AC 2010-1272: THE ROAD LESS TRAVELED: EXPLORING FACTORS THAT INFLUENCE AFRICAN AMERICANS TO PURSUE AND COMPLETE DOCTORAL DEGREES IN ENGINEERING AND APPLIED SCIENCE DISCIPLINES

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Abstract

Given the devastatingly low participation and completion rates of African Americans in engineering and applied science doctoral programs, it is imperative to understand what factors influence African Americans to pursue and complete doctoral degrees in engineering and applied science disciplines. The experiences of African American doctoral degree recipients have been overshadowed by efforts to understand and remedy the underrepresentation of African Americans in engineering and applied science fields of study. Therefore, the purpose of this paper is to identify factors that influence African Americans to pursue and complete doctoral degrees in engineering and applied science disciplines. Through the stories of study participants, insight into what is necessary to successfully complete graduate engineering and applied science education is documented.

Principles of Critical Race Theory (CRT), two doctoral degree persistence models, and graduate student persistence literature served as the conceptual framework for this study. In-depth and focus group interviews were conducted to learn about the factors that positively impacted the persistence of 19 African Americans who earned doctoral degrees in engineering and applied science disciplines from their lived experiences. Encouragement from others including peers, family, and professional engineers and applied scientists emerged as a significant factor influencing the decision to pursue graduate education in engineering or an applied science discipline. Participation in a summer research or internship program also impacted and solidified the decision of study participants to pursue an advanced degree. Key factors impacting doctoral degree completion included: peer support, faculty adviser support, support from university administrators, and family support. These findings were analyzed in relation to the research and higher education literature on the persistence of African Americans in graduate education.

In addition to identifying factors that influenced this group of African Americans to pursue and complete doctoral degrees in engineering and applied science disciplines, this paper serves to promote and include the expert knowledge of African American doctoral degree recipients in the scholarly discourse on the issue of low participation rates of African Americans in graduate engineering and applied science programs. Such knowledge will challenge traditional views on this issue and hopefully inspire new ways of addressing this issue. With African Americans and other minority populations growing at an exponential rate, people of color are quickly becoming the majority in key states across the nation. Therefore, it is imperative that all Americans have an opportunity to pursue graduate level degrees and to develop skills necessary to compete for professional positions in the science and engineering workforce. This mandate is required for the United States to maintain a competitive edge in the global marketplace, and to continue to make technological advances in this ever-changing world.

Introduction

Over the past decade, the number of African Americans completing doctoral degrees in engineering has remained consistently low. In 2008, 32,827 doctorates were awarded in science and engineering, of which African Americans earned 824 compared to Whites who earned 13,894[1]. Despite these daunting statistics, little attention has been focused on what inspires African Americans to pursue and complete doctoral degrees in engineering and applied science disciplines. Due to the emphasis placed on understanding the barriers to success, the experiences of black doctoral degree recipients in these academic disciplines have been overshadowed. As a result, African Americans who completed doctoral degrees in engineering or applied science disciplines have inadvertently been treated as bystanders and remain under-studied by researchers. Indeed, the body of literature on the underrepresentation of African Americans and other minorities in engineering and other quantitative-based disciplines is essentially void of the voices and successful experiences of doctoral recipients from underrepresented backgrounds. Therefore, it is imperative for African American doctoral recipients to have a voice and to participate in efforts to increase participation rates of underrepresented student populations in engineering and applied science disciplines. The inclusion of the voices and experiences of African American engineering and applied science doctoral recipients will significantly contribute to the higher education literature.

Much of the existing literature on the underrepresentation of African Americans in graduate degree programs relies heavily on quantitative research methods and as a consequence, the voices of study participants do not often emerge from the statistics presented. This tendency inadvertently results in African Americans and other study participants being silenced and reduced to percentages, making it difficult to learn about the experiences of individuals that complete doctoral degrees. The use of qualitative research methods in this study allowed the experiences of nineteen African American doctoral recipients in engineering and applied science to be documented and presented in their own voices. To identify factors that influenced the decision to pursue and complete the doctoral degree in engineering and applied science disciplines, the following research questions guided this study:

1. What factors influenced African Americans to pursue doctoral degrees in engineering and applied science disciplines from their experience?
2. What are the most influential factors that contributed to the persistence of African American doctoral recipients in engineering and applied science disciplines from their perspective?

Related Literature

Although the literature presented is not based exclusively on the experiences of African American doctoral recipients in engineering and applied science, the findings provide insight into the graduate school experiences of African Americans. The following have been identified in the literature as significant factors that impact the persistence of African American doctoral students and recipients: adviser-student relationships, mentoring, financial support, family support, and peer support. Despite the identification of these persistence factors, there still is a need to investigate the graduate school experiences of African Americans enrolled in engineering

and applied science disciplines, as most studies focus on African Americans enrolled in non-engineering fields of study.

Adviser-Student Relationships

The relationship that a student has with his or her academic adviser is one factor that contributes to the persistence of African American doctoral students. Hamilton[2] explored the impact of persistence factors on minority doctoral students (African American and Latino) and found academic advisement one of several "dominant success factors." In her study of the retention of Black and Hispanic doctoral students, Clewell[3] identified having a supportive adviser as a characteristic of minority graduate students that attain the doctoral degree. According to Harrison[4], positive interactions with faculty can reinforce the graduate student's "sense of belonging, academic achievement and in some cases, professional development" (p 231).

