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The Current State of High School Female and Minority Self-efficacy and Interest in STEM in Chatham County, Georgia

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Abstract

With the growing demand for science, technology, engineering, and mathematics (STEM) jobs in the U.S., the attainment of college degrees in these areas is of paramount importance. Both federal and state governments have established initiatives to grow the number of STEM degrees earned by women and racial minorities, as these groups graduate in STEM disciplines and work in STEM fields at a lower rate than that of their majority counterparts. The factors that can deter women and underrepresented minorities from pursuing STEM careers have been identified with one of the most prominent being low self-efficacy, or a reduced belief in one's capability of accomplishing a goal or task. This study aimed to assess the current level of self-efficacy of Chatham County, Georgia high school students in the STEM disciplines and their interest in pursuing a STEM career. No difference in the levels of self-efficacy in mathematics and science was reported by females and males; however, males reported significantly higher self-efficacy in engineering and technology compared to females. When asked about the future, females and males reported no difference in interest in a variety of STEM vocations; however, males had a significantly stronger preference for jobs in the areas of physics, computer science, medicine, energy, and engineering compared to females. Race did not influence self-efficacy in the three STEM areas, but interest in careers in the physical sciences was low among underrepresented minority students. Continued implementation of strategies to create and maintain female self-efficacy and interest in STEM, especially in engineering and technology, remains a necessity. While underrepresented minority students appeared to possess self-efficacy in the STEM disciplines during high school, strategies are needed to ensure their successful progression through STEM degree programs and later obtainment of a STEM job.

Keywords

Science, Technology, Engineering, Mathematics, Gender, Race

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Introduction

STEM (science, technology, engineering, and mathematics) jobs are recognized as some of the most in-demand vocations for the future of the U.S. workforce; the U.S. Bureau of Labor Statistics reported that a majority of the top 20 fastest growing occupations fall under the umbrella of STEM or STEM-related fields (United States Bureau of Labor Statistics, 2018). Within STEM careers, computer occupations are predicted to have the most new positions in the near future (Fayer et al., 2017). As the U.S. recruits future scientists and mathematicians into the STEM labor force, special attention should be paid to current inequities in gender and race. In a recent report by the National Science Foundation, employment data from 2017 revealed that males hold nearly two of every three STEM jobs (National Science Foundation, 2019). Females occupy approximately half of biological science and mathematics positions as well as a majority of the STEM-related health occupations (National Science Foundation, 2019), but are poorly represented as computer and information scientists (25%), physical scientists (29%, 17% of which as physicists), and engineers (16%) (National Science Foundation, 2019). The disproportion of females working in some STEM disciplines should not be surprising as the percentage of females who earn bachelor's degrees in computer science (18%), physical science (39%), and engineering (20%) is less than that of males (Fayer et al., 2017; National Science Board, 2018).

Along with females, racial minorities such as Blacks/African Americans, Hispanics, Native Americans, and Pacific Islanders are underrepresented in all STEM fields. Of employed scientists and engineers in 2017, the majority were White or Asian, making up 65% and 20% of the workforce, respectively, with the remaining positions occupied by Hispanics (7%), Black or African Americans (6%), and Native American, Alaskan Natives, Native Hawaiian, Pacific Islander, or multiracial combined (2%) (National Science Foundation, 2019). In terms of science and engineering bachelor's degrees earned in 2015, 58% were earned by White, 9% by Asian, 12% by Hispanic, 9% by Black, and less than 8% by American Indian or Alaska Natives, Native Hawaiian or Pacific Islander, and multiracial students (National Science Board, 2018).

The disproportion of females and racial minorities across STEM disciplines is a well-studied issue with decades of research focusing on the potential reasons behind the phenomenon. Factors that have been found to deter these groups from pursuing STEM careers can occur at any time during a student's schooling, from grade school to secondary education, and include feelings of exclusion or negative stereotypes in STEM culture (Marra et al., 2009; Rainey et al., 2018; Strayhorn et al., 2013), low self-efficacy in STEM subjects (Bandura et al., 2001; Huang, 2013; MacPhee et al., 2013; Pajares, 2005), peer and social unit influence (Espinosa, 2011; Shapiro & Sax, 2011), and familial persuasions and beliefs (Fouad & Santana, 2017; Shapiro & Sax, 2011) among others (Hill et al., 2010).

