

A Review of the Literature on Students' Experiences in Historically Black Colleges and Universities Dual-Degree Engineering Programs

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Abstract

Historically Black Colleges and Universities (HBCUs) have faced challenges in developing and maintaining engineering programs due to the lack of equitable resources including funds and technology. Partnerships between HBCUs and Predominantly White Institutions (PWIs) have emerged as a way to increase the number of Black students in engineering through Dual Degree Engineering Programs (DDEP), often classified as 3-2 programs. Students in these programs attend an HBCU to complete all pre-engineering courses (typically three years) and spend their final undergraduate years (typically two) at a PWI. At the end of the program, students would have earned two bachelor's degrees, one from the HBCU in a science, technology, engineering, or mathematics (STEM) field and the other from the PWI in an engineering discipline. While there are many advantages to institutional collaborations, HBCU students must learn to adapt to an entirely new system and culture at the PWI.

This scoping literature review examines research on Black students as they matriculate into a PWI from an HBCU while pursuing an engineering degree. The primary objective of this literature review is to gain a deeper understanding of the experiences of Black students in DDEPs bridging HBCUs and PWIs. The review specifically sought to address students' motivations for enrolling in DDEPs, the benefits and challenges involved with making the transition from an HBCU to a PWI, the factors contributing to their decision to pursue such a program, and their expectations regarding these experiences at the two distinct types of institutions. A total of 19 articles were identified and reviewed. Three main categories surfaced from the literature review, with two subcategories within the first theme: 1) references to HBCU DDEPs without the inclusion of student experiences; 1a) goal of increasing the number of Black students in STEM; 1b) engineering degree pathways; 2) HBCU student support and resources; and 3) the experiences of HBCU students in DDEPs. Synthesizing the literature revealed a crucial need for additional research on HBCUs in general. The study's results emphasize the necessity for exploring the lived experiences of students in HBCU DDEPs. Further exploration could focus on the support and resources provided by institutions to students during their transfer to PWIs. This exploration of DDEPs promises to offer valuable insights into how DDEPs between HBCUs and PWIs can effectively and successfully prepare Black engineering students for their future careers. The findings from this literature review identify areas for future research.

Introduction

The Morrill Act of 1862 marked the establishment of engineering as a major at institutions now recognized as Predominantly White Institutions (PWIs). At that time, the engineering collegiate culture systematically excluded minoritized groups. More notably, the path to obtaining a degree in engineering was not designed for and did not allow Black individuals to participate. Between that timeframe and the mid-1900s, a very small number of PWIs eventually allowed Black students to enroll in engineering. Historically Black Colleges and Universities (HBCUs), which were established in the mid to late 1800s, provided a pathway for most of the nation's black students to pursue degrees in the field. By 1965, the Higher Education Act, as amended, created an official HBCU designation and described it as an institution established and accredited, or in

progress toward accreditation, before 1964, with the principal mission of educating Black Americans (Arroyo & Gasman, 2014).

Since its inception, many HBCUs have grappled with the challenge of securing equitable resources, such as funds and technology (Harris, 2021). To this day, HBCUs are owed millions of dollars in funds promised to them by the American government (Harris, 2021). Throughout history, HBCUs have been compelled to substantiate their competence and relevance (Outcalt & Skewes-Cox, 2002), contending with the burdens of sustaining a fully functional university with minimal resources. On a positive note, policymakers have become increasingly aware of these challenges and have been prompted to not only push for rectifying the funding imbalance but also highlight the benefit to the nation by increasingly making use of this unique community within higher education.