Mentoring

Hamilton[2] and Willie, Grady, and Hope[5] consider mentoring a significant factor that contributes to the persistence of African American doctoral students. According to Patterson-Stewart[6] and her colleagues, some African American doctoral students believe it necessary to have an African American mentor and often seek such mentoring relationships outside of their academic department. King and Chepyator-Thomson[7] reported that mentors are critical to the persistence of African American doctoral students enrolled at predominantly white institutions. Oden[8] also found that positive mentoring and advising relationships were critical to the persistence of four African American students enrolled in a doctoral engineering program at a predominantly white institution. When faculty mentors were unavailable, Kelly and Schweitzer[9] found that African American doctoral students at one predominantly white institution resorted to either serving as or seeking mentors in other African American graduate students.

Financial Support

Although Brazziel and Brazziel[10], Miller[11], and Nettles[12] determined that black graduate students are less likely to receive financial support in the form of teaching and graduate research assistantships, King and Chepyator-Thomson[7], Willie, Grady, and Hope[5], and Wilson[13] concluded that financial support is a critical factor that influences graduate student persistence of African Americans. In testing a model of degree progress, Toliver[14] found that degree progress was particularly reduced when African American students did not have financial support. Lovitts[15] observed that while fellowships are used to recruit minorities into graduate schools, this form of support does not allow students to integrate into the academic department and degree completion is significantly reduced. St. John and Andrieu[16] recommend "comprehensive aid packages" for graduate students, as their research determined that graduate students who receive a combination of fellowships, loans, and assistantships were more likely to persist than graduate students without financial support.

Family Support

Family support is another important persistence factor identified in the literature. Miller[11] investigated the experiences of twelve black graduate students enrolled in a southern university and found family to be a critical source of support. In fact Miller[11] reported that "family support, in some cases, filled voids which existed in other deficient relationships between students and faculty" (p 111). Bickhman-Chavers[17] also identified family support as the "primary source of support" outside of the academic environment (p 159). Bingman[18] and Harrison[4] also found that family members motivate African American graduate students to complete the doctoral degree by instilling within these students the importance of education. Similarly, Clewell[3] observed that a characteristic of Black and Latino graduate student persisters was that their parents encouraged them to pursue advanced study in higher education. Phillips-Evans[19] concluded that family can serve as "relief from the everyday pressures wrought by the demands of school" (p 178).

Peer Support

In addition to receiving support from family members, African American doctoral students seek support from peers within and outside of their academic departments. However, Ellis[20], Miller[11], and Oden[8] observed a tendency for African American doctoral students enrolled at predominantly white institutions to seek support outside of their academic department or institution. Ellis[20] considers these outside support systems critical in assisting African American graduate students with succeeding academically, but these same relationships prevent them from becoming more socially integrated into their academic departments. According to Harrison[4] peer relationships provide "informal opportunities for learning in a safe place" in which students can share ideas and experiences and develop strategies for navigating the academic terrain and departmental politics (p 231). Similarly, Bingman[18] reported that interacting with other black graduate students allowed the opportunity to discuss various issues and concerns regarding successful matriculation and to fulfill social needs. Patterson-Stewart[6] and her associates found that African American peer relationships are critical to the psychological well being of African American graduate students enrolled at predominantly white institutions.

In summary, previous research on African American graduate students identified the following factors as having a positive impact on the persistence of this student population: adviser-student relationships, mentoring, financial support, family support, and peer support. Although this information is helpful in understanding the experiences of African Americans in graduate degree programs, the experiences of African American doctoral recipients in engineering and applied science are not well documented. Therefore, this study will provide information about the factors that influenced African Americans to pursue and complete doctoral degrees in engineering and applied science.

Conceptual Framework

Components of Girves and Wemmerus'[21] model of doctoral degree progress and Tinto's[22] longitudinal model of graduate student persistence were combined with critical race theory to form the conceptual framework for this study. Girves and Wemmerus[21] found that

involvement in the academic department, student-faculty relationships and department characteristics directly contributed to doctoral student progress. In testing Girves and Wemmerus' model, Toliver[14] concluded that the likelihood of degree progress is decreased for African American graduate students who are less involved with the academic department and receive no financial support. Therefore, it is expected that such factors as student-faculty relationships, involvement in the academic department, department characteristics, and funding will influence the persistence of African American doctoral recipients in this study.

Such factors are also included in Tinto's[22] longitudinal model of doctoral persistence, which illustrates the interaction of various variables that impact the persistence of doctoral students from entry into and completion of the doctoral degree program. Tinto's model identifies attributes and entry orientations that influence the student before entering graduate school and ultimately shape the students' goals and commitment to graduate study. The impact of external commitments (i.e., family and work) and financial resources are also taken into account during the pre-entry phase, as such factors will determine "the parameters of the student's participation in graduate school"[22] (p 239).

Once enrolled in the graduate program, the graduate student will encounter institutional experiences that will influence persistence. For example, the graduate student will be exposed to academic systems (i.e., classroom relations, faculty relations, and graduate positions) and social systems (i.e., peer relations and faculty relations) within the larger university environment and within the academic department/program. The student's membership in or integration into the academic and social communities will impact the student's transition and persistence into candidacy. Once the graduate student reaches the candidacy stage, relationships with faculty are critical.

These models illustrate the importance of academic and social integration. Students who are integrated into the academic and social communities of their graduate school program are more likely to persist. These models serve as a framework for understanding the academic and social experiences of doctoral students. However, graduate student persistence models fail to look at the issue of persistence from the lens of graduate students of color, as the racialized, gendered, and class-based experiences of underrepresented minority groups tend to be excluded. Focusing on a marginalized population permits others to learn about persistence from their perspective. Therefore, critical race theory was included in guiding the conceptual framework of this study.