Fortunately, efforts are being made to combat homogeneity in STEM. For example, the National Science Foundation has developed programs such as INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science) and LSAMP (Louis Stokes Alliances for Minority Participation) to broaden STEM participation of underrepresented groups (National Science Foundation, 2018b, 2018c), and Advance to encourage women in academic science and engineering careers (National Science Foundation, 2018a). In 2013, U.S. President Barack Obama put forth a STEM 5-Year strategic plan that included financial support and programming to broaden "the participation of women and girls and other groups underrepresented in STEM fields" (Holdren et al., 2013). Outside of government, groups such as the National Action Council for Minorities in Engineering, the American Chemical Society, and American Physical Society, to name a few, offer resources targeted at increasing participation of underrepresented groups in their respective fields (American Chemical Society, 2019; American Physical Society, 2019; National Action Council for Minorities in Engineering, 2013).

The purpose of the current study was to investigate the self-efficacy and career interest in STEM of today's high school students in Chatham County, GA with emphasis on females and underrepresented racial minorities. High school is an ideal time to poll students as intentions to seek a STEM degree and career have been shown to solidify by this stage (Sadler et al., 2012; Sahin et al., 2018). Assessing a student's self-efficacy was selected as it is has been identified as a strong indicator of the decision to pursue a STEM major and career (Mau & Li, 2018; Morgan et al., 2013; Sahin et al., 2018; Tai et al., 2006). The term self-efficacy describes a student's belief that he/she is capable of accomplishing goals or tasks (Bandura, 1986), and a high level of self-efficacy in STEM has been shown to inform career ambitions, increase confidence in STEM, and encourage continued persistence in STEM (Chemers et al., 2011; Pajares, 2005; Rittmayer & Beier, 2009; Sahin et al., 2018).

Gender differences in STEM self-efficacy at the high school level have been reported in the past with varying results; one study found equal levels of self-efficacy between males and females in the life and physical sciences with the exception of stronger female self-efficacy in earth science (Britner, 2008). A Finnish report found that the self-efficacy of males in science and mathematics was greater than that of females, except in biology (Uitto, 2014). A more recent study that surveyed both middle and high school students found that males had higher self-efficacy than females in science, but not math (Usher et al., 2019). Inquiries that specifically address STEM self-efficacy by race or ethnicity at the high school level are lacking (Wiebe et al., 2018). Given the efforts at the national level to increase the number of underrepresented groups pursuing STEM careers, we predicted that current high school females and racial minorities would report STEM self-efficacy and attraction to all STEM careers at a level equal to that of their majority peers.

Methods

Participants

In Chatham County, GA from 2016 to 2017, students from two public high schools were surveyed to determine their self-efficacy in STEM and interest in a career in STEM. Chatham County was an ideal location for data collection as race and average household income demographics are representative of those of the state of Georgia (United States Census Bureau, 2018). As a part of the survey, students were asked to report their gender as either male or female, their race as either Asian, Black/African American, Hispanic, Multiracial, Native American, or White/ Caucasian, and their grade level as either 9^{th}, 10^{th}, 11^{th}, or 12^{th}. Gender, race, and grade were treated as the independent variables for this study.

Non-Asian minorities are poorly represented in STEM careers (Beede et al., 2011; National Science Foundation, 2019). In order to determine if these underrepresented minorities have increased their level of self-efficacy and interest in STEM compared to their well-represented peers, the race categories of the survey were divided into the following two groups for a comparative analyses: 1) "White" which included those races that are well-represented in STEM, Caucasian and Asian, and 2) “Non-white” which included those minority races that are underrepresented, Black, Hispanic, and Multiracial.

Design

Data were collected using the Student Attitudes Towards STEM Survey-Middle and High School Students by the Friday Institute for Educational Innovation (Friday Institute for Educational Innovation, 2012; Unfried et al., 2015). The survey’s purpose is “to measure changes in students’ confidence and efficacy in STEM subjects …and interest in STEM careers” (Friday Institute for Educational Innovation, 2012). The first part of the survey instructed students to read 37 statements, then asked students to rate their confidence and self-efficacy in the three STEM areas of mathematics, science, and engineering and technology using a 5-point Likert scale where 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree Nor Disagree, 4 = Agree, and 5 = Strongly Agree. The science and engineering and technology sections each contained nine statements while the mathematics section contained eight statements. An example statement included: “I am good at math.” (Friday Institute for Educational Innovation, 2012).

