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Widening the Pipeline: Identifying Practices and Structures That Effectively Recruit and Retain African-American Females in Undergraduate Computer Science Programs at Historically Black Colleges and Universities

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WIDENING THE PIPELINE: IDENTIFYING PRACTICES AND STRUCTURES THAT EFFECTIVELY RECRUIT AND RETAIN AFRICAN-AMERICAN FEMALES IN UNDERGRADUATE COMPUTER SCIENCE PROGRAMS AT HISTORICALLY BLACK COLLEGES AND UNIVERSITIES

By
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Approval Page

This dissertation was submitted by Martha Lynnette Haigler under the direction of the persons listed below. It was submitted to the Gardner-Webb University School of Education and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Gardner-Webb University.

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> And the Lord answered me, and said, Write the vision, and make it plain upon tables, that he may run that readeth it. For the vision is yet for an appointed time, but at the end it shall speak, and not lie: though it tarry, wait for it; because it will surely come, it will not tarry. (Habakkuk 2:2-3)

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I am most grateful for the student participants – the *Hidden Figures* – as well as the director of undergraduate studies for CS at the HBCU in this study. They are all phenomenal African-American women, and I am convinced that the student participants have already begun their extraordinary journeys to success respectively.

Additionally, I would like to thank my cohort members and friends who started out on this journey with me, although we reached our destinations at different times. I am so grateful to have met each of you; and when I think of you, it is always with a smile.

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Finally, I dedicate this dissertation to the memory of my loving parents, Lillie U. and Willie Haigler, Jr. and to all those who have lost their lives during the COVID-19 pandemic as well as the racial pandemic that we, the living, are left to overcome.

Abstract

WIDENING THE PIPELINE: IDENTIFYING PRACTICES AND STRATEGIES THAT EFFECTIVELY RECRUIT AND RETAIN AFRICAN-AMERICAN FEMALES IN UNDERGRADUATE COMPUTER SCIENCE PROGRAMS AT HISTORICALLY BLACK COLLEGES AND UNIVERSITIES. Haigler, Martha Lynnette, 2020: Dissertation; Gardner-Webb University.

The underrepresentation of women and women of color in the disciplines of science, technology, engineering, and mathematics (STEM) is of little surprise to those of us who have kept abreast of the statistical data supporting this phenomenon. In order for the United States (U.S.) to remain "economically and globally competitive" (Ong, 2011, p. 32), it needs to increase its "advanced domestic science and technology workforce" (Ong, 2011, p.32). Perhaps, it is not a coincidence that the majority of students attending U.S. colleges are female, and the number of minority students entering college is on the rise. However, when one looks at the number of women of color entering college and the number of whom are pursuing a STEM degree, there is a significant decrease. Furthermore, the pipeline is even narrower for women pursuing computer science (CS) degrees. This exploratory qualitative study was focused on one historically Black university located in the southeast region of the U.S. This study utilized a grounded theory qualitative inquiry approach to identify practices and strategies utilized by the historically Black colleges and universities (HBCU) to effectively recruit and retain undergraduate African-American women in its CS program. The findings suggest the importance of K-12 experiences, supportive relationships among students and faculty, industry partnerships, and relevant and challenging experiences.

Keywords: recruitment, retention, African-American women, computer science, historically Black colleges and universities

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Chapter 1: Introduction

Statement of the Problem

Women earn approximately 18% of all computer science (CS) degrees in the United States, and African-American females earn fewer than 5% of those (U.S. Bureau of Labor Statistics, 2019). The "shrinking pipeline" problem for women in CS is a familiar and well-documented phenomenon, referring to the ratio of women to men in computing shrinking from early student (undergraduate and graduate) years to working (faculty rank and corporate) years (Varma, 2009, 2010; Zweben & Bizot, 2015).

Women's contributions to the field of CS can be traced back as far as 1842 with the development of the analytical engine by Charles Babbage. The analytical engine embodied the key parts of a computer system: "an input device, a processor, a control unit, a storage place, and an output device" (Capron, 1990, p. 667). If Charles Babbage was considered the "Father of Computers," the Countess of Lovelace (also known as Augusta Ada Lovelace) is rightfully credited as the "First Computer Programmer," since she helped develop instructions for carrying out the computations on Babbage's analytical engine.