In 2019, the National Academies of Science, Engineering, and Medicine (NASEM) released the report *Minority Serving Institutions (MSIs): America's Underutilized Resource for Strengthening the STEM Workforce*, elevating the conversation that MSIs have not been adequately researched or utilized to increase broadening participation efforts in within science, technology, engineering and mathematics (STEM). For HBCUs, their success in graduating Black students in STEM was highlighted along with the missed opportunity of advancing their efforts to assist the U. S. goal of staying competitive within the STEM workforce (National Academies of Sciences, Engineering, and Medicine, 2019). For example, scholars found that HBCUs, while only accounting for 3% of all post-secondary institutions in the United States, graduated 17% of all Black students (Gasman & Nguyen, 2016). Additionally, as of 2019, 14.5% of Black graduates were from HBCUs even though they made up less than 1% of all ABET-accredited programs (ABET, 2019; Deen, 2019; Fletcher et al., 2023). For Black women, a group representing less than 1% of all engineering degrees conferred annually, HBCUs graduated 22.5% of Black women with engineering degrees (Fletcher et al., 2023). These statistically significant findings articulate the value, impact, and importance of engineering at HBCUs and are an indicator of the potential of HBCUs within efforts to broaden participation in engineering. Even with this promising information, there continues to be visible underutilization of the institutions.

The area of Black students' journeys to degree completion and experiences at PWIs has been studied and reveals the intricate nature of their encounters. Additionally, studies have demonstrated that the journeys of Black students in engineering at HBCUs involve pivotal faculty interactions, heightened engineering identity, a profound sense of purpose, and a compelling sense of community (Fleming et al., 2013). The unique intersection of Black students' experiences in engineering across and within varying institutional types, however, appears to be less explored. Specifically, there is a gap in understanding related to the experiences of Black students who pursue undergraduate engineering degrees through DDEPs. Therefore, this paper aims to delve into the literature concerning the experiences of students at HBCUs enrolled in DDEPs.

Methods

Google Scholar: This is an online search engine housing a record of full text (or metadata) of scholarly publications across a variety of platforms and types (i.e. abstracts, books, conference proceedings, dissertations, masters thesis, peer-reviewed journals, technical reports, etc.) was

utilized as it not only housed articles from the highest rated and most cited engineering education journals (i.e. Journal of Engineering Education, International Journal of Engineering Education, etc.), it also provided access to non-conference and journal publications such as interviews from magazines, government reports and book chapters that would not have appeared in a direct search of those journal databases.

American Society of Engineering Education (PEER): this database was searched as a validity check to ensure that we did not miss any articles that may have not appeared in Google Scholar for any reason.

Google Search: A general exploration of the web using the key terms from above was conducted to ensure that no articles related to our study were missed.

Wikipedia: Similar to the Google search process, our team searched this source as an additional check of reports, papers, sources, etc. that may have not come up within the Google Scholar and ASEE PEER databases.

This scoping literature review employed a comprehensive approach by searching various databases. The review of papers within these databases spanned from October 2023 to January 2024. The exploration was carried out using specific keywords, namely "dual degree engineering program," "dual degree engineering," "3+2 engineering program," and "2+3 engineering program." For clarity, Table 1 presents the paper count for each keyword search alongside the corresponding database and a description of the database. An important note is that the above phrases and keywords had to appear in either the (1) subject line of the publication and/or (2) the abstract of the publication to be included in the study. Publications that met both requirements were also included in the results. While many literature reviews will include the highest number of articles found for a single database, we felt it was important to detail the number of articles found for each keyword/phrase.

Table 1. Search details for the database including the month and year the search was conducted, the term(s)/keywords used in the search, a description of the database, and the number of articles that were found.

| Database | Date of Search | Term(s) Searched | Overview of Database | Number of Articles |
|----------------|----------------|----------------------------------|--|--------------------|
| Google Scholar | October 2023 | Dual degree engineering program | An online search engine housing a record of full text (or metadata) of scholarly publication across a variety of platforms and types (i.e. abstracts, books, conference proceedings, dissertations, masters thesis, peer reviewed journals, technical reports, etc.) | 168 |
| Google Scholar | January 2024 | Dual degree engineering | | 286 |
| Google Scholar | January 2024 | 3+2 engineering program | | 84 |
| Google Scholar | January 2024 | 2+3 engineering program | | 1 |
| Google Scholar | January 2024 | "DDEP" and "engineering program" | | 27 |
| ASEE PEER | January 2024 | "DDEP" and "engineering | The Papers on Engineering Education Repository (PEER) | 4 |