Critical race theory (CRT) acknowledges the wealth of cultural knowledge that marginalized populations possess, which is often overlooked within the scholarly literature[23]. Through the voice and storytelling components of CRT, the experiences of marginalized populations are not only documented, but are given legitimacy and alternative perspectives are provided. According to Ladson-Billings[24],

> [t]he 'voice' component of CRT provides a way to communicate the experience and realities of the oppressed, a first step in understanding the complexities of racism and beginning a process of judicial redress. The voice of people of color is required for a deep understanding of the educational system (p 16).

By using CRT, African Americans will not be treated as silenced bystanders, but are instead themselves placed at the center of the topic being examined[23]. In doing so, the tendency for African Americans to be the objects of study as opposed to contributors to new knowledge in the higher education literature on overcoming barriers to access and retention will be countered. Therefore, the African American respondents are viewed as experts who possess knowledge about what it takes to navigate and complete the engineering and applied science educational pipeline. Through the lived experiences of study participants, essential factors that inspired them to pursue and complete doctoral degrees in engineering and applied science disciplines were revealed.

The Sample

Participants were recruited from the National Society of Black Engineers (NSBE) in summer 2007. An email about the study was sent to 184 NSBE members (53 females and 131 males) with the classification of doctoral degree. Thirty individuals expressed interest in participating in the study. Ten individuals were excluded because they were still enrolled in a doctoral program. The group was also narrowed down based on the availability of the prospective study participant. The snowball technique was also used to recruit additional study participants. This approach helped with scheduling individual interviews based on the geographic location of potential study participants. It also aided in scheduling the focus group interview, as one of the prospective informants for the individual interview worked at a company in which a sizable number of black engineers and applied scientists with doctoral degrees were employed.

Twelve participants (6 women and 6 men) were selected to participate in the in-depth interview phase of this study. Since an objective of this study was to have a balanced sample of women and men, attention was given to the gender of prospective study participants. Although the sample is not proportionate to the actual number of black men and women with doctoral degrees in engineering and applied science disciplines, critical race theory supports the inclusion of diverse perspectives in this exploratory investigation. The focus group on the other hand was more representative of the gender distribution of African American doctoral recipients in engineering and applied science disciplines.

Study participants completed doctoral degrees between 1989 and 2005. The average self-reported time to doctoral degree completion was 5.48 years, with time to degree completion ranging from 3 to 10 years. The average age at doctoral degree completion was 32.5. The doctoral degree recipients participating in this study represented the following engineering and applied science disciplines: applied science and technology (1), bioengineering (1), chemical engineering (2), civil engineering (1), computer science (1), electrical engineering (2), materials science and engineering (1), mechanical engineering (2), and industrial engineering (1). The majority of the sample completed doctoral degrees at predominantly white institutions, with the exception of one informant who earned her doctoral degree from an HBCU. Eight of the study participants attended public universities while four attended private universities. The average self-reported doctoral grade point average was 3.46. A total of four informants (three males and one female) were married while enrolled in the doctoral program. Three male informants reported having dependents while pursuing the doctoral degree. Nine of the study participants

were awarded Master of Science (M.S.) degrees from the same graduate institution prior to completing requirements for the doctoral degree. Four study participants pursued master's degrees prior to admission into the doctoral program; three informants completed the master's degree at a different institution from their doctoral institution. The average self-reported master's grade point average was 3.5.

A focus group was conducted as a secondary data collection method. The focus group took place at a company located in the Northeast. A total of seven African American doctoral recipients (6 males and 1 female) participated in the group interview. Focus group participants completed doctoral degrees in the following disciplines: applied physics (1), chemical engineering (1), computer science (3), and electrical engineering (2). The demographic information for the focus group is limited to the major area of study and gender.

Research Design and Methods

Since limited information exists about the graduate school experiences of African American doctoral recipients in engineering and applied science disciplines, and because the numbers of doctoral degree recipients are relatively small, qualitative research methods were used for this exploratory investigation. Qualitative research allowed the issue of persistence to be investigated from an African American perspective based on those students who have successfully navigated the educational pipeline from elementary to graduate school. Structured face-to-face in-depth interviews were the primary method of data collection. In-depth interviewing allowed the experiences of twelve African American doctoral recipients in engineering and applied science disciplines to be captured in their own words.

A focus group interview was the second data collection method. The focus group interview was conducted after the in-depth interviews to solicit additional information about the experiences of African American doctoral recipients, which may not have been revealed during the individual interviews. A total of seven informants participated in the focus group interview, which allowed the opportunity for all group members to interact, discuss their graduate school experiences by responding to a structured interview protocol, and to be actively engaged in the group discussion. A modified version of the in-depth interview protocol was used to gather additional data. The combination of individual and focus group interviews were useful data collection methods to examine the educational experiences of African American doctoral recipients to identify factors that contributed to their decision to pursue and complete doctoral degrees in engineering and applied science disciplines.

Traditional data analysis steps were used for this exploratory investigation[25] (p 9). Cross-case analysis was also conducted to compare and contrast themes across the informants' individual experiences. A matrix was used to organize the data and facilitate the process of identifying similar or diverging patterns. Themes that appeared in common multiple times across cases were labeled as critical factors contributing to the pursuit and completion of the doctoral degree. Divergent patterns were also identified and presented in contrast to the commonalities that existed across cases.

