Individual and Campus Factors Associated with Institutional Commitment among Black Students in STEM Programs

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Abstract

Black students have faced historical underrepresentation in higher education, particularly in science, technology, engineering, and mathematics (STEM) programs. While many Black students declare interest in STEM fields, universities retain too few Black students to graduation. The current study used survey data and a series of regression analyses to test predictors of institutional commitment among n=116 Black undergraduate and graduate students at a research-intensive Predominantly White Institution (PWI). Science identity and higher satisfaction with program and university climates were positively and statistically significantly linked to increased institutional commitment. We also show that these relationships vary between undergraduate and graduate students and between different types of STEM disciplines (i.e., social/behavioral sciences and other STEM disciplines). Efforts must be made at the individual, program, and university levels to support the retention of underrepresented students in STEM programs, with attention paid to the unique experiences of Black students in varying disciplines and degree programs. Study findings should be interpreted in light of the single-institution sample, which may limit generalizability.

Keywords: STEM, Black students, institutional commitment, science identity

1. Introduction

Black students are historically underrepresented in STEM fields (National Academies of Sciences, Engineering, and Medicine, 2022; National Center for Science and Engineering Statistics, 2023). National longitudinal data indicate that this problem is not primarily based on lack of awareness or interest in STEM. Wang (2013) showed that around 20% of Black high school seniors intended to major in a STEM field, and, two years later, around 18% of those students had enrolled in college and had actually declared a STEM major—a higher share than White students. However, STEM programs have particularly low retention of Black students when compared to business, humanities, and social sciences fields. Black students are more likely to switch majors or drop out of college altogether than to complete a STEM degree (Riegle-Crumb, King, & Irizarry, 2019).

Despite growing recognition of this disparity, persistent barriers such as educational inequities, decreased exposure to inclusive curricula and training, and failure to support students' social capital continue to hinder retention and graduation rates for Black students in STEM disciplines (Bottia, Mickelson, Jamil, Moniz, & Barry, 2021). The failure to retain Black students in STEM programs is not only an equity issue, but a policy issue of national importance. A report by the President's Council of Advisors on Science and Technology (2020) argued that for the country to achieve global leadership in future industries, the U.S. must diversify its STEM workforce at all levels. To accomplish this goal, we must better understand factors, including individual and campus characteristics, that contribute to disproportionately low retention levels among Black students in STEM disciplines.

Colleges and universities should not wait until they learn they failed to retain Black students in STEM. Instead, they should examine proximal indicators so they can anticipate student challenges and intervene to retain students. For instance, examining institutional commitment, defined as a student's overall sense of belonging, satisfaction, and intent

to continue attending their academic institution (Strauss & Volkwein, 2004), may help colleges and universities address disparities in retaining Black students in STEM. Commitment to an academic university or program is critical to the persistence and success of students in higher education, particularly in STEM programs that are often perceived as more rigorous and isolating for underrepresented students (Bottia et al., 2021; Funk, 2022). Institutional commitment influences greater student engagement in the classroom and more frequent interactions with peers, faculty, and advisers (Wang & Kennedy-Phillips, 2013). Perhaps most importantly, institutional commitment positively predicts both students' intent to persist and their actual persistence (Hausmann, Ye, Schofield, & Woods, 2009; Nora & Cabrera, 1993; Tinto, 1975), making it crucial to understand factors that may influence institutional commitment among STEM students.

1.1 Purpose

In this paper, we address the following research questions to better understand individual and campus factors that influence Black STEM students' institutional commitment:

(1) Which individual and campus factors are related to institutional commitment?

(2) Do the relationships between individual or campus factors and institutional commitment vary by whether students were in undergraduate or graduate programs?

(3) Do the relationships between individual or campus factors and institutional commitment vary by whether students were enrolled in different types of STEM programs?

We collected and analyzed original survey data to address our research questions. Specifically, we developed a novel instrument that included several previously validated measures and surveyed n=116 students who identified as Black or African American at a Predominantly White Institution (PWI). We analyzed the survey data using linear regression models and found that student characteristics (e.g., science identity) and campus factors (perceptions of program and university climate) influenced institutional commitment among Black students in STEM. We discuss our findings and their implications in greater detail later in the manuscript.