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|-----------|---------------------------|---------------------------------|---|----|
| | | program" | is the source for conference proceedings published by the American Society of Engineering Education (ASEE) (peer.asee.org) | |
| ASEE PEER | October 2023/January 2024 | DDEP | | 4 |
| ASEE PEER | October 2023/January 2024 | Dual degree engineering | | 23 |
| ASEE PEER | October 2023/January 2024 | Dual degree engineering program | | 20 |

Results and Discussion

The articles were initially sorted based on their relevance to the research question. The collection of non-relevant papers primarily formed a distinct category: informational databases on HBCUs. Despite their lack of direct relevance to the research question, these papers were designated as Theme 0, as they offered valuable insights into HBCU research, an area limited in existing research. Additional categories emerged during the review and synthesis process, which involved opening and reading each document to determine how DDEPs were discussed within the paper. Three themes surfaced during this comprehensive review: 1) references to HBCU DDEPs without the inclusion of student experiences; 2) HBCU student support and resources; and 3) the experiences of HBCU students in DDEPs.

Theme 1: References to HBCU DDEPs without the inclusion of student experiences

Fourteen articles explicitly mentioned HBCU DDEPs. Within this overarching theme of referencing HBCU DDEPs, the articles can be more precisely categorized based on the reasons and context in which the authors mention it. Mention of HBCU DDEPs can be separated into three distinct groups: those that emphasize broadening participation among underrepresented minorities in STEM, those that highlight its role as a pathway to earn an engineering degree, and those remaining articles within this theme that are outside the scope of this research question.

The first cluster of articles highlights HBCU DDEPs as a way to address the global need for increasing the representation of Black students in STEM. Noteworthy article titles such as “*A cooperative program increasing minorities and women in engineering*” (Crumbly et al., 1996) and “*Developing a Summer Bridge Course for Improving Retention in Engineering*” (Volcy & Sidbury, 2013) provide insight into why these articles surfaced through our search terms and categorized in this theme. Crumbly et al. (1996) conclude by emphasizing the program's commitment to producing more minority and women engineers in the future. Within this subset, articles recognized dual degree programs as instrumental in recruiting and retaining Black students (Brooks, 2001). Other articles viewed DDEPs as an opportunity for more institutional cooperation. Darnell (2002) contends that fostering collaboration between HBCUs and PWIs in close proximity offers a practical solution for broadening participation among underrepresented minorities. Coppin State University’s 5-year strategic plan aims to address the nation’s obligation to strengthen and diversify the STEM workforce (Eugene et al., 2013). A scholarship program between Spelman and NASA targets the enhancement of representation, especially among women from minority backgrounds, in STEM fields through a DDEP (Falconer & Guy, 1989).

The DDEP collaboration between The Atlanta University Center (AUC) and Georgia Tech Institute of Technology originated to enhance STEM access for minority students and focuses on attracting and increasing minority representation in STEM fields (Jackson, 2007). All the articles in this cluster referenced DDEPs as pivotal means for creating a broader impact in developing a diverse, globally competitive STEM workforce.

The second subcategory recognizes HBCU DDEPs as a vital pathway. In a study focusing on the success of Black males at PWIs, the author highlights DDEPs as one mechanism contributing to the positive school experience for Black students (Hardnett, 2023). The AUC, a consortium-based DDEP, asserts that students who complete the program graduate with two degrees from both institutions (Jackson, 2007). Regarding Morehouse students' opportunities to earn an engineering degree through the DDEP, Joseph (2023) views it as a means to reform and innovatively teach engineering, aiming to revolutionize HBCU to R1 graduate pathways. Dr. Rockward Micro Optics Research and Engineering Laboratory at Morehouse College has pioneered a pathway for students to participate in DDEPs between a majority of institutions that specialize in optics engineering (Rockward & Morehouse College, 2002). The primary motivation for articles in this category referencing DDEPs is to propose a viable route for underrepresented minority students in engineering.