Ada was the daughter of English poet Lord Byron and of a mother who was a gifted mathematician. Lady Lovelace's (Ada's) contributions cannot be overvalued. She was able to see that Babbage's theoretical approach was workable, and her interest gave Babbage encouragement. Additionally, she published a series of notes that eventually led others to accomplish what Babbage had not been able to do (Capron, 1990).

Historically, the inclusion of women's contributions to the field of CS has been addressed in one of two ways, either women like Ada have been omitted from the history

of computing and/or their contributions downplayed or a few select women have been labeled as superheroines, “devaluing the vital contributions of millions who are merely creative, intelligent, hard-working, and lucky enough to be in the right place at the right time” (Haigh & Priestley, 2015, p. 27).

The goal in highlighting the first coders or programmers, intended to empower women, has toggled between two extremes. On the one hand, the significance of women’s roles in computing is downplayed (Haigh & Priestley, 2015). On the other hand, the suggestion is made that only the exceptional and most gifted women need apply for computer-related labor (Haigh & Priestley, 2015).

A great deal is at stake here. “Women are conspicuous by their absence in computer science classrooms and in the programming teams, data centers, and computing research labs of America” (Cohoon & Aspray, 2006, as cited in Haigh & Priestley, 2015, p. 26). Gender disparity proliferates science and engineering undergraduate degree programs, especially for minority women. Women earned approximately 50% of bachelor’s degrees in all fields in 2016 and 50.4% of science and engineering bachelor’s degrees. However, women’s participation in science and engineering at the undergraduate level significantly differs by specific field of study. While women receive over half of bachelor’s degrees awarded in the biological sciences, they receive far fewer in CS (19%), engineering (21%), physics (19.3%), and mathematics and statistics (42.4%; National Science Foundation [NSF], 2019).

As early as the 1800s—when many historically Black colleges and universities (HBCUs) were founded—a clear delineation of the experiences that characterize the intersection of race and gender as it pertains to African-American women has existed

(Mack et al., 2011), "specifically as they relate to the underutilization and limited participation of Black women in the U.S. STEM enterprise" (Mack et al., 2011, p.151). These reports and articles provided two observations: a description of the "cost" of becoming and surviving as a scientist and a woman of color and blueprints for increasing the representation of Black women in STEM fields (Mack et al., 2011). Current research and literature support the fact that women now constitute approximately 50% of the U.S. college-educated workforce while being underrepresented (only 28%) in the science and engineering workforce. Hispanics, Blacks/African-Americans, and American Indians/Alaska Natives make up 11% of the science and engineering workforce, which is a smaller share of their proportion in the general population, i.e., 27% of the U.S. working age population (McFarland et al., 2018).

> While there have been many studies since 1970 on the experiences of *women* in STEM and on those of *minorities* in STEM, the unique experiences of women of color, who encounter the challenge of race and gender simultaneously, are often excluded from the research agenda. (Ong, 2011, p. 33)

African-American women in CS are included in this category (challenge of race and gender).

The lack of African-American females pursuing undergraduate degrees in CS presents a serious problem for several reasons. First, if the U.S. is to remain economically and globally competitive, it will need to increase its advanced domestic science and technology work force. U.S. colleges are already majority female, and there is an increasing number of women of color and minorities enrolling in colleges annually; therefore, women and minority students represent a growing potential source of domestic

talent to meet the demands of the country (Ong, 2011). Second, there is also the social justice argument (critical theory) for promoting women and African-American females in CS. The history of exclusion in STEM fields and the U.S. overall has resulted in an unfortunate outcome of underrepresentation that needs to be addressed. “It is important to continue to recognize and challenge sexism and racism that remains pervasive—though perhaps more subtle than 30 years ago—and which is experienced by women of color in multiplicative ways” (Ong, 2011, p. 32). According to a 2008 study conducted by the Harvard Business Review, approximately 50% of women working in STEM fields will gradually leave as a result of “hostile work environments” (Lien, 2015, para. 10). Furthermore, African-American women—like women of color at large—“are often the breadwinners, main supporters of children, and community leaders, so their successes and failures in a well-paid and well-respected field such as computer science could have significant impacts on more general community issues” (Ong, 2011, p. 32).