The second part of the survey titled “Your Future” included a list, description, and examples of 12 STEM vocations including Physics, Environmental Work, Biology and Zoology, Veterinary Work, Mathematics, Medicine, Earth Science, Computer Science, Medical Science, Chemistry, Energy, and Engineering. An example from this section included: **“**Physics: is the study of basic laws governing the motion, energy, structure, and interactions of matter. This can include studying the nature of the universe. (aviation engineer, alternative energy technician, lab technician, physicist, astronomer)" (Friday Institute for Educational Innovation, 2012). The survey instructed students to rate their interest in each career using a 4-point Likert scale where 1 = Not At All Interested, 2 = Not So Interested, 3 = Interested, and 4 = Very Interested.

Before the survey was administered, IRB approval was obtained from Georgia Southern University Armstrong Campus (named Armstrong State University at the time) and the Savannah Chatham County Public School system. One teacher at each of the two surveyed high schools collected signed student forms and parent or guardian consent forms. The survey was administered, and data were collected using SurveyMonkey.com.

Data Analysis

Data were reviewed before statistical analysis. A majority of statements within the confidence and self-efficacy section of the survey were written as positives (ex. "I am good at math. "); however, four were written as negatives (ex. "Math is hard for me."). The data collected from the four negative statements were reverse coded to ensure consistent meaning of ratings in each of the three STEM areas.

Preliminary analysis revealed that there was no significant change in ratings across the survey over time from 9^{th} to 12^{th} grade (data not shown);

therefore, grade level was removed as an independent variable, and data from each high school year were combined for further analyses. Data were analyzed with a two-way multivariate analysis of variance (MANOVA), and significance was determined at the $p \leq .05$ level. The first analysis compiled average ratings of self-efficacy in the three STEM areas of mathematics, science, and engineering and technology by gender and race. Any participant that did not respond to all statements or indicate gender or race within this section was removed from analysis. The second, two-way MANOVA focused on the average ratings of interest in the 12 STEM vocations by gender and race. Any participant that did not respond to all statements or indicate gender or race within this section was removed from analysis.

Results

Self-Efficacy in STEM Areas

A total of 154 participants completed the entire STEM areas survey section. Both genders and race groups rated their self-efficacy in mathematics, science, and engineering and technology as neutral to positive with average ratings between 3 (Neither agree nor disagree) & 4 (Agree), respectively (Table 1). Analysis of variance revealed no gender by race interaction, $p = .44$. Gender did significantly influence self-efficacy, $p = .002$, while race did not, $p = .22$. Males reported a significantly higher level of self-efficacy in engineering and technology than females, $F(1, 150) = 14.98$, $p < .001$ (Table 1).

Table 1.
Means and standard deviations (SD) of self-efficacy ratings in three STEM areas sorted by gender and race

	Mathematics Mean (SD)	Science Mean (SD)	Engineering & Technology Mean (SD)
Gender			
Male (n = 64)	3.62 (0.99)	3.47 (0.92)	**3.81 (0.70)**
Female (n = 90)	3.41 (1.14)	3.35 (0.84)	**3.31 (0.84)**
Race			
White (n = 67)	3.63 (1.08)	3.50 (0.93)	3.55 (0.80)
Non-white (n = 87)	3.40 (1.07)	3.32 (0.81)	3.50 (0.84)

Note: Bolded means indicate a significant difference between gender and race groups within each STEM area at $p \leq .05$, n = 154. Means are based on a 5-point Likert scale where 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree Nor Disagree, 4 = Agree, and 5 = Strongly Agree.

Vocational Aspirations

A total of 141 participants completed the entire STEM vocational survey section. When students were questioned about their desired future career, male averages across all vocations were above a rating of 2, indicating an overall interest in a career in STEM (Table 2). In contrast, with averages below a rating of 2 (Not so interested), the fields of medicine, chemistry, and energy were the least appealing to females. Both White and Non-white student averages across a majority of vocations fell between the rating of 2 and 3 (Interested) indicating an interest in a STEM career. However, the discipline of chemistry for White students and chemistry and energy for Non-white students appeared to be less appealing with rating averages below 2.

