

Exploring the Excellence of HBCU Scientists and Engineers: The Development of an Alumni Success Instrument Linking Undergraduate Experiences to Graduate Pathways

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Abstract

Historically Black Colleges and Universities (HBCUs) have made significant contributions towards ensuring Black student participation, retention, and success in science, technology, engineering, and mathematics (STEM) and continue to play a critical role in the production of graduates within these disciplines. Additionally, the pedagogical approaches, principles, and values characteristic of the HBCU experience have led to tremendous gains and success in promoting student achievement in STEM graduate programs. The dominance of HBCUs in the preparation of Black students for graduate programs suggests a need to better understand this under-explored success case and the practices of these institutions to support prospective students as they explore and apply to graduate school. Therefore, a survey instrument was designed to uncover success metrics of students that majored in STEM programs at HBCUs and have successfully transitioned into, or completed, graduate school. Survey development was built around the aims to 1) advance the contemporary telling of the HBCU undergraduate experience as a pillar for graduate success in the engineering and computer science fields, as well as 2) provide nuance to the complex pathways that have characterized success for these HBCU Alumni.

This research paper serves as a survey development paper, describing an overview of the initial survey drafted, development of its three key sections, the pilot process, the outline of the final survey instrument crafted from our pilot feedback, and the strategies and considerations implemented leading up to and during the survey deployment process. The resulting survey seeks to gather data on three major sections: (1) the dimensions of institutional climate experienced by HBCU alumni at their undergraduate institution, (2) respondent perceptions of their graduate school pathways (from preparation for and completion of graduate school), and (3) the dimensions of institutional climate and their individual success during our respondents' graduate school experiences.

Motivation

Historically Black Colleges and Universities (HBCUs) have made significant contributions towards ensuring Black student participation, retention, and success in science, technology, engineering, and mathematics (STEM) and continue to play a critical role in the production of Black graduates within these disciplines. For example, between 2002 through 2011, the National Science Foundation found that HBCUs comprised all ten of the top baccalaureate-origin institutions for Black students who went on to obtain a doctorate degree in science and engineering. Furthermore, in 2011, 24% of all Black graduates who obtained a doctorate degree in science and engineering attended an HBCU for undergraduate studies [1]. The dominance of HBCUs in the preparation of Black students for graduate programs suggests a need to better understand this under-explored success case and the practices of these institutions in supporting

prospective Black students as they explore and apply to graduate school. Furthermore, it is important to highlight not just *how* HBCUs have made their impact and strides in educational success, but also the underlying mechanisms that detail *why* HBCUs are able to produce such cases of excellence in STEM. Therefore, this paper details the development of a survey instrument designed to uncover success metrics of Black students that majored in engineering and computer science programs at HBCUs and have successfully transitioned into, or completed, graduate school. Survey development was built around the aims to 1) advance the contemporary telling of the HBCU undergraduate experience as a pillar for Black graduate success in the engineering and computer science fields, as well as 2) provide nuance to the complex pathways that have characterized success for these HBCU Alum.

However, placing *success* squarely at the center of one's research design and interests requires an awareness around the complexities of such an important, but potentially misunderstood concept. The recent National Academies of Science, Engineering and Medicine's [2] report on Minority Serving Institutions (MSIs) highlights this challenge. In their report, they underscore the need to contextualize traditional metrics of academic and STEM-pathway success through the careful consideration of the life history factors that uniquely impact students at MSIs. Therefore, we aimed to incorporate a wide, yet relevant, breadth of parameters into our survey to collect more robust and individualized success stories from our participants. Furthermore, the overall graduate pathways that are taken by students following matriculation provide an additional layer of complexity when understanding long-term success for undergraduates. For example, Crewe [3] states that success for HBCU alumni could potentially be viewed through a lens that may invariably marginalize the HBCU undergraduate preparation that was received and not properly credit these experiences as the initial condition leading to success for many graduates and professionals that are also HBCU alumni. Moreover, HBCU alumni may have unique trajectories in pursuit of their graduate degrees, either completing multiple degrees at HBCUs or only attaining their undergraduate degree at an HBCU before attending a different type of institution for graduate studies. As Crewe [3] further notes, depending on the institution that awarded the graduate degree(s), recognition of success may be framed around the alumni's non-HBCU campus environments rather than how one's undergraduate HBCU campus experiences helped lay the foundation for academic achievement. Such narratives are problematic and speak to the need to further highlight the critical and supportive role HBCUs play in producing Black STEM professionals. Additionally, there remains a critical gap in the literature that details the graduate school decision-making process for HBCU students, underscoring a need to investigate the link between undergraduate HBCU experiences to broader graduate and professional pathways.