The competitive job market has made it harder for African-Americans to secure positions in commonly sought-after careers; for example, sales, marketing, or legal careers. Meanwhile, careers in science, technology, engineering, and math (STEM) fields are both available and lucrative. However, STEM positions are not being sought after in high demand by African-Americans (Strauss, 2011). The reason turns out to be a complex equation of self-doubt, stereotypes, discouragement, economics, and sometimes just wrong perceptions of what math and science are all about (Beyer et al., 2003; Margolis et al., 2000).

The percentage of African-Americans earning STEM degrees has fallen during the last decade. In addition, findings report that women have a misguided lack of

confidence in masculine domains such as mathematics, chemistry, and CS (Beyer, Chavez et al., 2002; Beyer, Rynes et al., 2002). These two facts alone suggest the need to focus on recruiting and retaining more African-American females in undergraduate CS programs.

Purpose and Significance of the Study

In an effort to increase the numbers of underrepresented African-American females pursuing and attaining CS degrees, I originally planned to study at least two HBCUs and compare structures for recruitment and retention of African-American females in CS programs. However, access to HBCUs proved more daunting than originally anticipated. As a result, this exploratory study focuses on a limited population at one HBCU and analyzes structures for recruitment and retention in this localized context.

The theory influencing this qualitative study is critical theory and Black feminist thought. According to Creswell (2014) critical theory is "concerned with empowering human beings to transcend the constraints placed on them by race, class, and gender" (p. 65). Black feminism argues that sexism, class oppression, and racism are inextricably bound together. The way these relate to each other is called intersectionality. This theory is ideal for this research in that it explores the behavior of a particular group—African-American females majoring in CS—and the contextual factors that affected their choice in declaring CS as their major discipline at an HBCU. As stated by Charmaz in *Strategies of qualitative inquiry* as edited by Denzin and Lincoln (2013), "Global, national, and local social and economic conditions shape and are shaped by collective and individual meanings and actions. Yet when, how, and to what extent these conditions affect specific

groups and individuals may not be fully recognized" (p. 291).

The method of study that was employed was an exploratory qualitative study of the perceptions of African-American/Black women in a CS program at an HBCU. In the literature encountered to prepare for this study, several qualitative studies were identified. This study differs from previous ones in its focus on grounded theory. There are two important principles built into grounded theory.

> The first principle pertains to change. Since phenomena are not conceived of as static but as continually changing in response to evolving conditions, an important component of the method is to build change, through process, into the method. The second principle pertains to a clear stand on the issue of "determinism." Strict determinism is rejected, as is nondeterminism. Actors (participants) are seen as having, though not always utilizing, the means of controlling their destinies by their responses to conditions. They are able to make choices according to their perceptions, which are often accurate, about the options they encounter. Thus, grounded theory seeks not only to uncover relevant conditions, but also to determine how the actors respond to changing conditions and to the consequences of their actions. It is the researcher's responsibility to catch this interplay. The interactive approach is necessary whether the focus of a study is microscopic, say of workers' interactions in a laboratory, or macroscopic, as in a study of the health industry or the AIDS policy arena. (Corbin & Strauss, 1990, p. 8)

This exploratory qualitative study utilized the grounded theory paradigm because of its focus on perceptions of the conditions experienced by CS majors at an HBCU and how these conditions impacted African-American women who chose and persisted in this

major.

Research Questions

The focal question of this study was, "What practices and structures for increasing the number of African-American females in undergraduate CS programs at HBCUs are being utilized?" The following research questions guided the study:

1. Why do African-American females choose CS as a major?
2. What are the perceptions of African-American female CS majors about their academic preparation before declaring their major?
3. What are the perceptions of African-American female CS majors about their academic preparation during their progression in the major?
4. Why do African-American females enrolled in CS programs at HBCUs persist in their major?
5. What are the perceptions of African-American female CS majors related to structures and practices utilized at HBCUs to recruit and retain African-American females in CS programs?

Definition of Terms

African-American/African American

An American of African and especially of black African descent (Merriam-Webster, n.d.). The terms African-American and Black are used interchangeably throughout this paper.

Black Feminist Thought

The knowledge of Black women's critical social theory as a result of intersecting oppressions of race, class, and gender (Collins, 2009)

Computer science or CS

The study of computers and computing concepts. It includes both hardware and software as well as networking and the Internet. Hardware covers the basic design of computers and the way they work. Software includes programming concepts and specific programming languages (Christensson, 2014).