Findings and Discussion

In order to understand the factors that influenced African American doctoral recipients to pursue the doctorate in engineering or applied science disciplines, informants were asked to discuss who or what was a major influence in their decision. Overwhelmingly, informants revealed that someone else encouraged them and/or participation in a research or internship program influenced their decision to pursue the doctoral degree.

Encouragement from Others

According to informants, individuals including undergraduate faculty, black administrators, or professionals that worked with the student in an undergraduate research or internship program were credited with encouraging informants to pursue the doctoral degree. For example, Lance identified two faculty members who encouraged him to continue his education beyond the baccalaureate. Lance said,

> …Dr. [Dixon], she's the first African American woman to get a Ph.D. in chemical engineering from [graduate school]…she was one of my teachers at [undergraduate school] and she encouraged me to go onto graduate school. The other would be another professor of mine, Dr. [Campbell] … who actually was instrumental in me going to the [graduate school] where I eventually ended up going.

Parents were also considered a major influence, as they inspired their children to achieve more than they had accomplished educationally. Anthony's parents continually encouraged him to "do the best you can and strive for the highest." Cianni described her parents as "the biggest influence." Macy's parents constantly inspired her to "go farther than us." Clewell[3] found that parents were extremely instrumental in encouraging black graduate students to pursue post-secondary education.

Participation in a Research or Internship Program

May and Chubin[26] assert that participation in research is extremely important in encouraging undergraduate students to pursue graduate degrees in engineering and science. This proved to be true for many of the study participants, as it was their involvement and exposure to research as an undergraduate student that sparked their interest in graduate school. Curtis discussed the impact of his participation in a summer research program on his decision to pursue the doctoral degree

> I was involved in a program at [public state university]…in effect the organizer paired basically minority undergraduate students with some graduate students who were doing research….from that [experience] was you know what yeah I would like to get a doctorate. That is really what started the whole push…

Nathan, a participant from the focus group, also discussed how his involvement in a summer internship influenced his decision to pursue the doctorate. Nathan recalled, "the summer after my junior year I interned…working with various R&D [research and

development]. That was a really fulfilling experience. And from that experience I made the decision that I wanted to go to graduate school."

Informants that participated in a research or internship program identified a significant person or people at the research or internship site who was influential in their decision to pursue the doctoral degree. Joshua, a focus group participant, talked about Dr. [Smith], a black male professor, who was "instrumental in recruiting black students to work in the summer program. And he certainly was the first person that really made me think about engineering as a career. And he's a major influence." While working at a summer internship, Janay was inspired by a research team member. Janay recalled, "I worked that summer at a company and the head of the research team there was a Chinese guy and he pulled me aside at the end of the summer and said Janay I hope that you're going to graduate school and I did." Through her participation in a summer research program, Macy was able to discuss the advantages of going to graduate school or entering the workforce with other students in the research program. Macy explained,

> …the summer of my junior year I did an internship at [private university] in the research experience for undergraduate program…And I spent a lot of time with probably five other minority students…we really had a good time talking about the pros and cons of going to work versus going to graduate school…that was the summer when I came back and said to my adviser starting my senior year I'm going to graduate school. I'm not going to get a job.

Other Influences on the Decision to Pursue the Doctorate

There were however two exceptions to the study's main findings involving the influence of another individual and participation in a research or summer internship program on the decision to attend graduate school. A male study participant pursued the doctoral degree to secure a job promotion and a female participant indicated that she was responsible for making the decision on her own. It is important to note that both of these study participants worked for several years prior to entering the doctoral program and this might explain why they were not influenced by similar factors that other study participants revealed. However, the experiences of the majority of informants illustrate the importance of an individual who inspired them to pursue the doctoral degree and/or participation in a research or internship program that exposes undergraduates to the practical application of engineering techniques.

Factors Influencing Doctoral Degree Completion

To identify critical factors contributing to doctoral degree completion, informants were asked to discuss who or what was influential in their doctoral degree completion. From the in-depth and focus group interviews, four factors were identified as being influential to completing the doctoral degree. These four factors include peer support, faculty adviser support, support from university administrators, and family support. These factors were consistently mentioned as one of the major influences to the informants' doctoral degree completion. Additional factors such as having a mentor and funding were also considered important in completing the doctoral degree, but the frequency of such factors was much lower than the four factors identified.

Although the persistence factors are presented separately, it is important to acknowledge that in most experiences, a combination of factors contributed to the successful completion of the doctorate. Therefore, in addition to the required academic proficiencies required to complete the doctoral degree in engineering and applied science fields of study, combined factors of peer support, faculty adviser support, administrative support, and/or family support influenced the persistence of African American doctoral recipients in engineering and applied science. These sources of support also formed the study participant's support network, which was unique for each informant. The various combinations of key persistence factors contributing to degree completion ranged from study participants' having support from all four sources to having support from only peers or a faculty adviser.

Peer Support

Peer support was cited most frequently as a major influence in the doctoral degree completion of study participants. Anthony succinctly declared, "Engineering is difficult to do all by yourself." This statement highlights the importance of peer support in the persistence of African American doctoral recipients in engineering and applied science. Throughout the individual and focus group interviews, study participants discussed the value of peer support during doctoral degree program enrollment. Informants relied on their peers for academic, emotional, and social support. Bingman[18], Ellis[20], Harrison[4], and Oden[8] found that peer support has a positive impact on the persistence of African American doctoral students.