Taking these considerations together, we have developed a survey instrument that places HBCU undergraduate experiences as the core component for how we evaluate future success and academic decisions tied to attending graduate school. Given the exploratory nature of the survey, this paper deviates from traditional instrument development papers and focuses on the methodological decisions made during the process of developing, piloting, and disseminating the survey. In particular, the paper aims to provide future engineering education researchers with

examples of processes for innovating and developing research approaches. The subsequent sections describe the survey development process, including an overview of the initial survey drafted, development of its three key sections, the pilot process, the outline of the final survey instrument crafted from our pilot feedback, and the strategies and considerations implemented leading up to and during the survey deployment process. The resulting survey seeks to gather data on three major sections: (1) the dimensions of institutional climate experienced by HBCU alumni at their undergraduate institution, (2) respondent perceptions of their graduate school pathways (from preparation for and completion of graduate school), and (3) the dimensions of institutional climate and their individual success during our respondents' graduate school experiences.

Theoretical and Conceptual Foundations

Institutional Culture & Climate

While an individual's actions are critical to the pursuit and completion of a graduate degree, we recognized a need to examine the role different facets of institutional climate play on a Black HBCU undergraduate engineering student. Hurtado and colleagues developed a framework for institutional climate based on existing qualitative and quantitative research about the experiences of racial and ethnic groups within higher education [4], [5], [6], [7]. The institutional climate in this framework is expressed using five dimensions [6]: historical, organizational, compositional, psychological, and behavioral.

The historical dimension, for instance, explores an institution's legacy and its influence on "current campus climate and practices" [8]. The organizational dimension considers those structures and processes that exist within an institution that may have unforeseen effects on individuals or groups, while the compositional dimension uses objective measures (e.g., size, selectivity) to characterize social and ethnic groups. The psychological dimension illustrates "an individual's perception of institutional responsiveness" to the issue being explored [7]. Finally, the behavioral dimension describes "the context, frequency, and quality of [social] interactions" across groups within an institution [8]. These five dimensions of climate were complemented by existing explorations of African American and Black students' perceptions of their campus culture [9], [10]. In these studies, campus culture considered (1) classroom experiences, (2) faculty-staff relationship, (3) institutional support services, (4) peer interactions, (5) student effort to learn, (6) goal development and management, and (7) institutional commitment. As a result, we integrated these components of campus culture into our understanding of institutional climate to ground our data collection approach and provide a helpful framework for uncovering ways in which institutional climate can impact how a Black HBCU undergraduate engineering or computing student navigates their post-graduate planning and decision-making.

Identity and Success

Understanding how an institution's culture and climate support students' personal identities is a crucial, albeit often overlooked, element of promoting the success, persistence, and retention of minority students within STEM disciplines [11]. Furthermore, recent studies have highlighted the relationship between race and gender (for example) in STEM identity development, demonstrating the importance and effectiveness in understanding identity in shaping Black student experiences, particularly regarding student engagement as well as barriers to success within STEM majors [12] [13].

Regarding HBCUs, these institutions seek to provide and preserve cultural aspects that are not generally reflected or offered to minoritized students within Predominately White Institutions (PWIs) and broader society. In reviewing the impact of institutional climate on student development, scholars have highlighted how HBCUs offer sustainable models of inclusive STEM environments [14]. HBCUs excel identity development through the institution encouraging student-centric approaches that honor Black students with culturally competent practices, relevant teachings, and professional training [14]. There is much to be explored in how HBCUs model responsive institutional climate. Furthermore, HBCUs afford understanding for the Black student experience and non-traditional backgrounds by leveraging culturally competent practices, by which students firmly establish their individual identity [15]. With racial identity being less of a concern, Black students have the space to explore other parts of their identity, ultimately nourishing their self-efficacy and supporting their further classroom experience and professional identity.