Critical Theory

Perspectives that are concerned with empowering human beings to transcend the constraints placed on them by race, class, and gender (Fay, 1987). Critical theory is a social theory oriented toward critiquing and changing society as a whole, in contrast to traditional theory oriented only to understanding or explaining it (Crossman, 2019); synonymous with critical social theory. Critical theory will be the term used throughout this paper.

HBCUs

> The Higher Education Act of 1965, as amended, defines an HBCU as,
>
> any historically black college or university that was established prior to 1964, whose principal mission was, and is, the education of Black Americans, and that is accredited by a nationally recognized accrediting agency or association determined by the Secretary [of Education] to be a reliable authority as to the quality of training offered or is, according to such an agency or association, making reasonable progress toward accreditation. (Schlam, 2020, para. 1)

Pipeline Effect (A Metaphor)

The fact that as one progresses down the “pipe” of the study of CS, more women quit earlier than men. Rather than being actively rejected or turned down by some

individual or committee, women are choosing to leave the field, due mainly to the intrinsic nature of a heavily male-dominated field ("The Shortage of Female Computer Science Faculty at Stanford University," n.d.).

Delimitations of the Study

The purpose of a grounded theory study is to derive a general, abstract theory of a "process, action, or interaction grounded in the views of the participants" (Creswell, 2014, p.14). This study focused on the intersectional factors (namely class, gender, and race) influencing the recruitment and retention of African-American females in a CS program currently enrolled at an HBCU in the eastern region of the U.S.

There were several delimitations to this study. The first delimitation was the small sample size. The research project consisted of three student participants and one department representative (director), all from the CS department of the same HBCU. Findings of this study are limited by the small number of student participants, departmental representatives, and HBCUs.

Second, the time of year in which the study was conducted—mid to late March through June—yielded delimitation. I did not take into consideration the amount of time that it would take to invite students to participate and to finalize the selection process. This proved critical because two students backed out of the study prior to the interviews (data gathering); and, it was challenging to find replacements as most students had already left or were in the process of leaving the campus for the summer.

The third delimitation was the possibility that as a novice researcher, I may not have been clear enough in my questions to the student participants during the interview sessions or did not follow-up certain questions with probing questions as an experienced

researcher would have. As a result, time was spent during the analysis phase contacting participants for additional information.

Last, one of the student interviews was conducted via FreeConferenceCall.com, whereas the other two student interviews were conducted face to face in my worksite office. Although the interview was recorded with the student's permission, facial cues from the participant were absent from the data collected.

Limitations of the Study

The study has several limitations. First, the scope is limited in that I only examined practices and procedures influencing African-American female CS majors classified as juniors or higher at one specific HBCU; thus, the findings are not generalizable to all junior and senior African-American female CS students or to all HBCUs.

Second, personal biases may have arisen in that I am an African-American female who graduated from an HBCU and currently teach CS courses at an HBCU—not the HBCU in this study. To deal with biases during the study, I exercised extensive reflection and reflexivity (through journaling) as I proceeded through the interviews and document collection, which helped to bring these biases to my own awareness. In addition to journaling, I engaged in different conversations with colleagues, peers, and accountability partners to prevent my biases from influencing the process and the results of this study. Despite taking many precautionary steps to avoid implicating my own assumptions and biases on the findings, I could have inadvertently influenced the results of this study.

Another limitation was that I was not able to get multiple HBCUs (at least one

additional HBCU) to participate in the study; therefore, I had a very small number of participants.

I collected and analyzed data through student interviews and the director interview and reviewed documents, brochures, newsletters, websites, and email correspondence between the director and me. I was able to triangulate my data and identify emerging themes across the three data sources. However, due to the small number of student participants, I was unable to reach data saturation.

Last, as Creswell (2014) suggested, "qualitative research is interpretative research" (p. 187). Therefore, the results of this study are based on my interpretation of the data collected.

Organization of the Study

Chapter 1 presented the introduction, statement of the problem, the purpose and significance of the study, research questions, definition of terms, and the delimitations and limitations of the study. Chapter 2 reviews pertinent literature related to the research topic. The methodology and procedures that were used to gather data for the study are presented in Chapter 3. The results of data analysis and findings of the study are presented in Chapter 4. Chapter 5 presents a summary of the findings, conclusions, discussion, and recommendations for further study.