1.2 Background Literature

Individual background characteristics and factors such as science identity relate to college student success in STEM. Science identity is defined as "the degree to which students view science as an important part of who they are, perceive themselves as science people, and can picture themselves pursuing science in the future" (Pugh, Linnenbrink-Garcia, Koskey, Stewart, & Manzey, 2009, p. 5). Students can develop science identity through a variety of experiences in higher education. For instance, Singer, Montgomery, and Schmoll (2020) found that authentic learning experiences focused on diversity and inclusion help students develop their identities as scientists. Tran, Williams, Middleton, Clark-Taylor, and Priddie (2023) further revealed that factors like science identity and high school STEM credits are predictors of postsecondary enrollment in STEM majors, and having high science identity predicted Black student persistence in a STEM scholar program (Oseguera, Park, De Los Rios, Aparicio, & Johnson, 2019). Qualitative work has illuminated how young Black women may enjoy science but still be reluctant to see themselves as future scientists (Carlone & Johnson, 2007; Wade-Jaimes, King, & Schwartz, 2021). Black students also experience STEM differently depending on whether they are in undergraduate or graduate degree-granting programs. Prior research has documented structural barriers to persistence among Black graduate students in STEM (Burt, Williams, & Smith, 2018; Burt, Williams, & Palmer, 2019).

While there is growing awareness of challenges for Black students in STEM, there remains a gap in the literature on how individual and campus factors are associated with institutional commitment among Black students. Research also needs to examine whether the influence of individual and campus factors on institutional commitment vary among potential subgroups of Black STEM students. To address these gaps, the current study examined the association between individual and campus factors (i.e., science identity, academic program climate, and satisfaction with university climate for diversity) and institutional commitment among Black students enrolled in undergraduate and graduate STEM programs. Findings are significant for both educational institutions and policymakers aiming to improve the retention and success of Black students in STEM programs, as identifying these predictors can guide targeted interventions to create more supportive and inclusive environments.

1.3 Theoretical Framework

For Black students, navigating PWIs has unique challenges. All students are susceptible to stress from being in college, but racial minority students often deal with "more unique stresses experienced by minority students that heighten feelings of not belonging and interfere with minority students' effective integration into the university community (for

example, experiences with racism, questions about their right to be on campus)" (Smedley, Myers, & Harrell, 1993). Empirical research has shown that minority stress occurs apart from the general college stress related to academics, social and emotional experiences, and concerns about finances (Arbona & Jimenez, 2014). Additionally, minority stress can compound so that minority groups experience heightened levels of stress throughout their lifetime due to exposure to societal and interpersonal stressors related to their minority status (Meyer, 1995; 2003).

Although U.S. higher education institutions have become increasingly diverse, institutional policies and structures continue to reflect that colleges and universities were created to serve predominantly white, middle- and upper-class students of traditional age (Harper, Patton, & Wooden, 2009). Increases in student stress have mirrored increases in racial/ethnic diversity on campuses (Eagen et al., 2016). Research has shown links between minority stress and poor mental health and academic outcomes among Black students (Arbona & Jimenez, 2014; Arbona, Fan, & Olvera, 2018). We draw on the theory and empirical findings around minority stress to interpret our study findings. We hypothesize that beyond traditional factors that influence student persistence in STEM (i.e., science identity, age, sex), campus stressors, which we operationalize as students' perceptions of the department and campus climate, influence Black STEM students' institutional commitment. In other words, although we do not use direct measures of minority stress in this paper, based on our theoretical framework, we use perceptions of campus and university climate as proxies or potential sources of minority stress. This aligns with minority stress models (Meyer, 2003) that illustrate the influence of environmental circumstances (e.g., program and campus climate) and minority status on general stressors, which directly influence student outcomes.

2. Methods

During the Fall 2021 semester, n=116 students at a large public university in the U.S. completed a cross-sectional online survey using Qualtrics as part of a more extensive research study on the experiences of racial/ethnic minority students enrolled in STEM programs. Eligible participants were full-time undergraduate and graduate students, 18 years or older, and currently enrolled in an in-person degree program in a STEM discipline. We relied on the National Science Foundation's broad definition of STEM fields, which included computer and information sciences, engineering, mathematics, natural sciences, and certain social and behavioral sciences such as economics (Gonzalez & Kuenzi, 2012). All participants identified as Black or African American.

The survey took about 25-30 minutes to complete. The university's Institutional Review Board granted approval of the study, and all participants provided informed consent prior to completing the survey. Students were compensated for their participation in the overall research study.