Fletcher et al. [16] illustrates the former and highlights the top HBCU, Spelman College as an exemplary institution. The women-only HBCU historically provides a climate that centers asset-based practices yielding an environment—regardless of external factors— of professional excellence and scholarly development. Spelman leverages the strengths and unique features of their students by ensuring that they are not only prepared to be in any sector, but they embody excellence in their lives. The notions of identity begetting success are complex and present a further complicated concept when considering the pressures placed on students to navigate academia, specifically STEM disciplines. Though these notions seem esoteric individually, the outcomes are clearly quantified through the continued success of HBCU graduates because their identities and strengths are firmly established and championed by their institution and pedagogy, then enhanced professionally yielding the HBCU Success Story.

Survey Item Development

To guide the survey development process, we focused on keeping two factors central to our process: (1) the desired sample – our priority is to explore and understand the experiences of HBCU alumni and (2) the theoretical foundations – institutional and campus climate along with identity. To prioritize the research sample, we engaged with literature, including instruments with strong evidence of validity, focused on capturing the perceptions from HBCU students as well as Black students more generally. In addition, as will be discussed, we solicited feedback from subject-matter experts in research and methods. To leverage our theoretical foundations, we

pulled from existing research on undergraduate student support, campus culture and climate, as well as relevant theoretical frameworks regarding STEM education and identity in the initial drafts of the survey (e.g., [8], [17], [18],).

Overall, the process was iterative and followed the following phases: (1) developing an initial draft of the survey, (2) engaging with subject-matter experts, (3) pilot testing with educational researchers and members of the sample, and (4) conducting a cognitive interview. The survey was designed as part of a larger study exploring the success cases of HBCUs in graduating STEM Black students who go on to obtain graduate degrees. As part of that study, the survey plays an exploratory role and will be used to prioritize institutions for recruitment for in-depth qualitative case studies [19]. To support this larger project and to allow us to explore the data without a pre-determined set of factors, the resulting survey will be analyzed first using exploratory factor analysis and then cluster analysis techniques. In preparation for that analysis, we sought to establish evidence of face and content validity during and after each of these phases [20], [21]. To establish evidence of content validity, we prepared our initial survey draft by building upon existing instruments with strong evidence of validity, used subject-matter experts to evaluate survey items, and conducted a cognitive interview. The subsequent sections outline our process in more detail.

Initial Survey Draft

The first draft of our survey was developed initially using specific items taken from an existing instrument with strong evidence of validity [9], [10]. Brown et al.'s [9], [10] instrument was developed to explore African American and Black students' perceptions of campus culture across varying institutions including HBCUs and non-HBCUs. These surveys covered the individual and institutional variables related to campus culture including (1) classroom experiences, faculty-staff relationship, (2) institutional support services, (3) peer interactions, (4) student effort to learn, (5) goal development and management, and (6) institutional commitment. These institutional variables helped to frame our own initial survey items designed to assess these same factors for HBCU undergraduates in STEM.

To construct our instrument, we also engaged in a collaborative approach, having met with a diverse field of scholars from HBCUs and MSIs dedicated to STEM education, equity, as well as experts in quantitative research. For example, throughout our development process, we received insightful review and feedback from an expert in quantitative research and psychometrics whose focus is on graduate engineering education. Their expertise in graduate student development was of primary importance in refining the scope of our initial instrument as well as in item selection. We implemented Likert scale and Select-All-That-Apply items in Section 1 of our initial survey to explore areas of professional development, research participation, and extracurricular involvement. These items were adapted from the work of Lee et al. [22], with Select-All-That-Apply items modified to cover a broad range of STEM and non-STEM student involvement and activities. These modifications were inspired by items utilized by Godwin [17] that investigated various engineering- and career-related experiences during undergrad. Additional Likert items

incorporated into the initial survey were adapted from the *Engineering Efficacy* and *Engineering Values* scales developed by Walton and Liles [18], as we initially sought to incorporate aspects of engineering identity development into our investigation of HBCU undergraduate experiences. Additionally, open-ended items were developed to target additional areas of student identity and early interests in graduate school.