Chapter 2: Literature Review

Overview

The purpose of this chapter is to review the literature pertinent to the major themes of the exploratory qualitative study as based on the focal question, "What practices and structures for increasing the number of African-American females in undergraduate CS programs at HBCUs are being utilized?" The first section examines the current state of women in the technology industry, with an emphasis on the underrepresentation of women and women of color. The second section discusses the underrepresentation of minorities in CS and IT. The third section discusses the role of HBCUs in increasing the numbers of African-American women pursuing and attaining CS and IT degrees. The recruitment and retention of African-American female majors in STEM as it relates specifically to increasing the numbers of CS majors is the focus of the fourth section, followed by a section on systemic bias which hinders women and women of color from pursuing CS degrees. Finally, in the sixth section, contributions to the success of the recruitment and retention of African-American females in CS are discussed.

Status of Women in Technology Industry

During a panel discussion at the 2014 Grace Hopper Celebration of Women in Computing, held October 8-10 in Phoenix, AZ, Microsoft CEO Satya Nadella suggested that women who do not ask for raises will receive "good karma" (Riley, 2014, para. 1). Had he bothered to research the phenomenon of the decline in women working in technology fields, he would know that relying on karma, alone, has not helped women thus far.

In fact, women make nearly $11,000 less each year than men, according to the U.S. Census Bureau's latest report on income and poverty. That translates to women making 78 cents to every dollar made by men. For the last several years it has been 77 cents on the dollar, making this year's figures a tiny improvement (Riley, 2014). Nadella's comments, in addition to drawing criticism on social media, triggered a response by Maria Klawe, the session's moderator, who is also the president of Harvey Mudd College and a board member at Microsoft. Klawe stated that she had lost tens of thousands of dollars because she had failed to be assertive in salary negotiations.

Microsoft recently released workplace diversity statistics showing it has a problem with gender imbalance, particularly at the leadership level, much like other leading tech firms. Microsoft's workforce is 71% male, a figure that raises to 83% for both technical and leadership roles. Those figures are roughly in line with the gender breakdown at Google, Facebook, Yahoo, and Apple.

Furthermore, a Harvard Business study from 2008 found that as many as 50% of women working in science, engineering, and technology will, over time, leave because of hostile work environments (Lien, 2015). The reasons are varied. According to the Harvard study, they include a "hostile" male culture, a sense of isolation, and lack of a clear path. An updated study in 2014 found the reasons had not significantly changed. Furthermore, numerous scholars have contributed empirical evidence and theoretical conceptualizations concerning the factors affecting women's college decision-making processes in regard to STEM fields (Morgan et al., 2013). Among these empirical and theoretical contributions include the role of stereotype threat in hindering women's performance in mathematics (Spencer et al., 1999); institutional variables affecting

undergraduate STEM student completion rates (Eagan et al., 2010; Griffith, 2010; Perna et al., 2009); faculty influence on minority women's persistence in science (Johnson, 2007); the post-baccalaureate career and educational goals of women in STEM majors (Cole & Espinoza, 2011); and the overall role of gender-based stereotypes (Nassar-McMillan et al., 2011). Most women in the Harvard study said the attitudes holding them back are subtle and hence more difficult to challenge (Lien, 2015).

So far, no company has found a solution for retaining women. Google, whose engineering workforce is only 17% female (and per Dr. Marian Croak, Vice President of Access Strategy and Emerging Markets at Google, Inc., less than 4% of these are African-American), introduced a training program in 2013 that aimed to fight cultural biases. Employees play word association games and often are surprised by how quickly they link engineering and coding professions with men and less technical jobs with women.

Pinterest’s technical team is 21% female. It created an engineering promotion committee to ensure no one is overlooked. Gender, race, ethnicity and the like are not given special priority, but the committee is charged with making sure those issues do not get in the way of advancement. The company also has a recruiter whose focus is diversity.

Facebook, with a technical workforce that is 15% female, gathers its female employees from around the world for a leadership day filled with talks, workshops, and support. Women also organize themselves into Facebook groups to share knowledge and experiences. The company also offers special benefits like 4 months of paid maternity and paternity leave and free classes for women on returning to the workplace.

