Students' Perceptions of Barriers and Opportunities for STEM research: A study of freshmen students at an HBCU

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Abstract

In this study, we examined Black freshmen undergraduate students' perceptions of barriers and opportunities for research at an HBCU. Although there is literature about factors that support or limit students' access and attitudes towards research among a broader population, very little is known about these factors for Black students in STEM at HBCUs. We administered an adapted Attitude Toward Research (ATR) survey to 74 Black freshmen in STEM. The purpose of this study was to investigate and assess students' attitudes towards research. Our results show students demonstrated positive attitudes towards research, acknowledged the usefulness of research to their field/career, and indicated interests in research activities with no difference in gender. Our study highlights the need to enhance student interest and exposure to STEM research.

Keywords

Perceptions, barriers, factors, freshmen, STEM, under-represented minorities (URM)

Introduction

According to the U.S. Department of Education: "Today, few American students pursue expertise in STEM fields and we have an inadequate pipeline of teachers skilled in those subjects" and the President's Council of Advisors on Science and Technology (PCAST) calls for a million more STEM professionals by 2022 to meet growing economic and global demands in the STEM fields[1]. In 2012, African Americans accounted for only 7.5% of all STEM undergraduate degrees and only 4.5% of doctoral degrees awarded in STEM[2]. To meet global demands and to encourage diversity in these efforts, underrepresented populations, that include women and African Americans, must be supported in their progress toward attaining STEM degrees. Although Women and African American students are already underrepresented, they continue to leave STEM majors. It is important to understand factors contributing to underrepresentation and also to determine what elements help to promote attainment among underrepresented students; in order to help create a strong and diverse workforce[3].

Research has shown that minority students who enter college at undergraduate and graduate level with intended STEM majors at the same proportion as the rest of students not only have a higher attrition rate[4], but also a lower STEM degree completion rates[5]. It is further shown that one of the benefits of undergraduate research, experiences are to help sustain student's interest in their field and help stimulate interests in STEM[6]. As a result, exposing the students early to research opportunities and activities can be an influential tool in their engagement, interest in science, and retention in STEM majors and careers. Further, research experiences[7,8] have a significant impact on the retention and career-making decisions of undergraduate students in STEM. Yet, a majority

of under-represented minorities (URM) have limited access to research experiences during their undergraduate studies. In this study, we examined undergraduate Black students' perceptions of barriers and opportunities for research at a Historical Black College and University (HBCU) by focusing on freshmen who are yet to take any formal undergraduate research experiences, though some of them may have limited experiences during high school. Most of the literature[6,7,9-13] reviewed focuses on the factors that support or limit students' access and attitudes towards research among a broader population which includes the benefits of undergraduate research experiences for participants with bachelor's degrees in STEM-related disciplines, linguistic students, medical science students, and aspiring freshmen and college seniors STEM majors. The participants in the aforementioned studies have had one or more undergraduate research courses or an introduction to a research methodology course. We intend to investigate the perceptions of freshmen students concerning the barriers and opportunities to research among black students and if this perception is different among the genders of the participants.

Theoretical Framework
In this study, we used a social cognitive career theory (SCCT) of Lent[14] which allowed us to use "the measures of individual's efficacy, outcome expectations, personal inputs, and backgrounds, and contextual support and barriers to describe in more details the reasoning behind students' choice of academic majors and career" in STEM fields[15]. In particular, the SCCT' interest model (interest in career-relevant activities are a result of self-efficacy and related outcome expectations, SCCT's choice model that career-related interests foster a specific educational and occupational choice goals, SCCT's performance model- which involve both ability and motivations to examine and explore students' academic or career choices.

Method
Sample: This study surveyed 74 freshmen STEM students from Computer Science (13), Chemistry (5), and Biological Science (56) who were enrolled in a special project-based flip-precalculus class for high achieving STEM majors from a Historic Black College and University (HBCU) in the eastern part of the United States of America in the fall of 2017. Following the approval of the institution's IRB committee, students were contacted between class lectures and invited to participate in the survey. Participation in the study was voluntary and confidentiality was highly maintained. In addition, a copy of the informed consent was distributed to the participants.