Furthermore, Section 2 of the survey focused on gathering information about participants' perceptions of and preparation for graduate school. The initial open-ended questions developed assessed details concerning participant decisions to attend graduate school as well as the graduate application process. Various factors that intersect with respondent decision-making processes, including family [23], faculty, and peer influence were investigated using Likert scale items. Additionally, HBCU alumni's knowledge of existing graduate school preparation initiatives, their participation in such programs, as well as their engagement in on- and off-campus graduate school and career preparation activities were explored through our initial Likert scale questions.

Finally, to further scaffold our understanding of the successful transitions that bridge together one's experiences throughout their early scholastic career, we developed Section 3 of the survey to include aspects of one's graduate school experiences. We aimed to frame the experiences and opportunities reflected on within Section 1 around the successful transition into their graduate program, asking about such topics as preparedness, acclimation, and perceptions of their research obligations and advisor relationships within their program. We also used Likert scale items to survey respondents' perceptions of their graduate institution's campus climate. Specifically, Brown et al.'s [9], [10] items regarding institutional commitment were modified and included to investigate participants' reflections on their graduate institution of choice. Finally, we developed two open-ended questions within this section to assess (1) how their undergraduate experience most prepared them for graduate school and (2) the ways in which their undergraduate school experience was distinct from their graduate school experiences. This section was then followed by general demographic and educational background questions to further investigate potential differences in responses through an intersectional lens.

Subject Matter Expert Review - Advisory Board Feedback

The advisory board for this project included several individuals who have extensive and unique experiences and knowledge of HBCUs including being alumnae who match our target audience for the survey and others who work or have worked at one or more of the 15 ABET accredited HBCUs for over 10 years each. Each of these individuals was given the first draft of the survey and asked to complete it and provide extensive feedback including the design of the questions, flow of the questions and length of the overall survey. Recommendations ranging from the overall length of the survey to the flow of the questions were shared and incorporated where deemed necessary.

One advisory board member is a HBCU graduate and taught at a HBCU for over 10 years. They provided thorough feedback that added immense value to the final instrument. For example, one advisory board member encouraged deeper re-evaluation around how items assessing personal identity fit within the broader scope of success and graduate pathways explored in our survey. Additionally, another advisory board member was crucial in their support of refining the precise scope of several questions. They highlighted areas of concern, such as double-barreled Likert items and response options that did not clearly reflect the intent of the Select-All-That-Apply items provided. Overall, once that feedback was received, that information was thoroughly reviewed, and changes were made to the survey accordingly.

Subject Matter Expert Review - Pilot Item Testing with Broader STEM Community

We began piloting the survey in late June, including the recruitment of pilot testers that fit within our target population for the final survey. These pilot testers were chosen by our internal research team and presented with a standardized email sent out to the respective contacts of each research team member. Thus, snowball sampling was used in the recruitment of pilot testers. Email outreach included sending a request of their participation, pilot instructions, and a link to the current draft of the survey. Furthermore, in August of 2020 two authors (T.L.F. and J.P.J.) presented our Phase 1 survey to the STEM Transformation Institute (STEM TI) at Florida International University. This meeting was part of a weekly series hosted each semester for researchers across various STEM departments (consisting primarily of faculty, postdoctoral researchers, and graduate students) to present their current work. Those in attendance completed our survey and provided their feedback through group discussion as well as through a Google form provided during the presentation. Taken together, 42 participants completed the pilot survey.

Striking a balance in developing a clear and concise survey that also aimed to assess a great deal of information regarding students' academic journeys (from undergraduate experiences to successfully enrolling in graduate school) was a clear theme that emerged from our pilot test presentation with STEM TI. That is, the feedback received from the STEM TI scholars highlighted concerns around the length of the survey as well as discussion of potential formatting options (i.e., the merits and potential constraints of choosing matrix items as opposed to individual Likert items) that may ameliorate time to complete while still preserving the depth of topics explored. Additional feedback also allowed us to also reflect on the use of key academic terms used in the survey language (e.g., intersectionality), which while accurate in their use, may deter from providing clarity for respondents when interpreting survey items.