Apple's global engineering workforce is 20% female (Lien, 2015). The preceding examples inform the reader that despite the fact that Fortune 500 companies of old, such as Bell Laboratories and IBM, have or are being replaced with more modern research and development companies such as Twitter, Facebook, and Google, the underrepresentation of women and women of color in corporate America still persists. Furthermore, the literature supports the following findings:

- Although women fill close to half of all jobs in the U.S. economy in 2015, they hold less than 25% of STEM jobs. This has been the case throughout the past decade, even as college educated women have increased their share of the overall workforce (Noonan, 2017).
- Women with STEM jobs earn 35% more than comparable women in non-STEM jobs, considerably higher than the 30% STEM premium for men. As a result, the gender wage gap is smaller in STEM jobs than in non-STEM jobs (Noonan, 2017).
- Women with a STEM degree are less likely than their male counterparts to work in a STEM occupation; they are more likely to work in education or healthcare (Noonan, 2017).
- There are many possible factors contributing to the discrepancy of women and men in STEM jobs, including a lack of female role models, gender stereotyping, and less family-friendly flexibility in the STEM fields (Beede et al., 2011).

These points and statistics suggest the need to focus on encouraging women to pursue STEM disciplines and careers. More specifically, they suggest the need to focus on

encouraging African-American women to pursue CS disciplines and careers. Underrepresentation of African-American women pursuing CS degrees as well as women in general pursuing CS degrees factors into underrepresentation of African-American women in the workplace.

Underrepresentation of Minorities in CS

Recently, I had the pleasure of reconnecting with one of my colleagues and friends, Marian (Rogers) Croak, whom I met and befriended while living and working in New Jersey. Marian attended Princeton University and the University of Southern California and has a PhD in social psychology and quantitative analysis (1982). Marian joined American Telephone and Telegraph (AT&T) at Bell Laboratories in 1982.

During the years of separation, Marian worked her way up at AT&T. By the time Marian and I reconnected in August 2015, Marian had retired from AT&T (November 2014) as Senior Vice President of Applications and Services Infrastructure. Named to that role in 2012, she was

> Responsible for a team of more than 2,000 developers, engineers and program managers who manage over 500 programs impacting AT&T's enterprise, consumer, and mobility services and create the tools developers inside and outside AT&T are using to build new apps and services (Women in Technology Hall of Fame, n.d., para. 1).

Prior to her last position at AT&T, Marian was Vice President of the Services Network in Research and Development at AT&T Labs. In that position, she managed 500+ world-class engineers and computer scientists responsible for more than 200 programs impacting AT&T's wireline and wireless services. Her responsibilities ranged

from project management and service planning to development and testing. To date, Marian has over 200+ patents (there are additional ones under review by the U.S. Patent Office) credited to her – the highest number of any female at AT&T.

One of her patents allows contributors to donate digitally to charity events such as Hurricane Katrina and Haiti Earthquake victims. Her invention allows for a five digit code (for example, 90999) to be texted to a given fundraiser along with a donation amount. A similar concept is used to allow fans to vote via text for their favorite singers on *American Idol*. Most of her patents were developed while she was employed at AT&T, where her diverse and successful career culminated in her position as Senior Vice President of Architecture and Advanced Services Development (Gedeon, 2014).

Marian accepted a position at Google, Inc. in November 2014, after retiring from AT&T. She is the Vice President of Access Strategy and Emerging Market. Marian has received numerous awards including the 2013 and 2014 Edison Patent Awards, was inducted into the Women in Technology International's Hall of Fame in 2013, and named by Fierce Wireless as one of ten 2014 Most Influential Women in Wireless ("First International 5G Summit," 2015).

The fact that Marian is female and African-American should not be that significant some 34 years after she began her stellar career in technology. However, the truth is that Marian continues to be somewhat of a "lone ranger," navigating her way in, still, a male-dominated profession. During recent conversations with me, she spoke of the isolation she often experiences in this highly competitive and professional field. Marian is passionate in regard to mentoring young women and has served as a mentor while at AT&T and now at Google; but the question remains, "How can the number of women of

color pursuing careers in technology increase?"

In the last decade, the debate on underrepresentation of minorities in CS academic programs and the expected shortfall of candidates from the traditional source (18-year-old White males) has resulted in various measures to increase minority participation in CS education. This shortfall is expected because it is projected that underrepresented minority populations will comprise the largest percentage of the U.S. population by the year 2050, while White percentages are expected to decline (Vespa et al., 2018). Despite this fact and these efforts, minorities remain underrepresented in the CS field at the undergraduate level; that is, a significantly smaller proportion of certain minority groups are found in CS than in the total student-age population. African-Americans, Hispanics, and American Indians are considered underrepresented minorities, whereas Asians are not. For instance, in 2000, African-Americans earned 3,497, Hispanics earned 2,155, and American Indians (or Native Americans) earned 172 of the CS bachelor degrees awarded; the figures for Whites and Asians were 21,719 and 5,401 respectively (Varma, 2006). See Table 1 for a breakdown using percentages.