2.1 Measures

Demographic and student characteristics. Standard questions were used to collect data on age and sex. Students indicated their degree level (undergraduate or graduate) and their academic discipline within STEM (computer and information sciences, engineering, mathematics, natural sciences, or social and behavioral sciences).

Institutional commitment. Participants completed the College Persistence Questionnaire (Davidson, Beck, & Milligan, 2009), which includes a 4-item institutional commitment subscale. Example items include "How likely is it that you will earn your degree from [university]?" and "How confident are you that this the right university for you?" Participants rated items on a scale from 0 (not at all) to 4 (very much), and an overall mean score was computed. The institutional commitment subscale was previously validated with a Cronbach's alpha of 0.78 (Davidson et al., 2009). In this study, reliability analysis of institutional commitment items yielded a Cronbach's alpha of 0.61, which is an acceptable value in science education research (e.g., Griethuijsen et al., 2014).

Science identity. Science identity was assessed using four items that measure the personal importance of science to one's identity (Pugh et al., 2010; Robinson, Perez, Nuttall, Roseth, & Linnenbrink-Garcia, 2018). Items include "I consider myself a science person," "Being involved in science is a key part of who I am," "Being someone who is good at science is important to me," and "Being good in science is an important part of who I am." Participants rated items on a scale from 1 (strongly disagree) to 5 (strongly agree), and a mean score was computed. The science identity scale was previously validated with a Cronbach's alpha of 0.93 (Pugh et al., 2010). The scale had similar reliability in this study (α=0.91).

Academic program climate. Nine items adapted from the 2020-2021 Diverse Learning Environments Survey (Higher Education Research Institute, 2020) assessed how students perceive the climate and their experiences within their academic major or program. Example items include "Faculty are approachable" and "I feel a sense of belonging to my academic major." Items were rated on a scale from 1 (strongly disagree) to 4 (strongly agree), and a mean score was computed. In this study, reliability analysis of program climate items yielded a Cronbach's alpha of 0.61.

Satisfaction with university climate for diversity. Twelve items adapted from the 2020-2021 Diverse Learning Environments Survey (Higher Education Research Institute, 2020) assessed participants' satisfaction with the university in multiple areas including the racial/ethnic diversity of the faculty and staff, the atmosphere for religious differences, and the respect for expression of diverse beliefs. Participants rated their satisfaction with each item on a scale from 1 (very dissatisfied) to 5 (very satisfied), and a mean score was computed. In this study, reliability analysis of university climate for diversity items yielded a Cronbach's alpha of 0.90.

2.2 Analysis

Researchers used a series of linear regression models to analyze the associations between three predictor variables (science identity, academic program climate, and satisfaction with university climate for diversity) and institutional commitment while controlling for age and sex. Models were run in the whole sample and in samples stratified by degree level (undergraduate or graduate) and academic discipline (social/behavioral sciences and all other STEM disciplines) to examine differential associations. The research team used SPSS Version 29.0 for analyses with a 0.05 alpha level. Missing data was less than 5% for all analytic variables.

3. Results

The sample had a mean age of 21.3 years old and was 72% female and 33% first-generation students. Most participants were undergraduate students (81%) and enrolled in a STEM program in the social and behavioral sciences (54%). On a potential scale from 0 to 5, participants had a mean institutional commitment of 3.28.

For our first research question, we found that all three predictor variables were significantly and positively associated with institutional commitment (see Table 1). Specifically, increased science identity and higher satisfaction with program climate and university climate for diversity were associated with increased commitment to the university. A one-point increase in the science identity scale was positively associated with a 0.14 point increase in institutional commitment. Academic program climate had a large relationship with institutional commitment ($B = 0.73$, $p < 0.05$). Finally, satisfaction with the university climate for diversity had a moderately sized relationship with institutional commitment ($B = 0.33$, $p < 0.05$).

When the sample was stratified by degree level, positive associations between both academic program climate and satisfaction with university climate for diversity with institutional commitment were only significant among undergraduate students (see Table 1). The parameter estimates for the analyses of the undergraduate student subsample were largely similar to the findings for the whole sample. The similarity was not surprising given that undergraduates constituted the majority of the entire sample.