Questionnaire: An adapted Attitudes toward Research (ATR) survey with 31 close-ended and 5-point Likert Scale questions from previous studies[16,17], that are appropriate for the study was administered to students by the researchers and were collected immediately after completion. The questionnaire consists of questions related to research interests, and perceived barriers or opportunities for research access. The participants comprised of $11(15\%)$ males, $63(85\%)$ females. Of the total of 74 students whose report is presented here, only 25 (34%) have previous research experiences in their high school.

Data analysis: Questions from the questionnaire were grouped into 7 factors to form a Likert scale data: research usefulness and relevance to life and career, access to research, positive attitudes to research, negative attitude to research, prerequisite and qualifications for research and research difficulty were created. Of the questions, 4 questions measure research anxiety, 8

questions measure research usefulness and relevance to life and career, 2 questions measure access to research, 8 questions measure positive attitude to research, 2 questions measure negative attitude to research, 2 questions measure pre-requisite and qualifications to research and 3 questions measure research difficulty. A reliability test was conducted on each of the factors where a Cronbach subscale's alpha of 0.70 or more indicates that the subscale has an adequate level on inter-item reliability.

A descriptive statistic was used to describe demographics. The average responses of the subscale factors were presented as mean ± standard deviations. Data analysis were performed by means of *R-Studio with R x64 3.4.2 for Windows*. Data was checked for normality using Q-Q plot and Shapiro-Wilk Normality test. A Mann-Whitney U-test was used to compare the difference across the gender of the students on perceived barriers or opportunities for research access measured by the research difficulty, anxiety, usefulness, perceived access to research, positive and negative attitude, prerequisite and qualifications as well as the relevance to education, life, and career.

Results
Cronbach's analysis was conducted on the factors subscale of the ATR survey and the results presented in Table 1.

Table 1: Reliability analysis

Factors	Cronbach α
Anxiety	0.72
Usefulness	0.67
Positive Attitude	0.85
Negative Attitude	0.62
Research access	0.78
Pre-requisite & Quals.	**0.02**
Difficulty	0.74

Any factor with a subscale α-level of 0.70 or more indicates that the subscale has an adequate level on inter-item reliability while any factor level less than 0.70 indicates that the subscale did not have an adequate level on inter-item reliability. Further analyses on those variables found that deleting any of the items would not have significantly increased the α-level as a result, student's research pre-requisite and qualification was excluded from the analysis because the subscale α-level was too low.

A five-point Likert scale is considered an interval scale and the mean is significant so the following characterization of the variable based on the mean was used: **1.0-1.80** means strongly disagree, **1.81-2.60** means disagree, **2.6 -3.40** means neutral, **3.41-4.20** means agree and **4.21-5.0** means strongly agree. Table 2 below shows the overall mean score and standard deviation of each factor of the Likert scale data. Anxiety has a mean of 2.5375. This means that the students do not have any perceived research anxiety when asked if research makes them nervous, anxious, stressful or scared. Research difficulty has an overall mean of 3.2703. This means that some of the student are neutral when it comes to research being a complex subject, difficult, or complicated. Besides, majority of the students agreed that research is useful in their career, is valuable, it will facilitate their long-term career, connected to their field, relevant to their life, and research thinking does apply to their personal

life with an overall mean of 4.2372. An overall mean of 3.7483 for positive attitude to research means that the students not only enjoy and liked doing research, but also believed that research is

Table 2: Mean and standard deviation of the variables

Variables	Mean	Std Dev.	Descriptive Equivalent
Anxiety	2.5375	0.7491	Disagree
Usefulness	4.2372	0.5190	Agree
Positive Attitude	3.7483	0.6125	Agree
Negative Attitude	2.1036	0.7664	Disagree
Research Access	2.7973	0.6477	Neutral
Difficulty	3.2703	0.8683	Neutral

interesting and benefits students. Further, the students did not agree about not having enough time and motivation for research as reflected by an overall mean of 2.1036. With questions pertaining to their perceived access to research such as difficulties in accessing research materials, finding a supervisor, and having enough time in school to do research the student's response was neutral with a mean of 2.7973. These results showed that freshman students possess positive attitudes towards research, acknowledged and know the usefulness of it. More so, they do not exhibit a negative attitude and anxiety towards research but remained neutral when it comes to difficulties and access to the research opportunities available to them in their respective departments.