The last three articles are consolidated as the third subcategory due to their departure from the context of the literature review. One article in particular introduces a relatively novel perspective on DDEPs, showcasing noteworthy results and impressive retention rates (Carvell & Greene, 2022). Although the new program offers an alternative to the traditional 3+2 engineering model and demonstrates overall success, its relevance to the targeted audience of this literature review is not explicitly addressed. Another article merely references DDEPs in the biography of the author, who held the position of coordinator of the DDEP at the AUC (Murenzi & Clark Atlanta University, 2000). The National Research Council (1986) discusses a 3+2 curriculum as a proposal for an engineering curriculum.

All the articles within the first theme share a common absence, namely the exploration of student experiences. While these articles delve into various aspects of HBCU DDEPs, they overlook the crucial dimension of student experiences. Providing a detailed account of dual degree engineering students' lived experiences, especially their journey through the transition from attending an HBCU to transferring to a PWI, would offer valuable insights into the profound impact of these programs. It is evident that many of the review articles date back about 20 years, and even the more recent ones fail to adequately capture student experiences. Delving into this specific niche group and their encounters not only enriches the educational literature but also has the potential to outline strategies and techniques for effectively preparing and cultivating Black students in engineering.

Theme 2: HBCU Student Support and Resources

During the article review, a recurring theme emerged: there is substantial support for HBCU students in DDEPs, primarily (but not exclusively) during the initial years at the HBCU. Among the articles, five papers specifically highlighted students' access to networks and their corresponding needs. Existing literature has consistently identified support and community as an

indispensable factor contributing to the success of Black students at PWIs (Thompson & Campbell, 2013).

An article within Theme 2 acknowledges the challenges students face during the transition, emphasizing that support stems from those who have previously navigated the program and more commonly from administration on the HBCU side (Crumbly et al., 1996). The article underscores the importance of students' relationships throughout the program: "This bonding is particularly important in the challenging technical classes and in stress cultural transition from a Historically Black College to a large research university"(p. 777). Meanwhile, the Women in Science Scholars Program at Spelman University offers robust support and resources for scholars during the first two years, including close supervision by the program director (Falconer & Guy, 1989). Notably, when discussing DDEPs, it is observed that the discourse on support and resources is predominately one-sided and often neglects exploration or acknowledgment at the partnering institution. Hardnett's (2023) study further sheds light on this issue, finding that:

One individual noted the difference between the HBCU he came from and the PWI he currently attends. He spends most of his leisure time at his HBCU and only comes to his PWI for classes, with most of his network building at his HBCU. He noticed the PWI support services did not fit his needs (p. 134).

In Jackson's (2007) chapter describing the AUC DDEP, a comprehensive section is dedicated to detailing the program services, including recruitment, scholarships, tutorial, and counseling, as well as training and development. Each heading meticulously delineates the measures through which the AUC supports students to ensure success in the DDEP. While this chapter briefly acknowledges the establishment of a point of contact at partner institutions, a noticeable gap persists across all the papers with little to no mention regarding program services specifically provided to students during their transfer process and afterward.

Theme 3: The experiences of HBCU students in DDEPs

This literature review aimed to delve into the lived experiences of students who participated in HBCU DDEPs. Throughout the entire review process, only two articles were identified that incorporated student quotes, shedding light on their experiences in a DDEP. One of these quotes was previously discussed in Theme 2, as the author's findings pertained to student community and support services at the PWI. An excerpt from a magazine article features a quote from Dr. Calvin Mackie quoted him as stating, "I wouldn't have survived Georgia Tech if I had gone there first" (Collison, 1999). Although this quote provides valuable insight into HBCU students' experiences in DDEP, it is important to note that Dr. Mackie was initially introduced to the AUC DDEP but opted to complete his bachelor's degree at Morehouse College before pursuing his graduate degrees in mechanical engineering from Georgia Tech.

The reviewed articles underscored the limited amount of research on HBCU students' experiences, particularly those in DDEPs (refer to Table 2). While the anticipated research questions were not fully addressed in this review, the review reveals promising categories for future investigation.