Since the majority of informants were enrolled in doctoral programs at predominantly white institutions (PWI), they were either the only African American or one of a few African Americans in their academic department and/or school. As a result, study participants sought solace and support from black graduate students enrolled in other academic disciplines at their institution. Similarly, Oden[8] observed that African American doctoral students enrolled in the electrical engineering department at a PWI predominantly established peer relationships with other black students outside of the academic department compared to white doctoral students who developed peer relationships within the academic department. Bingman[18] also reported African Americans who completed doctoral degrees in math, science, and engineering at a PWI received support primarily from other black students on campus and such peer relationships contributed to their success in graduate school.

In seeking support from other black graduate students, study participants became active in black graduate student associations and/or the National Society of Black Engineers (NSBE) student chapter on their campus. According to Feagin and Sikes[27] and Taylor and Olswang[28], involvement in African American student organizations can ease the negative impact of racially hostile campus environments. After experiencing what Janay described as a "discriminatory event," she connected with black non-engineering graduate students. Janay explained,

> …I am very thankful for all of these experiences because that opened me up to look outside of the laboratory and outside of the engineering department because there [were] no blacks in the engineering departments besides me at that time. And so I went to other departments in pre-med and so forth and [graduate school] has a really great program for black grad students, a union where they meet once a month over dinner. So, I really got

> involved in that and that really was motivation. So, you got the chance to speak and support each other….It really made the world of difference and just to see them and to share our time together helped me a lot in refocusing my energy and completing things.

Miranda also highlighted the importance of peers to her doctoral degree completion

> I would have to say the two major influences were and actually it's really odd but they're social oriented in that I had some really good friends who were either in doctoral programs or in graduate school. It was kind of like a community of students that you know everybody was trying to move forward and so I became an active member of the Black Graduate Student Association. And we would put on a national conference in [graduate school]…We even began a journal club or just people presenting their work before their defense to help each other. And then the National Society of Black Engineers, I still stayed active in their student chapter.

For several of the study participants, peer support proved to be especially instrumental during the final stages of the doctoral program. This is not to say that peer support was not an important factor throughout the entire process, but it is evident that peer support was necessary at the critical stage of completing the doctorate. For example, Macy discussed the "power of networking," as she described an experience in which she had difficulty printing her dissertation. One of her best friends who had recently completed a doctoral degree in another academic discipline flew in from out of town to help Macy and actually submitted the bounded copies of Macy's dissertation to Macy's defense committee. After sharing that experience, Macy elaborated on the "power of networking,"

> You just can't underestimate the value of you needing people whether it be to actually get the work done…So the network is going to be very important whether it's your social network or professional network, but please don't underestimate the power of it.

Focus group participants shared similar experiences in which peer support was critical, particularly during the final phase of completing the doctoral program. According to Alex,

> especially towards the end of my graduate studies we had assembled somewhat of a nice critical mass of black graduate students…And I was able to pull a lot of encouragement and a lot strength and a lot of excitement and energy from that group. And I think that was very helpful to finishing the degree.

Joshua, another focus group participant, described how he and a few other doctoral students formed a dissertation group. He stated, "we met once a week and we were in a variety of disciplines and we just came together and talked about what we needed to do to finish up." He continued, "I'd say and then more broadly the kind of friends I had particularly among black graduate students, black engineering graduate students. Yeah I would say those were the primary."

In seeking peer support from black graduate students primarily outside of the academic department, it is clear that informants were looking for individuals who understood the

experience of being a black graduate student at a predominantly white institution. However, forming such relationships contrasts with prevailing graduate student persistence models, which advocate the importance of forming relationships within the academic department, as integral to the social integration necessary for doctoral degree completion. Even though informants received peer support from other black graduate students outside of the academic department, they were still successful in completing the doctoral degree without being socially integrated into the academic department.

In addition to finding support from peers outside of the academic department, informants discussed the important role of support from the research laboratory group. The fact that many engineering and applied science doctoral students spend a significant amount of time in the research laboratory, this aspect of the doctoral experience in engineering and applied science should not be overlooked as a source of support. Although study participants indicated that they were the only black doctoral student working in their faculty adviser's research laboratory, some of them received support from other individuals working in the research laboratory. Carlton received invaluable support from his research group colleagues. Carlton revealed, "I relied heavily on the people at my lab. A lot of us were friends that were in graduate school that started around the same time. We maintained friendships until today even." Carlton also received support from other individuals in his lab who "were senior to me that just had gone through the process to help me and they helped me immensely with the oral presentation component," stated Carlton. Graduate students in Janay's research group read drafts of her dissertation chapters before she submitted them to her adviser. "It improved my dissertation quite a bit. I just went out and got students in my lab and I said you have to read a chapter and I need you to be hard on me before I hand this to my adviser," Janay commented.

The role of the research laboratory group as a source of peer support may only be unique to doctoral students in engineering and science disciplines, as it was not a key finding in other studies conducted on the persistence of African American doctoral students or recipients reviewed for this study. Lance also discussed the importance of the members of the research lab. Lance stated,

> My experience at graduate school in terms of my research group and the support that I got and the encouragement that I got also helped a lot. And I think those things are key and instrumental. I think those were the more important tools and skills that I got as opposed to the actual knowledge.

Relying on support from research laboratory group members must not be confused with socialization into the academic department. The research laboratory group may consist of a variety of graduate students (not necessarily from the same academic department), post-doctoral fellows, and professional research associates without a designated student status. Therefore, involvement in or socialization into the research laboratory should not be considered the same as socialization into the academic department in which the doctoral student establishes significant relationships with other doctoral students in the academic department.