Although the numbers have increased slightly over the years, African-Americans, Hispanics, and American Indians are still underrepresented in computer and information sciences. Specifically, in 2017-2018, African-Americans earned 6,862 (8.62%), Hispanics earned 8,084 (10.16%), and American Indians earned 262 (0.33%) of the CS bachelor degrees awarded; the figures for Whites and Asians were 42,080 (52.87%) and 12,609 (15.84%) respectively (Snyder et al., 2019).

Table 1

CS Undergraduate Degrees Awarded to U.S. Citizens and Permanent Residents (2000)

	Bachelor's Degrees	Working Populations
Total	32,944	7,227,620
White	21,719(65.93%)	67.9%
Asian	5,401 (16.39%)	16.8%
Black	3,497 ((10.61%)	7.5%
Hispanic	2,155 (6.54%)	6.0%
American Indian (Native American)	172 (0.52%)	[a]-----

Note. Adapted from Varma (2006, p. 129).

[a]The estimate for the American Indian (Native American) is not shown because of a small number of sample observations.

> To improve the underrepresentation of minorities in CS education, the pipeline metaphor has been proposed. It is believed that if sufficient minorities are encouraged to enter the CS field, the racial disparities will disappear. Though important, such a focus tends to neglect the persistence of barriers to entry and retention of minorities into CS. (Varma, 2006, p. 129)

Fisher and Margolis (2002) summed it up as follows:

> Why should it matter if the inventors, designers, and creators of computer technology are mostly male? At the most basic and individual level, girls and women who have the necessary talent and inclination but do not become engaged in the technology are missing the educational and economic opportunities that are falling into the laps of computer-savvy young men. Computing salaries are high, jobs plentiful, and entrepreneurship opportunities unbounded. Furthermore, a command of IT is an asset in many contexts outside the field itself. Since so many

> facets of education and the economy are driven by technology, an understanding of the workings "under the hood" can be invaluable. The stakes are high for the national economy as well. The IT profession, by most accounts, is in the midst of a severe workforce shortage; it is estimated that more than 900,000 jobs are unfilled. One survey of software projects found that 40% had been canceled and another 35% had serious problems, with much of the difficulty attributed to a shortage of skilled workers. The cost to the economy of this labor shortage has been estimated at $3 billion to $4 billion per year in Silicon Valley alone; yet every day, talented girls and women who could fill these gaps are disaffected or discouraged from pursuing computing careers. (p. 2)

Role of HBCUs

There seems to be an ongoing debate regarding the significance of HBCUs. As recently as 4 years ago, the Access to Affordable College Education Act (2016) was discussed and debated that would slash the tuition of five state universities, namely Elizabeth City State University, Fayetteville State University, the University of North Carolina at Pembroke, Western Carolina University, and Winston-Salem State University. Three of the five universities (Elizabeth City State University, Fayetteville State University, and Winston-Salem State University) are HBCUs. The University of North Carolina at Pembroke was founded in the late 1800s as a teaching college for American Indian students. Today, the enrollment population consists of a large number of African-American and American Indian students (Seltzer, 2016a).

Other parts of the bill, which did not single out those five universities, drew criticism as well. Most significant among them were the potential for University of North

Carolina system's administration to recommend name changes for institutions, if they deemed it necessary to improve application numbers, academic strength, and student diversity.

Students and alumni of HBCUs as well as the NAACP and other critics cited several concerns with the bill. First, they saw the tuition provision undercutting finances at universities without large endowments or powerful supporters to advocate for new funding in the legislature. The tuition requirements would have placed the collective revenue loss at an estimated $60 million per year at those four universities serving predominantly minority students. Second, it was not clear where the funding for the tuition cut would come from and whether funding would be sustained over time. Additionally, the critics and protestors were cautious of potential name changes of HBCUs as breaks from history that would end decades of loyalty from Black students and alumni.