Table 2. Overview of reviewed articles and associated emergent themes.

| Author | Theme | Summary |
|-------------------------|-------|---|
| Adam (1999) | 0 | This monograph database comprises collective case studies from U.S. and Canadian institutions, addressing recruitment, remediation, and retention challenges in technology change. It features entries on recruitment (43), remediation (50), and retention programs (50) for each institution, with specific focuses such as first-year student recruitment. The database encompasses Historically Black Colleges and Universities (HBCUs) and Predominantly White Institutions (PWIs). |
| Armsby (1961) | 1 | Armsby, the Chief for Engineering Education at the Division of Higher Education, discusses the 3+2 program, noting a partnership between Lincoln University and Drexel. |
| Brooks (2001) | 2 | This dissertation presents a case study and professional biography of Dr. Yvonne Walker-Taylor, the first female executive at Wilberforce University. Her tenure as president saw the establishment of various educational initiatives, including the university's dual-degree engineering program in collaboration with the University of Dayton. Notably, the program led to an enrollment increase in computer science and engineering in 1986, playing a pivotal role in recruiting and retaining students at Wilberforce, particularly addressing the need for Black engineers in the U.S. |
| Carvell & Greene (2022) | 1 | The emergence of a new program at Marian University and Indiana University Purdue University Indianapolis (IUPUI) provides an alternative to the traditional 3+2 engineering model. In this five-year program, students are enrolled at both institutions simultaneously, earning two bachelor's degrees. |
| Collison (1999) | 3 | This excerpt shares a student's experience with the dual-degree engineering program between the AUC and Georgia Tech Institute of Technology, an opportunity he discovered at a high school college fair. |
| Crumbly et al. (1996) | 1, 2 | The Cooperative Developmental Energy Program (CDEP) at Fort Valley State College, initiated in 1983 with funding from The U.S. Department of Energy established a long-term relationship between the college and the energy industry. Focused on creating a technology-oriented labor base for minorities and women. The program collaborates with UNLV, providing a 3+2 dual-degree program in Mathematics and Electrical Engineering. |
| Darnell (2012) | 1 | This article explores the hypothesis that Black college partnerships serve as an attractive prospect for promising professors, researchers, and administrators, akin to the Harlem Renaissance movement. The paper argues that institutional cooperation presents a viable solution for broadening participation among underrepresented minorities. |
| Eugene et al. (2013) | 1 | In this 5-year strategic plan, Coppin State University plans to address the nation's need to strengthen and diversify the STEM workforce. |
| Falconer & Guy (1989) | 1, 2 | The Women in Science and Engineering Scholars Program, established in 1987 through a collaboration between Spelman and NASA, aims to boost the representation of women, particularly from minority backgrounds, in STEM fields. Participants in this program pursue engineering degrees through the dual-degree engineering program involving Spelman (AUC) and institutions such as Georgia Tech, Rochester Institute, Boston University, or Auburn University. |

| | | |
|----------------------------------|---------|--|
| Gill (1992) | 0 | This is a comprehensive reference book listing all minority student support programs for higher education, encompassing volunteer programs, pre-college initiatives, undergraduate programs, graduate programs, and other sources. |
| Hardnett (2023) | 1, 2, 3 | This dissertation is a qualitative descriptive study aimed at understanding how Black American male college students describe the way they build their social capital networks and how college programs support services to assist them in developing their social capital networks at a PWI. |
| Jackson (2007) | 1, 2 | This chapter describes the Atlanta University Center's Dual Degree Engineering Program and the model used to increase the number of minorities in engineering, science, and technology through consortia. |
| Johnson (1992, 1994) | 0 | This artifact is a structural research database of HBCUs on the faculty capabilities, research interests, and university research facilities. |
| Joseph (2023) | 1 | The paper discusses the options available to Morehouse students to earn an engineering degree through Michigan Robotics, which offers HBCUs and MSI undergraduate institutions a Robotics curriculum via the Distributed Teaching Collaborative (DTC). |
| Murenzi (2000) | 1 | This is a report on Visualization and Simulation in an integrated modeling and testing environment. |
| National Research Council (1986) | 1 | This is a book on the Panel on Undergraduate Engineering Education performed by the National Research Council. In Chapter 4 The Curriculum, 3+2 curriculum is mentioned as a recent proposal for the engineering curriculum. The report considers 3+2 programs as experimental approaches to the professional model. |
| Payton et al. (2012) | 1, 2 | Supported by statistical data, the study applies the Involvement, Regimen, Self-Management, and Social Networks (IRSS) theory to an early college program at Clark Atlanta University. |
| Rockward (2002) | 1 | This document is a proposal for a Micro Optics Research and Engineering (MORE) Laboratory at Morehouse College by Dr. Rockward. |
| Volcy & Sidbury (2013) | 1 | The article highlights the pressing need for increased engineering graduates, with a focus on retaining students who initially pursue engineering but change majors. Recognizing this challenge, especially among women and minority groups, Spelman's Dual-Degree Engineering Program addresses the issue through a summer bridge engineering course. |