Cognitive Interview

Cognitive interviews provide a fruitful opportunity to have a survey respondent understand and verbally express their mental processing of each question as they walkthrough the survey with the interviewer [24]. In doing so, researchers can refine the survey instrument as to increase the likelihood that questions are well understood as intended, so that respondents may ultimately

provide more thoughtful and relevant answers that align with the instrument's design goals [24]. A two-hour cognitive interview with an advisory board member was conducted by one co-author (J.P.J.). The advisory board member that participated in the cognitive interview was prompted to take the full pilot survey aloud and, as a respondent, discuss their initial reactions and interpretations of each question in addition to offering their answers to each question based on those interpretations. Following the interview, the advisory board member transitioned into the role of consultant (from previous survey respondent during the interview) and provided additional feedback as to how to best improve the survey. This included recommendations around item wording and structure to help reduce incongruence between our intended meaning of a survey item/question and how they perceived that same item/question.

Responses from the interviewee were insightful in helping revise survey flow and organization, so that we could more clearly assess success stories at key transitional periods in a student's academic journey (i.e., from undergraduate, to decision making about graduate school application, to first year graduate school experiences). Finally, thoughtful responses regarding the different conceptual interpretations of success were encouraging in helping us further refine items for inclusion in the final survey, as seen in Tables 1 and 2 below, particularly for those items inquiring about experiences with barriers to success (such as prejudice and discrimination).

Final Survey Revisions

Table 1. Item Frequencies by Type (Pilot)

Item Type	Section 1: Undergraduate Decisions	Section 2: Application Decisions	Section 3: Graduate Decisions	Total
Open-Ended	3	1	2	6
Likert	20	18	13	51
Select-All-That-Apply	3	0	0	3
Matrix	0	0	0	0
Total	26	19	15	60

Table 2. Item Frequencies by Type (Final)

Item Type	Section 1: Undergraduate Decisions	Section 2: Application Decisions	Section 3: Graduate Decisions	Total
Open-Ended	3	1	2	6
Likert	15	7	8	30
Select-All-That-Apply	3	1	0	4
Matrix	0	2	1	3
Total	21	11	11	43

For the final version of the survey, three Matrix questions (which themselves include 4-5 Likert Items) were included and allowed us to decrease the total number of individual/independent

Likert items across the three sections of the survey by 41%. This change helped directly address Pilot and Advisory Board concerns regarding length of the survey while preserving the depth/breadth of the survey because Matrix questions featured contextually similar items. For example, the first Matrix questions are all about factors that encouraged participant to apply to grad school to begin with. The second Matrix concerns factors that influenced the programs they prioritized applying for and the third Matrix explores which aspects of undergrad most prepared them for grad school experiences. Consolidating contextually similar Likert items in a Matrix allowed for more unique Likert items covering a breadth of topics to stand out better and hopefully minimize attrition by not overwhelming participants with infinite scrolling and perceived lack of progress. For example, the grad school sections asked more unique questions about participants' views of their own success, that is, their confidence in grad school, influence of lack of diversity within program, ability to communicate their ideas to advisor, etc. Essentially, we took deeper dives into respondents' program experiences.

Content

Items developed through learnings from literature were cut, slightly modified, or changed entirely in service to the HBCU specific topics our team needed to explore. For example, questions designed around Walton and Liles [18] and Brown et al. [9], [10] were edited extensively or removed because they were too general relative to the scope of our survey. Particularly, the Walton and Liles [18] items were almost removed completely by the time we reached the final version of the survey because "engineering identity" did not become as much of a focus towards the end as it was at the beginning, prior to the pilot phase. We chose to approach identity questions more generally by asking open-ended questions about which aspects of the participant's identity were or were not supported in undergrad. In the graduate school section, we asked whether undergraduate or graduate experiences played a bigger role in developing a strong researcher identity. Based on this, Walton and Liles [18] inspired portions of the identity-based questions, but none of their items were used. Lastly, Brown et al. [9], [10] items that remained were modified to have a more HBCU specific context. (e.g., institution climate, classroom experiences, faculty and staff / social support, peer interactions items) and were strategically narrowed in focus and changed to reflect some specific aspect of HBCU experiences. For example, asking students if they felt their faculty served as role models (or about other aspects of mentoring, in general) or asking about how their HBCU's values and principles encouraged them to achieve academic success.

