# Students' Perceptions of Barriers and Opportunities for STEM Research: A Study of Freshmen Students at an HBCU

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*This study examined freshmen undergraduate African American students' perceptions of barriers and opportunities for research at a Historical Black College and University. Although much is known about factors that support or limit students' access and attitudes towards research among a broader population, very little is known about these factors for African American STEM students at HBCUs. With the purpose of investigating and assessing student attitudes towards research that included 6 factors categorized into research-related activities, awareness of the importance of research, perception of available resources/opportunities for research, usefulness of research to their academics and career choices, an adapted Attitudes Toward Research survey was administered to 74 freshmen students from different STEM disciplines. Results indicate that students demonstrated positive attitudes towards research, acknowledged the usefulness of research to their field and career, and indicated interests in research activities. Also, there was no difference in the distribution of the factors of research across categories of gender. Our study highlights the need to enhance student interest in research and research-related activities in STEM.*

*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. That's why President Obama set a priority of increasing the number of students and teachers who are proficient in these vital fields." A 16% increase in STEM jobs is projected in the years 2010-2020. The Department of Education shares the former President's commitment to support and improve STEM education by ensuring that all students have access to high-quality learning opportunities in STEM subjects to create a diverse work field. Considering the above, there is an urgency in the need to increase the retention of students who are recruited into STEM disciplines.

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 (Olson & Riordan 2012). In 2012, African Americans accounted for only 7.5% of all STEM undergraduate degrees and only 4.5% of doctoral degrees awarded in STEM (NCES, 2014). To meet global demands and to encourage diversity in these efforts, underrepresented populations, including 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 to determine what elements help to promote attainment among underrepresented students; to help create a strong and diverse workforce. (National Science Board, 2007; Griffith, 2010).

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 (Depass & Chubin, 2014), but also a lower STEM degree completion rates (Anderson & Kim, 2006). It is further shown that one of the benefits of undergraduate research, experiences is to help sustain student's interest in their field and help stimulate interests in STEM (Russell et al. 2007). 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.

Research experiences have a significant impact on the retention (Eagan, 2013) and career-making decisions of undergraduate students in STEM (Hurtado et al., 2009). Yet, most 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). Although most of the literature presented 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, (Russell et al., 2007), linguistic students (Belgrave et al. 2015), medical science students (Siemenset al., 2010; Memarpour et al., 2015; Ismail et al., 2014; Anbari et al., 2015), and aspiring freshmen and college seniors STEM majors (Eagan et al., 2013).

The participants in the aforementioned studies have had one or more undergraduate research courses or an introduction to a research methodology course. In our study, our focus is on freshmen who are yet to have any formal undergraduate research experiences, though some of them may have limited experiences during high school. 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 et al. (1994), 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 (Kier et al., 2014, p. 6). 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 student's academic or career choices.

## METHOD

### Sample

This study surveyed 74 freshmen STEM students who were enrolled in a Precalculus and a Biology class for 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. The STEM departments of the sampled students are Computer Science, Chemistry, and Biological Sciences. 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 (Papanastasiou, 2005, 2014; Siemens et al., 2010) that are appropriate for the study was administered to students by the researchers and were collected immediately after completion. The questionnaire consists of two parts namely demographic information, questions related to research interests, and perceived barriers or opportunities for research access. The participants were 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 toward research, negative attitudes toward research, prerequisites and qualifications for research, and research difficulty. Of the questions, 4 measure research anxiety, 8 measure research usefulness and relevance to life and career, 2 measure access to research, 8 questions measure positive attitude toward research, 2 measure negative attitude toward research, 2 questions measure pre-requisites and qualifications toward research, and 3 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 was performed by means of *R-Studio with R x64 3.4.2 for Windows*. The 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 genders 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, prerequisites and qualifications, as well as the relevance to education, life, and career.

**RESULTS**

The demographic characteristics of participants is presented in Table 1 below.