Based on the experiences of study participants, peer support whether from peers of the same or different ethnicity or race in engineering and applied science disciplines or in non-

engineering disciplines, was a critical factor in the completion of the doctoral degree. Such relationships allowed the study participants to be part of a supportive community in which they could share experiences with other graduate students who were going through similar experiences. This aspect was especially evident in established relationships with other black graduate students regardless of their discipline of study. With non-black peers, African American study participants were able to bond based on the commonality of the doctoral experience in terms of the significant milestones such as the qualifying examinations, proposal defense, and dissertation defense.

Faculty Adviser Support

Having support and encouragement from a faculty adviser was identified as a factor influencing doctoral degree completion of study participants. This finding confirms previous research that Clewell[3] and Harrison[4] conducted which reported the positive impact of faculty adviser-student relationships on the persistence of African American doctoral students. Hamilton[2] determined academic advisement to be one of several "dominant success factors" in the persistence of African American doctoral students. Nerad and Miller[29] describe the faculty adviser as playing an important role in the academic development of students by providing guidance on course selection and monitoring academic progress. Although informants referred to these professors as "faculty advisers," they appeared to have a professional relationship with informants beyond traditional advising. The faculty advisers as identified by study participants distinguished themselves as individuals who had a sincere interest in the development and success of their students. These faculty advisers exhibited more mentor-like qualities. However, the study participants did not use the term mentor to describe these individuals. Although Tinto[22] does not provide a definition he asserts, "it is the faculty-mentor relationship that is most likely to shape completion" (p 241). Perhaps the relationships that informants had with their faculty adviser can be categorized as a "faculty-mentor relationship."

In Janay's experience, she worked with her faculty adviser previously as an undergraduate student. Therefore, she had a long-standing working relationship with him. "You know he really believed in me because he had seen me perform throughout…he knew what I was capable of and so he wanted me to finish," said Janay. Kelvin described his relationship with his faculty adviser as a "father son relationship." Kelvin's adviser helped him to become a better writer and "helped educate me in how the academic system works," remarked Kelvin. Anthony revealed that his faculty adviser also was instrumental to his completion of the doctoral degree and that he "had a good connection with [his] adviser." Anthony enthusiastically described his adviser as

> always encouraging in the sense of the projects that we worked on together. He gave me a lot of freedom to do things on my own…He would give me good input and fair appraisal…He and I got along very well because he always valued my opinion highly, as opposed to me trying to just compete to see who's going to win.

Jason also identified his faculty adviser as a factor to completing the doctorate. According to Jason, "He was definitely instrumental to me finishing. He would say positive things about me when I needed to hear it." Jason also revealed that his faculty adviser was "determined to

increase the number of underrepresented people in engineering." Similarly, Emma, a participant from the focus group, indicated that, "my adviser was a very significant factor." Carlton also spoke enthusiastically about his second faculty adviser. With a smile Carlton said,

> He was a big proponent in pushing me. He was mom away from home, so he figured out what buttons it took to push me and just started pushing my buttons and helped me finish at an accelerated rate near the end by just giving me impossible goals.

Overall, the positive relationships that existed between the informants and their faculty advisers proved to be critical to their overall persistence and ultimate degree completion. Faculty advisers provided the necessary encouragement and guidance that many of the study participants needed to get through the doctoral program. This finding is consistent with other research documenting the essential role of faculty in doctoral degree completion.

Support from University Administrators

Support from university administrative staff proved especially important in the experiences of study participants who had difficulty with his or her faculty adviser and had to deal with challenges in the academic and social environments at predominantly white institutions. Given the lack of black faculty in engineering disciplines, study participants sought support primarily from black female administrators who served in such roles as deans or directors of minority or multicultural affairs or program coordinators of fellowship programs on campus. They also relied on support from black administrators from their undergraduate institutions in which they had developed and maintained relationships. Researchers have documented the importance of minority affairs offices on the persistence of black students. From the experiences of some of the study participants, these same offices or personnel also had a positive impact on their persistence. Therefore, efforts should be made to designate a minority affairs professional or office at graduate schools of engineering and applied science on predominantly white campuses. The existence of such an office or designated personnel communicates to graduate students of color that there are additional resources of support for them on campus.

Joshua, a focus group participant, described the support of administrative personnel

> …a woman who had a Ph.D. in Spanish and she played an administrative role in our department and she was just the kind of person who checks up on people. And I think that kind of checking up was useful. And frankly I would even extend it to a couple of secretaries who it was just good that there were people that were kind of looking out for you even if they didn't understand the process.

Macy also relied on the support and encouragement from one of the deans at the graduate school

> I think that if Dean [Smith] had not been the type of person she was making herself readily available day and night, always having that open door, I would not have finished…So without Dean [Smith] without a doubt there was no way.

In fact, Macy thanked Dean Smith and other administrators in the Office of Minority Affairs in the acknowledgement section of her dissertation

> I also want to extend my gratitude to my champions, people who have supported my cause. If it were not for Dean [Smith] and the Office of Minority Affairs, I would not have stayed at [graduate school] to complete my Ph.D. This woman has been like a mother to me. Thank you for everything you did for me. You are my angel.

Nia also identified the support of two black female administrators, one of them the president of her undergraduate college and the other served as the program director of the fellowship program at her graduate school. Nia elaborated,

> with Dr. [Jones] I think by just constantly being that source of support and telling me that I can do it. And whatever I needed she was willing to help to make sure I got through the program …with Dr. [Parker] her benefit was that she had just gone through that same experience. So, she was maybe like five or six years older than us. While she was over the program, she was still very down to earth. She had the same experiences of coming from a small black college to a major white institution.