Data Collection Strategies and Considerations for Dissemination

The initial plan included releasing the survey, as documented within our established timeline for the grant, around January of 2020. During our initial call with our advisory board, it was quickly realized that we did not allocate enough time for the development of the instrument. Then, in March of 2020, two months later, the COVID-19 pandemic interrupted most operations within higher education institutions. Our team continued to work on the development of the survey throughout the rest of the Spring and used the summer and early fall as an opportunity to review

the final draft of the survey with the advisory board and other groups as a part of the pilot process. During this time, members of our team were contacted by NSF, because of this project, to investigate the impact of COVID-19 on engineering at HBCUs. Therefore, we then had two projects going simultaneously that focused on overlapping populations, in some instances. This was in addition to the survey fatigue that had been reached given the extensive data collected during the pandemic. Given the unprecedented times and events taking place, our team decided to wait until late fall 2020 to release the survey instrument.

The target audience for the survey consisted of students who were currently enrolled or planning to enroll in a graduate level degree who received a bachelor's degree in engineering or computing from a HBCU or someone who received any type of undergraduate degree from an HBCU (most likely STEM) who was currently pursuing or completed a graduate level degree in engineering or computing. Therefore, there were two primary pathways for reaching these individuals. First, HBCUs who had ABET accredited engineering and/or computing programs, approximately 15 total, were documented and contacts at those institutions were contacted. Second, the National Science Foundations (NSF) list of top 50 baccalaureate origin institutions who graduate the most Black students, in particular, who go on to receive a PhD in science or engineering was used to expand the contact list [1]. This source highlighted several additional HBCUs that play a critical role in our research focus even though they may not have an engineering program, college, or school. For example, Clark Atlanta University, Morehouse College, and Spelman College (also referred to as the AUC) have a dual-engineering degree program that has been in existence for over 40 years. As a part of that 2+3 program, many of the students transfer to 4-year institutions that have engineering programs and complete their degrees there. Additionally, our team created a database of contacts at HBCUs or organizations that work closely with HBCUs (i.e., United Negro College Fund (UNCF), National Society of Black Engineers (NSBE), etc.) in preparation for the releasing of our survey. Overall, once that list was finalized, emails and social media posts were sent to varying individuals at their institutions including faculty, staff, deans, department chairs, and even executives including provosts and presidents of the institutions.

Finally, we created the Twitter account, @STEMathHBCUs, to have an outlet for survey outreach as well as to supplement email outreach, especially given the current COVID-19 pandemic and various forms of communication being used. Our goals included reaching as many individuals who qualified for the survey as possible to conduct a cluster analysis as the basis for selecting institutions to recruit for a more in-depth qualitative study of these success cases (see [19] for more detail on the phases of this project). The survey was released via email and social media platforms (i.e. Twitter, Facebook, LinkedIn, etc.) in December of 2020. Additionally, we released the survey again in January and February of 2021 to increase our outreach efforts.

Discussion and Future Work

The motivation that drove the creation of our instrument centered on being able to highlight future survey results concerning these cases of student success in STEM not only to institutional

stakeholders at HBCUs, but also stakeholders at PWIs and other MSIs who strive to increase enrollment and persistence numbers for Blacks in engineering and computing. We hope that through our contribution, the implementation of this survey instrument will further insight within STEM, chiefly engineering and computer science, so that such spaces for the expression of Black academic success and excellence can become commonplace across all institutions. This work seeks to shed light on the areas where additional resources would secure the continued and further success of Black STEM students across a wide variety of institutions. In doing so, we may potentially reveal issues of inequity and encourage the dismantling of these academic barriers. Additionally, we aim to amplify the voices of these success cases and highlight the continued need to support HBCUs in championing Black student participation and excellence in STEM, which is vital in ensuring the future of education in our country.

Acknowledgements

The information provided in this paper is based upon work supported by the National Science Foundation under Grant Award 1923229. Any opinions, findings, and conclusions or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. The authors thank N'Khoy Stoutt for his commitment to survey development. The authors also give a special thanks to the advisory board for their expertise and guidance throughout this project as well as to the STEM Transformation Institute.

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Appendix

Below are the three main blocks of the survey.