Table 2.
Means and standard deviations (SD) of STEM vocational interest ratings sorted by gender and race

	Gender		Race	
	Male (n = 59)	Female (n = 82)	White (n = 63)	Non-white (n = 78)
Vocation	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Physics	**2.41 (0.93)**	**2.07 (0.87)**	**2.37 (0.97)**	**2.09 (0.84)**
Environmental Work	2.34 (0.99)	2.17 (0.87)	**2.48 (0.95)**	**2.05 (0.87)**
Biology & Zoology	2.39 (0.93)	2.40 (1.00)	2.54 (1.03)	2.28 (0.91)
Veterinary Work	2.17 (0.75)	2.27 (1.03)	2.13 (0.94)	2.31 (0.90)
Mathematics	2.36 (0.92)	2.55 (1.07)	2.32 (1.03)	2.59 (0.99)
Medicine	**2.34 (1.03)**	**1.99 (1.08)**	2.19 (1.12)	2.09 (1.03)
Earth Science	2.34 (0.88)	2.12 (0.91)	**2.38 (0.91)**	**2.08 (0.88)**
Computer Science	**2.58 (0.97)**	**2.12 (0.92)**	2.30 (0.94)	2.32 (0.99)
Medical Science	2.25 (0.99)	2.38 (1.08)	2.37 (1.08)	2.30 (1.02)
Chemistry	2.10 (0.87)	1.88 (0.84)	1.98 (0.85)	1.96 (0.86)
Energy	**2.36 (0.92)**	**1.79 (0.83)**	**2.14 (0.98)**	**1.94 (0.84)**
Engineering	**2.98 (0.86)**	**2.18 (1.00)**	2.48 (1.08)	2.55 (0.98)

Note: Bolded means indicate a significant difference between gender or race groups within each vocation at $p \leq .05$, n = 141. Means are based on a 4-point Likert scale where 1 = Not At All Interested, 2 = Not So Interested, 3 = Interested, and 4 = Very Interested.

Statistical analysis revealed that gender and race significantly influenced vocational interest ($ps \leq .05$) while there was no gender by race interaction (p = .40). Females and males had similar levels of interest in many of the STEM vocations, $Fs(1, 137) \leq 3.15$, $ps \geq 0.08$; however, females had significantly less interest in physics, medicine, computer science, energy, and engineering compared to males, $Fs(1, 137) \geq 4.93$, $ps \leq .03$. With respect to race, non-White students had a reduced interest in physics, environmental science, earth science, and energy compared to White students, $Fs(1, 137) \geq 4.98$, $ps \leq .03$. Vocational interest did not statistically differ by race in the remaining vocational categories, $Fs(1, 137) \leq 2.55$, $ps \geq .11$.

Conclusions

In today's job marketplace, positions in STEM are on the rise, yet women and racial minorities remain underrepresented in many STEM fields (Fayer et al., 2017; National Science Foundation, 2019; United States Census Bureau, 2018). This problem has been recognized nationally, and efforts have been made to increase participation from these groups. Our study aimed to report the current STEM self-efficacy and career interest of students in high school, the period of time when STEM self-efficacy and career plans are becoming concrete (Sadler et al., 2012; Wiebe et al., 2018).

Outcomes from our study suggest that the self-efficacy of females in the areas of science and mathematics are comparable to that of males but less so in the area of engineering and technology. Our findings are partially consistent with previous works. With respect to mathematics, a meta-analysis documented greater STEM self-efficacy in male verses female high school students (Huang, 2013), while a 2014 study that used the Student Attitudes Towards STEM Survey polled students grades 4-12 and found that females had a similar level of mathematical self-efficacy as males (Unfried et al., 2014). Our mathematical self-efficacy results along with those of Unfried et al. (2014) may help explain the current

STEM degree and employment data which shows that females are approaching equity with males in mathematics (National Science Foundation, 2019). As with our study, Unfried et al. (2014) found that females had lower self-efficacy in engineering and technology compared to males. The same group also found that attitudes in science fluctuated from 4-12th grades between the two genders with females having a slighter stronger self-efficacy in science than males in the last 3 grades of high school (Unfried et al., 2014), a finding that we did not confirm.

At first glance, the results from the current study are especially encouraging as connections have been established between self-efficacy in mathematics and the intent to major in a STEM field (Wang, 2013), especially in the physical sciences (Wiebe et al., 2018). Despite gender equality in mathematics self-efficacy, females in our study still reported a lower interest in careers in the physical sciences including physics, computer science, and energy, and remained less interested in engineering and technology compared to males. These findings are similar to other studies that reported reduced female interest in the subject of physics by high school (Baram-Tsabari & Yarden, 2011) and lower attraction to core STEM careers based in physics, environmental work, mathematics, earth science, computer science, chemistry, energy, and engineering compared to males in grades 4-12 (Wiebe et al., 2018).