**TABLE 1**
**DEMOGRAPHY OF RESPONDENTS**

| *Demographic variables* | | *N (%)* |
|---|---|---|
| Gender | Male | 11(15) |
| | Female | 63(85) |

Cronbach's analysis was conducted on the factors subscale of the ATR survey and the results presented in Table 2. For *research, the anxiety* subscale's $\alpha$-level was 0.72. For *research usefulness, the subscale* $\alpha$-level was 0.67, for *perceived access to research,* the subscale $\alpha$-level was 0.78, for *a positive attitude to research* the subscale $\alpha$-level was 0.85, for *negative attitude to research*, the subscale $\alpha$-level was 0.62, and finally, for *pre-requisites and qualifications for research, the subscale* $\alpha$-level was 0.02. Question item 6 on the survey was deleted to increase the reliability subscale $\alpha$-level for *research difficulty* from 0.37 to 0.78. Any factor with a subscale $\alpha$-level of 0.70 or more indicates that the subscale has an adequate level of inter-item reliability, while any factor level less than 0.70 indicates that the subscale does not have an adequate level of inter-item reliability. Further analyses of those variables found that deleting any of the items would not have significantly increased the $\alpha$-level.

**TABLE 2**
**RELIABILITY ANALYSIS**

| *Factors* | Cronbach $\alpha$ |
|---|---|
| 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 |

A five-point Likert scale is considered an interval scale and the mean is significant. In line with Mohd et al. (2011) and Alos et al. (2015), the following characterization of the variable based on the mean was used.

**TABLE 3**
**LEVEL OF VARIABLE**

| *Mean Score* | *Description* |
|---|---|
| 4.21-5.0 | Strongly Agree |
| 3.41-4.20 | Agree |
| 2.61-3.40 | Neutral |
| 1.81-2.60 | Disagree |
| 1.0-1.80 | Strongly Disagree |

Table 4 shows the overall mean score and standard deviation of the Likert scale data. From it, the overall mean scores for each of the factors. With a mean of 2.5375, the student's response shows they do not have any perceived research anxiety when asked if research makes them nervous, anxious, stressful, or scared of research. Research difficulty has an overall mean of 3.2703. This means that some of the students are neutral when it comes to research being a complex subject, difficult, or complicated. Further, the majority of the students agreed that research is useful in their career, is valuable, will facilitate their long-term career, is connected to their field, relevant to their lives, and research thinking does apply to their personal lives, with an overall mean of 4.2372. An overall mean of 3.7483 for a positive attitude toward research means that the students not only enjoy and like doing research, but also believe that research is interesting and benefits them.

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. Finally, as mentioned under the *data analysis section, the* student's research pre-requisite and qualification was excluded from the analysis because the subscale $\alpha$-level was too low.

**TABLE 4**
**MEAN AND STANDARD DEVIATION OF THE CHARACTERISTIC VARIABLE**

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

These results showed that freshman students possess positive attitudes towards research, acknowledge it, and know its usefulness. 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.

**TABLE 5**
**MANN-WHITNEY U-TEST**

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

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 5.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 (Papanastasiou, 2005, 2014) and Siemens et al. (2010)) that are appropriate for the study.

Our study has shown that freshman students do not exhibit a negative attitude or anxiety towards research but remain 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 lives and careers 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 males and females. This result is in line with the findings reported in Russell et al. (2010), even though a Burgoyne et al. (2010) reported otherwise.

Although previous research such as Siemens et al. (2010) has shown that students with previous experiences have better attitudes towards research, the result of our study showed that students have a positive disposition towards research, even though only a handful of the participants reported having previous research exposure while in high school. A similar finding was reported by Belgrave et al. (2015) when they investigated linguistic student's attitudes towards research studies among linguistic students, albeit a little different. An observation of this study is that there are more female participants in research activities than male participants. This contrasts with previously reported studies where male participants dominate females in undergraduate research activities (Salgueira et al., 2012; Burgoyne et al., 2010). Of note, is that there are more female students than male student's enrollment in most HBCU's. We believe that this unproportionate disparity may have some causal effect in determining the significance of perceptions of barriers and opportunities across genders.

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 (Elaine, 2004; Eagen, 2013; Lopatto, 2007; Russell, 2007), engaging freshmen students in authentic research experiences has an influence on students' level of engagement, interest in science, and retention in STEM majors and careers. 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., (2010) suggested that "an effective time to attract students to STEM may well be while they are in elementary school" (p. 548). Finally, we argue that 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 and biology class. Secondly, the disparity between the male and female participants in the study was too large. 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.