BLOCK 1: Undergraduate Experience

Likert Items (7-Point; Strongly Agree to Strongly Disagree):

Please identify the degree to which you agree or disagree with each statement below concerning the academic support you received and your overall experiences at your undergraduate HBCU.

1. *Attending an HBCU helped give me the confidence to pursue a graduate degree.*
2. *I developed connections with influential members (i.e., faculty, administration, or staff) of my undergraduate HBCU.*
3. *Faculty at my undergraduate institution served as my role models for how to achieve academic success.*
4. *The values and principles of my undergraduate HBCU encouraged me to achieve academic success.*
5. *My interactions with academic support staff (i.e., advisors) had a positive influence on my academic success as an undergraduate student.*
6. *I was well informed about the academic support services (e.g., tutoring, writing assistance, etc.) that were available to me at my undergraduate institution.*
7. *I received sufficient financial assistance (i.e., Pell grant or scholarship) during my time as an undergraduate.*
8. *My undergraduate institution properly addressed discriminatory words, behaviors, symbols, attitudes, or gestures directed at students.*
9. *Please identify the degree to which you agree or disagree with each statement below concerning the academic support you received and your overall experiences at your undergraduate HBCU.*
10. *I received support regarding my overall professional development (e.g., resume writing, interview preparation, career fairs, etc.).*
11. *I regularly interacted with STEM students who planned to apply to and attend graduate school.*
12. *I regularly interacted with STEM students from different demographic groups (e.g., different races, genders, ages, etc.).*
13. *I received helpful information about STEM-related opportunities (e.g., research, academic, professional, etc.) from my student peers.*
14. *Overall, I was empowered by my professors' commitment to my academic success.*
15. *I had a STEM faculty member whom I considered as my mentor.*
16. *Overall, faculty members encouraged me to make connections with my classmates.*

Select-All-That-Apply and Multiple Choice Items:

17. *Which of the following research or academic opportunities did you complete during your time at your undergraduate institution? Please select all that apply.*

- *Participated in an internship, co-op, or field/lab work*
 - *Participated in a summer bridge program*
 - *A TRIO research program (e.g. Louis Stokes Alliances for Minority Participation (LSAMP), Ronald E. McNair Program, etc.)*
 - *The Maximizing Access to Research Careers (MARC) Undergraduate Student Training in Academic Research (U-STAR) program*
 - *HBCU-UP Program or an HBCU focused research program*
 - *Conducted undergraduate research at your institution*
 - *Conducted undergraduate research at another institution*
 - *Attended a research conference*
 - *Attended a professional development conference/workshop*
 - *Presented at a research conference*
 - *Published a peer-reviewed article in an academic journal*
 - *Other, please specify: _____*
 - *None of the above*
18. *How many semesters (including Summer) did you spend doing undergraduate research?*
- *0*
 - *1-2*
 - *3-4*
 - *5-6*
 - *7 or more*
19. *During your time at your undergraduate institution, which of the following student organizations, if any, were you involved in? Please select all that apply.*
- *A non-STEM related fraternity or sorority*
 - *A non-STEM related honor society*
 - *A volunteering / community outreach organization*
 - *A faith-based student organization*
 - *An LGBTQ+ student organization*
 - *A non-STEM study abroad program*
 - *Other, please specify: _____*
 - *None of the above*
20. *During your time at your undergraduate institution, which of the following STEM activities, if any, were you involved in? Please select all that apply.*
- *An out-of-class student design project / competition*
 - *A STEM-related fraternity or sorority (e.g., Theta Tau, Alpha Omega Epsilon, etc.)*
 - *A STEM-related honor society*
 - *An engineering or computing student organization (e.g., NSBE, SWE, ASCE, etc.)*
 - *An engineering or computing outreach / service organization (e.g., Engineers Without Borders)*
 - *A TRIO student support program*
 - *A STEM-related study abroad program*
 - *Other, please specify: _____*
 - *None of the above*

Open-Ended Items:

21. *Please explain which undergraduate experiences and / or interactions contributed the most to your decision to pursue graduate school?*
22. *Please explain what aspects of your personal identity (e.g., race, ethnicity, gender, sexual orientation, etc.) were supported during your time at your undergraduate HBCU.*
23. *Please explain what aspects of your personal identity were NOT supported during your time at your undergraduate HBCU?*

