solution to filling this gap for women (Fassinger & Hensler-McGinnis, 2005; Hollingsworth & Fassinger, 2002; Ishiyama & Hopkins, 2003; Lam, Ugweje, Mawasha, & Srivatsan, 2003).

The next research question explored why women choose to pursue science and engineering focused education. The motivations for choosing to pursue education in their respective fields were strikingly similar for WIPSE as compared to WILS. By far, the strongest motivation reported by women was the sheer enjoyment of learning their

respective subjects. Both WIPSE and WILS also reported being motivated by the potential job opportunities available in their fields and by altruistic application of their education. One unique motivator was found among WILS and that was related to having a positive work environment that included working with animals or people. The findings of this study replicate prior research indicating women are motivated to choose science and engineering education when they enjoy learning the subject, believe it can offer something of importance to humanity, and believe it can provide financial and personal independence (Eccles 2007; LeBold et al., 1983; Rutherford, 2007; Wender, 2004). This suggests that fostering women's enjoyment of science and helping them to recognize humanitarian applications of science and career opportunities of science may be a way to attract more women to choosing STEM focused education.

Finally, this study also asked research questions regarding the career development of women who enter physical science and engineering versus life science. Research questions included, were other options explored, what were their future aspirations and commitment to career goals, and what were better alternatives for their future? Important differences and similarities emerged between women in the different majors.

For career exploration, both WIPSE and WILS had previously explored other careers. However, WIPSE primarily explored careers that were more directly related to their current interests, whereas WILS considered both related and unrelated careers. Additionally, WIPSE reported self-reflection was a part of their exploration. Finally, encouragement and mentorship was viewed as important by WIPSE, who had also expressed concerns about math skills deficits. This was not described by WILS. These findings corroborate prior literature that suggests the importance of career exploration

opportunities for women, particularly women in non-female-dominated fields (Whitmarsh et al., 2002).

Regarding future aspirations and career goals, WIPSE demonstrated unique patterns from WILS. The career goals of WIPSE that were initially clear and specific at Time 1 became more vague and even undecided by Time 2. This was quite different from WILS, who showed the opposite trend from Time 1 to Time 2, where their career goals became more solidified. There was one exception for women from all majors: Plans for attending graduate school remained clear and concrete at both Time 1 and 2. There was no mention by WIPSE or WILS of aspirations to work part-time or regarding potential work-family considerations or conflicts. This finding diverges from previous research indicating that these are prominent issues for women when making education and career choices (Ceci, et al., 2009; Leslie, McClure, & Oaxaca, 1998; Lubinski et al., 2001).

For reports about commitment to goals and aspirations, findings showed that changing educational majors was a common experience for WIPSE but was not for WILS. However, WIPSE were more committed to their current career paths and less willing to make vocational changes, whereas WILS were more open to vocational changes. Lastly regarding better options for the future, women in physical science and engineering were more able to identify options for their future than were women in life science. Both groups of women identified learning more as a better option but WIPSE also identified improving their quality of life. For example, they described wanting flexibility in life and having less stress as better options.

Limitations

Several limitations are important to acknowledge. One limitation is an absence of detailed information on when and how data collection of interview reports occurred. For example, almost half of the interview reports collected from participants were not dated at one or both times of data collection. For participants who did not have dates on either interview report, the first interview report found in the file was assigned to Time 1 and the second to Time 2. The assumption that interview reports were organized in student files chronologically was made based on how the dated interview reports were organized in student files with the earlier dates first. Interview reports that did have dates on them showed great variation in the length of time between Time 1 and Time 2 for individual participants. This raises concerns regarding the consistency of how data collection procedures occurred. The variation in length of time between Time 1 and 2 may yield interpretations of the longitudinal data capricious. For example, findings showed overlap in participant responses at Time 1 and 2 in the current study which could be attributed to participants' stable attitudes over time or could be that a short time lapse between Time 1 and 2 essentially measured the same developmental period of participants. Because of these limitations in the data, interpretations are offered with caution. Despite limitations, this study aims to highlight the importance of understanding women's educational choices and aspirations and to encourage future research on this topic. In particular, it is important to consider successful women in STEM who are also from low-income families, are first generation, or ethnic minority. Future research aimed at understanding the unique needs, experiences, and strengths of women in STEM who are overcoming multiple barriers is recommended for gaining more in depth insight for how maximize their educational success.

Implications

The overall implication of this study is that women in male-dominated education fields such as physical science and engineering have both similarities and differences from women in life science where women are more well represented. Parental support, autonomous career planning, enjoyment of learning, wanting job security, humanitarian interests, and career exploration were similar for both WIPSE and WILS. However, timing of education and career decisions were later, future aspirations were less clear at graduation, commitment to goals was higher, and stress was higher for WIPSE than WILS. Therefore, interventions to support women in all STEM education programs could benefit from including components such as: assisting in career planning, fostering enjoyment of learning, providing information about job opportunities, connecting application of STEM to socially conscious and humanitarian issues, and providing career exploration opportunities. However, interventions that aim to specifically support the unique needs of women in male-dominated STEM fields must be more comprehensive. For example, WIPSE from this study became more indecisive about their careers over time and may benefit from efforts that assist in this area. Additionally, WIPSE indicated struggling with higher stress levels and could benefit from learning stress-management skills.

This study extends previous literature on women in science and engineering to focus on successful and high-achieving ethnic minority women, first-generation women, and women from low-income families. The insights provided by this study may directly inform educators, career counselors, and policy makers in their work to assist disadvantaged students in STEM. Research focused on high-achieving women facing

multiple obstacles is particularly valuable because these students can provide an insider's perspective on how they have successfully overcome obstacles.

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Conclusions

Women and some ethnic minority students are persistently underrepresented in STEM education and careers (Babco & Bell, 2004; NSF, 2009). The disproportionate absence of women and some ethnic minorities in STEM is clearly problematic because of inequity but it is also a concern for the U.S.'s economic growth. The juxtaposition of two trends – the rising STEM occupational demands in the U.S. and the declining numbers of U.S. citizens pursuing STEM education or careers – has raised concerns that the U.S. will forgo its global standing in scientific and technological innovation to other countries such as China or India (National Science Board, 2004). To keep pace with STEM labor demands that advance the U.S. economy in a global market, policy makers are turning more attention towards understanding how to encourage women and ethnic minorities to pursue and persist in STEM education and careers.

This dissertation is focused on gaining a more in-depth understanding of the challenges, choices, aspirations, and perceptions of successful, underrepresented undergraduates in STEM fields. The two studies offer insights about potential improvements for efforts to increase the representation and success of women, ethnic minority, low income, and first-generation students in undergraduate STEM education.

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Appendix A

Identity Status Interview

The next series of question ask about your career goals and how you decided upon them. Please describe your thinking in as much detail as possible, especially on questions about how you reached decisions about your future.

1. What do you plan to do with your major, in the future?
2. When did you decide on your major? On the career you intend to pursue?
3. Did you ever consider other majors and/or careers? Please describe (a) which one(s) and (b) how much you pursued these other goals; read about them, talked to people about them, actually took courses in the area.
4. What is most attractive about your current major/career?
5. Most parents have plans for their children, things they'd like them to go into or do. Did your parents have any plans like that for you? (Briefly describe).
6. How do your folks feel about your plans now?
7. How willing do you think you'd be to change your plans if something better came along?
8. What might be a better option, in your terms?