When the sample was stratified by academic discipline and included both undergraduate and graduate students, the positive associations between science identity and satisfaction with university climate for diversity with institutional commitment were only significant among students in the social/behavioral sciences using the NSF definition of STEM (see Table 1). The association between academic program climate and institutional commitment was only significant among students in STEM disciplines other than the social/behavioral sciences.

Table 1. Results of linear regression models examining the associations between individual and campus factors and institutional commitment, by degree and academic discipline

Individual and campus factors		Whole sample n=116	Undergraduate students n=94	Graduate students n=22	Social/behavioral sciences n=63	Other STEM disciplines n=53
	Mean (SD)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Science identity (1-5)	3.59 (1.01)	0.14 (0.06)*	0.10 (0.07)	0.14 (0.13)	0.14 (0.07)*	0.24 (0.14)
Academic program climate (1-4)	2.96 (0.39)	0.73 (0.15)*	0.73 (0.17)*	0.57 (0.38)	0.36 (0.22)	1.14 (0.23)*
Satisfaction with university climate for diversity (1-5)	3.41 (0.65)	0.33 (0.09)*	0.33 (0.10)*	0.16 (0.24)	0.34 (0.10)*	0.32 (0.18)

Note. SD = standard deviation. SE = standard error. Other STEM disciplines include computer and information sciences, engineering, mathematics, and natural sciences. Estimates control for age and sex.

*p<0.05

4. Discussion

The present study examined factors influencing institutional commitment among Black students in STEM programs, focusing on three primary predictors: science identity, academic program climate, and satisfaction with the university climate for diversity. Results indicated that all three predictors were significantly and positively associated with institutional commitment for the whole sample, which aligns with prior research. For instance, our findings are consistent with Chen et al. (2021), who found that a strong science identity is associated with increased academic performance and a greater sense of belonging, particularly for racial/ethnic minority students. Similarly, Jenkins (2012) found that perceptions of equity within academic environments play a vital role in shaping career commitment, particularly among underrepresented groups, and research by Dost (2024) emphasized the importance of feeling safe within the STEM community for underrepresented students. In conjunction with previous research, the current study suggests that strong science identity, academic program climate, and satisfaction with university climate for diversity are linked to institutional commitment among Black students. This is an important finding, because institutional commitment has been shown to support a broader sense of belonging, engagement, and actual retention within higher education (Hausmann et al., 2009; Nora & Cabrera, 1993; Tinto, 1975; Wang & Kennedy-Phillips, 2013).

These findings can be interpreted through the lens of minority stress models (Meyer 1995; 2003), as Black STEM students may perceive campus and program climate as key sources of minority stress. Meyer (2003) depicts minority stress processes as incorporating environmental circumstances with minority status, which leads to exposure to both general and minority stressors that can impact health and functional outcomes. For Black STEM students at a PWI, campus and program climate act as environmental circumstances that interact with their minority status to influence the stressors they experience. In turn, these stressors may negatively impact their health and academic outcomes, including their degree persistence. Additionally, science identity may act as an individual-level buffer within the minority stress process. Students with higher science identity may possess a clearer sense of belonging with the scientific community on campus, which could help offset stress associated with racial discrimination within the STEM environment. Science identity could be protective against stressors by fostering resilience, which is consistent with coping and stress-ameliorating factors described in minority stress models (Meyer, 2003).

When stratifying by degree level, our study revealed that the associations between program climate and satisfaction with university diversity climate with institutional commitment were only significant among undergraduate students. While graduate and undergraduate students are both members of the university environment, varying characteristics between the two subgroups may contribute to differences in associations between study predictor variables and institutional commitment. Graduate students may be at a different developmental stage than undergraduate students based on age and other existing career and family roles. Graduate students' institutional commitment may not be as influenced by university and program climate, as they may spend more time off campus than undergraduate students and mostly interact with a small group of advising faculty. Our findings for graduate students were likely limited by a small sample size. Future research should collect data from larger samples of graduate students to explore how advisor interaction is linked to institutional commitment among Black graduate students, as advisor satisfaction is associated with decreased burnout among graduate students in prior research (Allen et al., 2022).

Additionally, findings revealed nuances in the association between predictor variables and institutional commitment by academic discipline. The associations between both science identity and satisfaction with university climate for diversity with institutional commitment were only significant among students in social and behavioral sciences. These findings may result from the fact that students in social/behavioral sciences often face critiques about the rigor of their fields of study and their inclusion in the definition of STEM (Office of Behavioral and Social Sciences Research, 2010), which could drive a sense of importance around science identity to assert their place within the scientific community. As previously mentioned, Carlone and Johnson (2007) explained that science identity can either be reinforced or challenged by others. Future research should continue to examine institutional commitment and student success across a broad range of STEM fields, including areas that overlap with the social and behavioral sciences, to identify potentially transferrable ways to support Black student success across disciplines.