Discussion and Future Work (TF)

Within the National Research Council (NRC) *Undergraduate Engineering Education* report (1986), the following was stated in support of DDEPs given the complexities surrounding engineering programs at 4-year institutions:

To increase elasticity in enrollment capacities and diversity of educational background of engineering enrollments, a pilot group of colleges and engineering schools be funded to demonstrate effective structures for dual-degree programs. Experience gained from this pilot group could then be applied, if needed, to a wider group of institutions. In addition, the experience gained would be relevant to the often-debated model of preprofessional followed by professional engineering education (pg. 75).

While the findings cannot speak for the entire DDEP community, when considering diversity and the need to further understand students' experiences and DDEPs, we can highlight that there is little attention being given at the level recommended in 1986. Considered along with the results of this study, below are the key areas that should be prioritized within future work related to DDEPs:

1. Exploration of students' experiences at HBCUs before and after attending PWIs
2. Increased understanding of students' decision-making linked to the DDEP (to enroll versus staying at HBCU for an alternative 4-year degree)
3. Increased research using quantitative data related to DDEPs.

The findings highlighted in the themes above emphasize the importance of further studying the experiences of Black students who participate in DDEPs housed at HBCUs given the unique components of their journey that are not covered by studying Black student experiences who only attend PWIs or those who only enrolled and completed degrees at HBCUs. This review highlighted just how scarce the literature is when it comes to understanding these experiences. This type of research, more notably, would equally benefit HBCU and PWI stakeholders alike.

Policy Implications

Given the growing diverse population within the United States, increasing demand within engineering (and related fields) for the STEM workforce, and an increasing number of students choosing to attend minority-serving institutions (MSIs), it would serve as a benefit to the broader engineering education community to better understand this unique pathway for students to obtain engineering degrees. Institutions participating in DDEPs must increase efforts to track students as they navigate to and from their institutions. In the process of conducting this review of the literature, university websites for data directly linked to DDEPs were searched, and, outside of what was found in the literature, there were no databases available highlighting quantitative data related to these programs.

Conclusion

This detailed review of the literature on DDEPs at HBCUs serves as an initial step in exploring Black students' experiences within these programs. We were intentional in including any study conducted on DDEPs at HBCUs overall, with no restriction on the date of publication. Three overarching themes were found across all studies that were included: (1) references to HBCU DDEPs without the inclusion of student experiences, (2) HBCU student's support and resources, and (3) the experiences of HBCU students in DDEP (the initial sole focus of the study). There

were three key areas we believe need to be the focus of future work: (1) an exploration of students' experiences at HBCUs, before and after attending PWIs, (2) an increased understanding of students' decision-making linked to the DDEP, and (3) an increased focus by the institution to track quantitative data related to DDEPs. This review can serve as a starting point for the proposed future work. Additionally, this study highlights the missed opportunity for our community to more deeply understand this unique population of students. As the U.S. continues to grow more diverse, there are increasing workforce challenges from student recruitment, alleviating attrition challenges, and meeting the demands within engineering and computing-related fields.

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