Surprisingly, females in our study were not drawn to a career in medicine. Wiebe et al. (2018) indicated that females had a stronger interest in Biologicallyand Medically-related careers (Medicine, Medical sciences, Veterinary sciences, and Biology & Zoology) than males. Currently, medicine is a field that is well-populated by females (National Science Foundation, 2019). Additionally, the Association of American Medical Colleges reported that females are entering and matriculating through medical school at the same rate as males (Association of American Medical Colleges, 2017). A closer look at our data revealed that the career of ‘Medical Sciences’ had the second highest mean interest score for females while the career of ‘Medicine’ ranked second to last (Table 2). In the survey, the vocation of Medicine is described as “maintaining health and preventing and treating disease. *(physician’s assistant, nurse, doctor, nutritionist, emergency medical technician, physical therapist, dentist)*,” while Medical Sciences is described as “researching human disease and working to find new solutions to human health problems. *(clinical laboratory technologist, medical scientist, biomedical engineer, epidemiologist, pharmacologist)*” (Friday Institute for Educational Innovation, 2012). It is possible that our data is indicating that the current career interest of females may be shifting more to the research-based, medical sciences and away from the more traditional, healthcare provider careers in medicine.

In regard to race, we found that the self-efficacy of Non-white students was no different than that of their White counterparts in all three areas of STEM. Underrepresented minorities were interested in most STEM vocations comparably to that of White students except for physics, energy, earth science, and environmental work which were the least appealing. Promisingly, underrepresented groups showed similar levels of interest in engineering careers. Wiebe et al. (2018) found that underrepresented races had a stronger interest in the core STEM careers (e.g. physics, mathematics, engineering, etc.) than their majority counterparts. Combined, the current study along with Weiber et al. (2018) indicate that racial minorities have a solid interest in STEM before college. Perhaps STEM self-efficacy and interests during high school is not the reason for a lack of racial minorities declaring STEM majors and/or seeking careers STEM. Instead, it is likely that this group does not persist in STEM in college at the same rate of their majority counterparts (Bonous-Hammarth, 2000).

Results from the current study are a mere snapshot of the high school students of Georgia as the data were collected from one county and included less than 200 participants. While we do report some encouraging results, our findings are overshadowed by the fact that there is still room for improvement. If self-efficacy is so crucial in the pursuit of and persisting in a STEM major and career, how can we foster and strengthen these characteristics in female and underrepresented minority students in grade school, the time when they are deciding on their future? We suspect that targeted intervention programs for students in middle and high school may be the most impactful as the self-efficacy that influences the desire to become a STEM professional can start in middle school (Degenhart et al., 2007) and can decline as students progress to high school (Rittmayer & Beier, 2009; Unfried et al., 2015).

What should be included in such intervention programs? As reviewed by Rittmayer and Beier (2009), STEM self-efficacy is developed from and supported by four factors including 1) mastery experiences in a subject, 2) vicarious experiences like working with a mentor, 3) social persuasions such as positive feedback, and 4) psychological reactions around performance in STEM subjects. Two recent meta-analyses and a review that highlighted gender and underrepresented minorities in STEM converged on a similar conclusion: previous performance, especially in mathematics, and support (familial, financial, parental) are the best predictors of STEM self-efficacy at the middle and high school levels (Fouad & Santana, 2017; Lent et al., 2018; Sheu et al., 2018). K-12 programs specifically targeted at females and underrepresented minorities could address one or more of the four pillars of self-efficacy. For example, a recently published high school intervention program based on the pillars of self-efficacy led to increased career and STEM self-efficacy in Latina and White females (Falco & Summers, 2019). Counseling sessions in this program focused on highlighting the students' previous successes in STEM, combating negative performance self-talk, incorporating role models, and practicing positive affirmations. We suggest that a similar program that specifically addresses engineering self-efficacy in women could be impactful. While racial minorities did not report low self-efficacy in STEM, intervention programs at the high school level may strengthen this self-efficacy enough to withstand any decline during college years. College personnel could also work to maintain self-efficacy in these students to prevent the loss of current STEM majors.

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