The result of a Mann-Whitney U test conducted to compare perceived barriers and/or opportunities about research in STEM fields at an HBCU between males and females of freshmen STEM student is presented in Table 3.

Table 3: Mann-Whitney U-Test

Variables	Gender	N	W	p
Anxiety	M	11	322.5	0.7194
	F	63		
Usefulness	M	11	304.5	0.5266
	F	63		
Positive Attitude	M	11	307.5	0.5575
	F	63		
Negative Attitude	M	11	321	0.6996
	F	63		
Research Access	M	11	302.5	0.4972
	F	63		
Difficulty	M	11	284.5	0.3457
	F	63		

At 5% level of significance, the results shows there are no significant differences (W=322.5, p=0.7194) in the distribution of research anxiety between male and female; no significant differences (W=304.5, p=0.5266) in the distribution of research usefulness between male and female; no significant differences (W=307.5, p=0.5575) in the distribution of positive attitude across categories of gender; no significant differences (W=321, p=0.996) in the distribution of negative attitude towards research between male and female; no significant differences (W=302.5,p=0.4972) in the distribution of access to research across categories of gender;

and finally no significant differences (W=284.5, p=0.3457) in the distribution of access to research across categories of gender.

Discussion and Conclusion

 In this study, we present an exploration of freshmen's perceptions of barriers and opportunities for STEM research at an HBCU using an adapted Attitudes toward Research (ATR) survey with 31 close-ended and 5-point Likert Scale questions from previous studies[16,17] that is appropriate for the study. Our study has shown that freshman students do not exhibit a negative attitude and anxiety towards research but remained neutral when it comes to difficulties and access to the research opportunities available to them in their respective departments. Nevertheless, students believe they have positive attitudes towards research and acknowledge the usefulness of research in their life and career as an influencing factor in their attitudes towards research. Surprisingly, with respect to gender, there was no significant difference in the attitudes of students towards research in the seven research factors considered between male and female. This result is in line with the findings reported in Russell et al.[6] even though a previous study[18] have reported otherwise. An observation of this study is there are more female research activities participant than male participants. This is in contrast to previously reported studies[18,19] where male participants dominate the females in undergraduate research activities. Of note, is that there are more female than the male student's enrollment in most HBCU's due to some factors such as facing more obstacles that ranges from access to experienced teachers, rigorous high school demands, harsh discipline experience during high school and juvenile justice system, and lack of fundamental tools to get into college which may be lacking in black neighborhood. We believe that this unproportionate disparity may have some causal effect in determining the significance between the perceptions of barriers and opportunities across gender.

From the findings of this research, we believe that freshmen students in STEM programs should be exposed to research early and a way to achieve this is by engaging them in authentic research experiences. Thus, in line with previous research findings[6,7,20] that engaging freshmen student in authentic research experiences have an influence on students' level of engagement, interest in science, and retention in STEM majors and careers. So, we propose intentional HBCU faculty involvement in the active recruitment and retention of our minority students through exposure and engagement in early and sustained research opportunities. These include traditional-based research experiences or course-based undergraduate research experiences (CUREs) to broaden participation in STEM majors and the workforce in broadening the participation of minorities in STEM fields. Scholars such as Russell et al.[6] suggested that "an effective time to attract students to STEM may well be while they are in elementary school" (p. 548) so providing these students with these authentic research exposures is an effective way of introducing students of different backgrounds to research, thereby potentially broadening the diversity of the workforce and scientific community.

There were certain limitations to this study. First, the sample size was small (N=74). The low sample size may not be an accurate representation of the entire population of freshman STEM students since our focus was on STEM majors who are registered in a special precalculus class. Secondly, the disparity between the male and female participants in the study was too large. Although, this reflects the demographic representation of STEM majors in the University, studies[21] have shown that black men are attending college at lower rates than black women. We hypothesize that reducing this gap may have a significant difference regarding attitudes toward

research across the categories of gender. Finally, our focus on freshmen STEM students is limited. Therefore, this study will be implemented with upper-level students this upcoming year.

Acknowledgement

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