Bingman[18] asserts that African American college administrators enhance the support that faculty provides to students. However in this study, support from African American college administrators actually filled a void for informants who did not have supportive and nurturing relationships with faculty. Informants turned to black administrators for encouragement and support. They could share the harsh realities that many of them faced as being the only black student or one of a few black students in the engineering program. They were able to express their frustrations and concerns with someone who looked like them and understood the experience of racism and discrimination.

Such relationships demonstrate the need for the development and recruitment of African American faculty in engineering and applied science disciplines, especially at predominantly white colleges and universities. Due to the absence of black faculty on predominantly white campuses, black doctoral students seek support from black administrators on campus. Although black administrators are able to provide solace, they are not in the position to provide the necessary socialization into the academic discipline that a faculty member can provide. Therefore, if black doctoral students are unable to cultivate a positive relationship with his or her faculty adviser, he or she may miss out on critical opportunities to develop as research scholars by engaging in such activities as publishing papers and presenting at conferences. More importantly, increasing the number of black faculty in engineering disciplines will provide more opportunities for black doctoral students to develop mentoring relationships with faculty who look like them and can identify with their experience.

Family Support

Support from family members was also identified as an important factor contributing to completing the doctoral degree in engineering and applied science. Outside of the academic environment, Bickman-Chavers[17] determined family support to be the "primary source of

support" for African American doctoral recipients. Additionally, Miller[11] found family support substituted the poor relationships African American graduate students had with faculty. Bingman[18] also found family support and encouragement contributed to the success of African American doctoral students. Based on existing research and the findings of this study, family members can provide the necessary encouragement and motivation that African Americans need to persist in doctoral study.

Despite the fact that family members have the ability to encourage and motivate African American doctoral students to persist, study participants also revealed that family members did not understand the doctoral student experience or process. This lack of understanding or inability to relate to the experience placed a limitation on the type of support family members provided. Referring to his parents and younger brothers, Curtis recalled,

> …whenever I would go home or had the chance to go home at Christmas or some holiday they were always there and the encouragement was there and even though they may not have understood, they had a copy of my thesis and it sits there. And they're like that's what he did. I may not be able to read it or understand it, but that's what he did.

Macy shared a similar recollection about how support from family is often limited to words of encouragement given the lack of engineers in one's family, "…a lot of us are first-generation graduate students. So, I can call my mother to get advice and hear I love you and I know you can do this. That kind of motivational stuff." Alex, a focus group participant, provided additional evidence of family not understanding the doctoral experience. Alex remarked,

> …my grandparents were really worried about me the whole time, especially my mother's parents. My grandmother used to say, "I don't know what happened to Alex. He was so smart, but it's taking him so long to finish school". So, I would say, "Yeah it's taking me a little while Grandma, but I'm going to have a really nice degree when I finish."

There were a couple of exceptions to family not fully relating to or understanding the graduate school experience. Alex, a focus group member, stated, "My parents they both had graduate degrees and so they understood." Carlton's parents were also familiar with the doctoral process. Carlton explained,

> …my parents had a huge influence on me because they had already gone through the process. And they had seen what works and they know what doesn't work…My mom had a background in nutrition, so I could communicate with her on some aspects of my research and with my dad on the more engineering aspects of my research.

Study participants who were married received support from their spouses. In some cases spouses provided more than emotional support and encouragement; they provided financial support and managed the household. Commenting on his wife's support Alex, a focus group participant, said,

> …my wife was also very helpful. We really made a great team. She was actually working full-time. So not only did she tolerate things, she supported me while I was

> going through school. But we made a good team. I mean I had a very rough week, which was a lot of weeks. She helped fill in and made our household run smooth.

In a few cases, study participant's spouses who were also pursuing doctoral degrees provided additional support, encouragement, and motivation. Willie, Grady, and Hope[4] concluded that African American doctoral students with spouses who earned advanced degrees were more likely to complete the doctoral degree. Having a spouse simultaneously enrolled in a doctoral program proved to be a positive factor in the degree completion of some of the study participants. Curtis stated, "My wife who at the time was a graduate student there gave me a lot of encouragement." Jackson, a focus group participant, discussed how his wife who was also pursuing the Ph.D. inspired him. Jackson said,

> One thing that helped me was that I got married in 2005, two years before I finished and my wife was also pursuing her Ph.D. … her momentum to me was just so astounding. So, I was really feeding off her energy near the end to really complete. She actually defended a month before I did. Having her having that energy in the house with me really helped me get things done. It helped out a lot.

Anthony also explained the benefit of him and his wife both being enrolled in doctoral programs at the same time. Anthony stated,

> My wife also did her Ph.D. in business. So, we were both in school at the same time. So again that helped. We understood each other's commitments…we complemented each other in the sense that we were both pursuing academic careers.

Overall, study participants received support from various family members while enrolled in the doctoral program. Family members provided emotional support and encouragement that essentially aided in persistence to doctoral degree completion. Study participants with spouses enrolled in doctoral programs at the same time, seemed to benefit the most because they were able to inspire each other and understood what they were both going through. Having a parent(s) with a graduate or doctoral degree also proved useful to a few informants as their parents could relate to the graduate school experience and provide advice from their own experiences.

In summary, four persistence factors were identified as having a major influence on the doctoral degree completion of study participants. These factors included peer support, faculty adviser support, support from university administrators, and family support. Previous research establishes the importance of these persistence factors on African American doctoral students. Therefore, it appears regardless of academic disciplines, similar factors influence the persistence of African American doctoral recipients.