BLOCK 2: Graduate School Applications and Decisions

Matrix Items (7-Point; Strongly Agree to Strongly Disagree):

1. Please rate your level of agreement regarding how the following factors played a role in encouraging your decision to apply for graduate school.
 - *My family encouraged me to apply to graduate school*
 - *My professors encouraged me to apply to graduate school*
 - *My student peers encouraged me to apply to graduate school*
 - *My decision to apply to graduate school was positively influenced by my experiences with STEM-related organizations*
 - *My decision to apply to graduate school was positively influenced by the research opportunities I participated in*
2. Please rate your level of agreement regarding how the following factors played a role in the way you prioritized the graduate programs that you applied to.
 - *I prioritized applying to graduate programs that best fit my research interests*
 - *I prioritized applying to graduate programs that were reputable*
 - *I prioritized applying to graduate programs that I was confident I would get accepted into*
 - *I prioritized applying to graduate programs that were near home*
 - *I prioritized applying to graduate programs that were affordable and / or provided financial support*

Likert Items (7-Point; Strongly Agree to Strongly Disagree):

Please identify the degree to which you agree with each statement regarding your decision to apply to graduate school as well as the application process.

3. *My family's preferences for specific graduate programs influenced the applications I chose to submit.*
4. *The graduate programs I decided to apply to were influenced by my faculty mentors and / or professors.*
5. *I struggled between deciding to apply for graduate school or applying for work (or continuing work) after graduation.*
6. *I was worried applying to a graduate program would conflict with my commitments to my family.*
7. *I was encouraged to attend a non-HBCU for graduate school.*
8. *I was encouraged to attend an HBCU for graduate school.*
9. *Attending graduate school was a common expectation of students in my undergraduate major.*
10. *I was confident I would be successfully accepted to a graduate school program.*

Select-All-That-Apply Items:

11. *Which of the following resources did you use when applying for graduate school? Select all that apply.*
 - *Standardized test preparation resources (e.g., tutoring for standardized tests, practice tests, online services, etc.) (1)*
 - *Resources provided by my undergraduate institution (e.g., workshops, presentations, etc.)*
 - *Resources offered outside of my undergraduate institution (i.e., from other organizations)*
 - *Guidance from peers who already had or were also applying to graduate school*
 - *Guidance from faculty mentors*
 - *Guidance from academic advisors and other academic support staff*
 - *I did not use any resources when applying to graduate school programs*

Open-Ended Items:

12. *What other details would you like to share about your decision to go to graduate school and / or your application process?*

BLOCK 3: Graduate School Experience

Matrix Items (7-Point; Strongly Agree to Strongly Disagree):

1. Please rate your level of agreement each of the following statements. Each statement reflects how an aspect of your undergraduate experience prepared you to succeed as a graduate student.
 - *STEM-related courses from my undergraduate degree prepared me for my graduate school coursework*
 - *The STEM-related research opportunities outside of my courses prepared me for my graduate research*

- *The academic support I received at my undergraduate institution (has) helped me transition into my first semester (or quarter) of graduate school*
- *Overall, my undergraduate institution prepared me for academic success as a graduate student*

Likert Items (7-Point; Strongly Agree to Strongly Disagree):

Please identify the degree to which you agree or disagree with each statement regarding your experiences in graduate school.

2. *I was confident in my success as a graduate student upon completion of my first year in my graduate program.*
3. *My research experiences at my undergraduate institution have helped me to develop a strong identity as a researcher during my time in graduate school.*
4. *My research experiences at my graduate institution have helped me to develop a strong identity as a researcher during my time in graduate school.*
5. *I was confident I could meet the expectations of my graduate advisor when I started the graduate program.*
6. *I am / was confident in communicating my ideas with my graduate research advisor.*
7. *A lack of diversity within my graduate program had a negative impact on my mental health.*
8. *I am confident I made the right choice in choosing the institution I attend / attended for graduate school.*
9. *Overall, I am satisfied with my decision to attend graduate school.*

Open-Ended Items:

10. *Please share any additional details regarding how your undergraduate experiences prepared you to be successful as a graduate student.*
11. *Please share any additional details regarding how similarities or differences in your undergraduate and graduate school experiences may have influenced your success in graduate school.*