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**REFERENCES**

Alos, S.B., Caranto, L.C., & David, J.J.T. (2015). Factors affecting the academic performance of the student nurses of BSU. *International Journal of Nursing Science*, *5*, 60–65.

Anbari, Z., Mohammadbeigi, A., & Jadidi, R. (2015). Barriers and challenges in research by Iranian students of medical universities. *Perspectives in Clinical Research*, *6*, 98–103.

Anderson, E.L., & Kim, D. (2006). *Increasing the success of minority students in science and technology* (No. 4). American Council on Education.

Bangera, G., & Brownell, S.E. (2014). Course-based undergraduate research experiences can make scientific research more inclusive. *CBE—Life Sciences Education*, *13*, 602–606.

Belgrave, K.L., & Jules, J.E. (2015). Students' attitudes towards research: Applying best practice principles through a student-centered approach. *Students Attitudes towards Research*, pp. 1–18.

Burgoyne, L.N., O'Flynn, S., & Boylan, G.B. (2010). Undergraduate medical research: The student perspective. *Medical Education Online*, *15*, 5212.

Chubin, D.E., & DePass, A.L. (2014). *Understanding interventions that broaden participation in research careers: Growing the Community* (Vol. IV). Understanding-interventions.org.

Eagan, M.K., Jr., Hurtado, S., Chang, M.J., Garcia, G.A., Herrera, F.A., & Garibay, J.C. (2013). Making a difference in science education: The impact of undergraduate research programs. *American Educational Research Journal*, *50*, 683–713.

Griffith, A.L. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters? *Economics of Education Review*, *29*, 911–922.

Hurtado, S., Cabrera, N.L., Lin, M.H., Arellano, L., & Espinosa, L.L. (2009). Diversifying science: Underrepresented student experiences in structured research programs. *Research in Higher Education*, *50*(2), 189–214.

Ismail, I.M., Bazli, M.Y., & O'Flynn, S. (2014). Study on medical students' attitude towards research activities between University College Cork and Universiti Sains Malaysia. *Procedia-Social and Behavioral Sciences*, *116*, 2645–2649.

Lopatto, D. (2007). Undergraduate research experiences support science career decisions and active learning. *CBE—Life Sciences Education*, *6*, 297–306.

Memarpour, M., Fard, A.P., & Ghasemi, R. (2015). Evaluation of attitude to, knowledge of, and barriers toward research among medical science students. *Asia Pacific Family Medicine*, *14*, 1. https://doi.org/10.1186/s12930-015-0019-2

Mina, S., Mostafa, S., Albarqawi, H.T., Alnajjar, A., Obeidat, A.S., Alkattan, W., & Abu-Zaid, A. (2016). Perceived influential factors toward participation in undergraduate research activities among medical students at Alfaisal University-College of Medicine: A Saudi Arabian perspective. *Medical Teacher*, *38*, S31–S36.

Mohd, N., Mahmood, T.F.P.T., & Ismail, M.N. (2011). Factors that influence students in mathematics achievement. *International Journal of Academic Research*, *3*, 49–54.

National Center for Education Statistics (NCES). (2014).

Olson, S., & Riordan, D.G. (2012). Engage to Excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Report to the President. *Executive Office of the President*.

Papanastasiou, E.C. (2005). Factor structure of the attitudes toward research scale. *Statistics Education Research Journal*, *4*, 16–26.

Papanastasiou, E.C. (2014). Revised-Attitudes toward Research Scale (R-ATR): A first look at its psychometric properties. *Journal of Research in Education*, *24*, 146–159.

Russell, S.H., Hancock, M.P., & McCullough, J. (2007). Benefits of undergraduate research experiences. *Science, 316,* 548–549.

Salgueira, A., Costa, P., Gonçalves, M., Magalhães, E., & Costa, M.J. (2012). Individual characteristics and student's engagement in scientific research: A cross-sectional study. *BMC Medical Education, 12,* 95–104.

Siemens, D.R., Punnen, S., Wong, J., & Kanji, N. (2010). A survey on the attitudes towards research in medical school. *BMC Medical Education, 10,* 4.