Recommendations for Future Research

This study revealed that African Americans sought support, advice, and guidance from their peers, faculty advisers, university administrators, and/or family members. Such experiences are more useful in guiding future research on African Americans and other underrepresented minority groups in engineering and applied science disciplines. Rather than

looking to prevailing models of doctoral student persistence, which are not reflective of the experiences of African Americans in doctoral education, more research relying on the experiential knowledge and expertise of this group is critical to understanding the factors necessary to succeed in engineering and applied science doctoral programs.

The graduate school experiences of African American doctoral degree recipients from predominantly white institutions of higher education were documented in this study. Based on the findings, it is unknown if the experiences of African American doctoral degree recipients from historically black colleges and universities are similar or different. Therefore, a comparative study examining the graduate school experiences of African American doctoral recipients in engineering and applied science disciplines from historically black colleges and universities and from predominantly white institutions should be conducted to determine the impact of these institutional types have on doctoral student persistence in engineering and applied science disciplines. A study of this nature might provide evidence of best practices that can be used to recruit, retain, and graduate African American doctoral recipients.

Although study participants recalled factors that influenced the decision to pursue the doctorate, a study examining currently enrolled African American college students should be conducted to closely examine the decision making process while students are experiencing it. Investigating the decision to pursue the doctoral degree when college students first make this important decision can facilitate better documentation and understanding of the decision making process and the types of support and encouragement provided to reinforce commitment to the goal of earning the doctoral degree. Such information can be critical to the development and implementation of recruitment and retention policies and practices.

Implications for Practice

This research study revealed the importance of support from a variety of sources is critical to the persistence of African American doctoral recipients in engineering and applied science disciplines. Informants sought emotional support and encouragement from university administrators. University administrators were there to listen to issues that African American doctoral students encountered and coped with while pursuing the doctoral degree. It is also important to note that not all of the university administrators were staff in a minority or multicultural affairs office. In many cases, informants established informal mentoring relationships with university administrators. Given the essential role of university administrators on the persistence of African American doctoral students, efforts must be made to acknowledge the importance of university administrators to the retention and persistence of doctoral students of color. University administrators must also be included in the development and implementation of retention plans. Faculty advisers should form partnerships with university administrators to ensure that African American doctoral recipients are receiving the optimal level of support.

Peer support was overwhelmingly identified as an influential factor on degree completion, especially from peers of the same race. The peer group not only provided social and emotional support, but academic support was also the focus of such interactions. Given the positive impact of peer support on doctoral persistence, efforts must be made to recognize the

importance of these groups by providing the necessary resources for such groups to flourish and feel that they matter rather than being a marginal group on campus. Some informants emphasized the lack of resources available to graduate students of color and as a result these individuals had to create support programs on their own. Resources, such as meeting space and funding, must be made available to graduate students of color to encourage the creation of peer support groups.

Many of the informants made the decision to pursue the doctorate in engineering during the junior or senior year of college. However, the decision should be made much earlier so prospective African American doctoral students have adequate time to participate in research internships which will help them to further develop and hone their research skills and expose them to various research projects. More efforts and emphasis must be placed on exposing African Americans and other underrepresented groups to engineering and applied science as early as elementary school. Professional engineers and applied scientists must be encouraged to visit elementary, junior high, and secondary schools in order to expose African American students and other underrepresented minorities to the field of engineering and applied science. Engineering companies can collaborate with school officials to establish programs in which students visit laboratories. Additionally, professional engineers can visit the school to talk about what they do and work with school teachers to incorporate engineering projects into the curriculum. More opportunities for junior high and secondary school students to participate in summer research programs are also needed to develop engineering and applied science talent.

Carrying out these recommendations can help to increase the recruitment and persistence of African American doctoral recipients in engineering and applied science. Although there are existing efforts such as engineering pre-college programs, summer research programs for college students, and national fellowship programs designed to increase the number of African Americans and other underrepresented groups in engineering and applied science disciplines, more action must be taken, as these populations remain grossly underrepresented. This study documents the significant impact that one person and/or a research internship can have on the decision of African Americans to pursue the doctoral degree in engineering or applied science disciplines. This study also highlights the importance of African American doctoral recipients having support from their peers, faculty adviser, university administrators, and family, which was critical to the successful completion of the doctoral degree in engineering and applied science disciplines.

Conclusion

In this study, four factors contributed to the persistence of 19 African American doctoral recipients in engineering and applied science disciplines. These factors include support from peers, faculty adviser, university administrators, and family. Although these factors were described individually, in most cases a combination of these forms of support contributed to the doctoral degree completion of study participants. Study participants revealed that they relied on encouragement from a variety of people, especially from other black students and administrators. The fact that these students were seeking support from people who could relate to the experience of being black at a predominantly white institution demonstrates the importance and the necessity of a critical mass of black doctoral students in engineering programs.

Graduate school faculty and administrators can use the findings of this study to inform recruitment and retention strategies. For example, given the importance of peer support to the success of African American doctoral recipients in engineering and applied science disciplines, efforts can be made to recruit and admit a cohort of black doctoral students. Since faculty members play a critical role in admitting and graduating doctoral students, then they must be educated about the importance of diversifying engineering programs, especially at the doctoral level. It is also evident that faculty played a significant role in encouraging participants in this study to pursue the doctoral degree. Therefore, all faculty members should be aware of potential graduate students drawn from the pool of undergraduate students that they teach. Faculty must be encouraged and supported by their institutions to identify promising African Americans and other underrepresented minorities and encourage these students to consider pursuing the doctorate in engineering or applied science disciplines. Attention to these influential factors can be useful in efforts to recruit, retain, and graduate African Americans in the engineering and applied science pipeline.

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