The association between academic program climate and institutional commitment was only significant for students in STEM disciplines outside the social/behavioral sciences such as computer and information sciences, engineering, mathematics, and natural sciences. Results suggest that program climate may be more important for students enrolled in historically traditional STEM disciplines. The National Academies of Sciences, Engineering, and Medicine (2019) emphasize that faculty are often directly involved with STEM students, actively mentoring and preparing them for careers in these fields. They also note that underrepresented students are less likely to receive mentoring than their

peers. Faculty involvement may particularly be strong for students in the hard sciences, where courses are characterized by high levels of academic rigor (Tomkin & West, 2022). Such hands-on guidance may explain the association between academic program climate and institutional commitment among students in STEM fields other than social/behavioral sciences observed in our study. Again, future research should consider variation across the broad range of STEM fields. STEM department faculty and administrators should be mindful of the climate they create, recognize that climate can predict institutional commitment, and acknowledge that Black students may perceive the climate differently than White faculty and students.

This study has several strengths, including its focus on multiple predictors of institutional commitment, which allows for a nuanced understanding of how different factors contribute to Black students' commitment to their institutions. The differentiation by degree level and academic discipline highlights populations that may benefit from targeted interventions. This paper used a novel survey instrument with previously validated items and measures to examine an important and understudied topic—institutional commitment among Black students in STEM programs at a PWI.

However, there are notable limitations. One important limitation of the study is that we did not directly measure minority stress (our theoretical framework) and instead used proxy measures to consider how perceptions of department and campus climate may influence institutional commitment by creating stressors for students. Nevertheless, our approach of focusing on measuring climate is supported by prior research, which demonstrated that students in racial/ethnic minority groups have worse perceptions of campus climate than White students (Rankin & Reason, 2005). Additionally, we note that our findings are correlational and do not support causal inference or generalize beyond the single institution sample. Finally, the use of self-reported survey data may introduce bias, as responses could be influenced by social desirability or recall biases (Hassan, 2006; Latkin, Edwards, Davey-Rothwell, & Tobin, 2017). The institutional commitment and academic program climate scales demonstrated relatively low internal consistency. While these levels fall within an acceptable range in science education research (Griethuijsen et al., 2014), they may have introduced measurement error. Furthermore, the sample was predominantly composed of undergraduate students, limiting our statistical power during stratified analyses and our ability to generalize findings to graduate student populations. Additionally, the study took place at a single PWI, which may not fully capture the diverse experiences of Black students across various academic settings.

Finally, this study intentionally focused on Black STEM students at a PWI to conduct analysis within a historically underrepresented group as opposed to comparing them to majority peers. Because of this approach, we cannot discern whether similar associations between science identity, academic program climate, satisfaction with the university climate for diversity, and institutional commitment would emerge among other racial/ethnic groups. Future research should explore these relationships across multiple student populations and institutional settings to identify whether the significant relationships found are unique to Black STEM students or are generalizable to higher education students more broadly.

5. Conclusion

Study findings have implications for institutional practice. Leaders in higher education should prioritize creating environments that actively reduce minority stressors and foster belonging for Black students in STEM. Faculty and staff, particularly those working in STEM programs, should receive professional development and training related to inclusive pedagogy and how to tailor teaching and mentoring to the unique needs of student subgroups. To foster science identity, students should be provided with opportunities for research engagement and should have exposure to mentors and role models who affirm their belonging in science. Campuses should provide targeted academic and psychosocial support for Black students, particularly in the early stages of a degree program when institutional commitment is still forming. Program and campus climate should be consistently assessed, and results should be used to inform programming and student services.

Future research should examine individual and campus factors associated with institutional commitment among Black students across multiple institutions to enhance generalizability and implement and evaluate programs for retention and success among students underrepresented in STEM fields. As departments and campuses retreat from efforts to support diversity, equity, and inclusion in higher education (Creitz, 2025), it will be increasingly important to examine the interrelationships among students' backgrounds, campus environments, and retention in STEM higher education.

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