As a result of backlash from the schools' supporters, the amendment dropped the three HBCUs from the low tuition proposal in June 2016. The low tuition plan now includes only two University of North Carolina campuses—University of North Carolina at Pembroke and Western Carolina University.

> At those schools, tuition would be set at $500 a semester for in-state students and $2,500 for out-of-state students, starting in 2018-19. The state will include money to offset the reduced tuition revenue at the two campuses, according to the language in the provision. (Seltzer, 2016b, para. 3)

To summarize the reasons for the protest of the bill's original inclusion of three HBCUs, one would first be reminded of the need for HBCUs in the first place; HBCUs

were institutions founded to teach Black students in a time of legally enforced education segregation. Although legally enforced education segregation is no longer allowed, this does not mean that systemic racism and microaggressions of African-American students and other minorities are no longer experienced or practiced. The main problem with the funding of the tuition cut is, originally, there was no provision for it in the language of the bill. However, the amended bill does signify that the state will include money to offset the cut, but there is nothing to guarantee future senators will agree to do so. HBCUs are and should be treated as valuable resources. Hence, care must be administered by the state, legislature, and other governing bodies that will not pose challenges for HBCUs and other institutions that tend to serve lower income, underprepared, and first-generation students.

Even celebrities have weighed in on the discussion. For example, author and television and radio talk show host Wendy Williams recently shocked many African-Americans, including Roland Martin, when she made a general statement on the BET program, *The Wendy Williams Show*, which aired on July 7, 2016:

> On the other hand, I would be really offended if there was a school that was known as a historically White college. We have historically Black colleges. What if there was the National Organization for White People, only? There's the NAACP [National Association for the Advancement of Colored People]. (France, 2016, para. 3)

Roland Martin, a journalist and the host and managing editor of TV One's *NewsOne Now*, the first daily morning news program in history to focus on news and analysis of politics, entertainment, sports, and culture from an explicitly African-American

perspective, responded to Williams's statements in a very clear and adamant way.

Martin dedicated an entire segment of his show to dispelling the critique of Williams in regard to the NAACP and HBCUs. Martin's rebuttal was so effective and strong that he was invited by Williams to appear on *The Wendy Williams Show* (which aired July 14, 2016), where they discussed the matter further. This led to Williams publicly apologizing on live TV for the careless and thoughtless statements she made in regard to the need (or lack thereof) for HBCUs and the NAACP.

Essentially, Martin reminded Williams of why HBCUs were founded in the first place—because African-Americans were not allowed to attend White universities prior to the Civil Rights Act (1964). He traced the history, beginning in 1619 with the start of slavery; 1863, when the Emancipation Proclamation was signed; 1865, when the last slaves in Texas learned that they were free and the 13th Amendment was ratified to ensure the end of slavery; 1877, the end of Reconstruction in U.S. history, which attempted to redress the inequities of slavery; and, Jim Crow laws (1877-1950s), which enforced racial segregation. Martin stated that during the 1960s, we dealt with the Civil Rights Act (1964), the Voting Rights Act (1965), and the Fair Housing Act (1968, amended the Civil Rights Act). Martin's main point was that it was not until 1970 that African-Americans were technically considered fully free Americans. So, had it not been for the HBCUs that were founded prior to the Civil Rights Act (1964), freed slaves would have had no way to be educated.

Martin summed his thoughts:

> Education is still the most vital issue facing us because it's tied to income equality, folks who are in prisons. It's tied to every critical issue. If we are getting

> educated then we are on a much better path to getting empowered. And, we should still fight for the other issues as well, but without an education, you're screwed in America. (Williams et al., 2016, 2:51)

Indeed, HBCUs play a critical role in the education of African-Americans. Although approximately 90% of African-Americans attend predominately White institutions, 21 of the top 50 institutions (42%) for educating African-American graduates who persist to attain their doctorates in science and engineering are HBCUs (National Center for Education Statistics, n.d.). Xavier University, an HBCU, awards more undergraduate degrees in biological and physical sciences to African-American students than any other university in the nation (Fiegener & Proudfoot, 2013). HBCUs are also a more relatively important source of STEM degrees for African-American women than African-American men. According to NSF (2013), 15.8% of all science and engineering bachelor's degrees awarded to African-American women in 2010 were from HBCUs, compared to 14.5% of bachelor degrees in STEM fields awarded to African-American men. Coupled with these findings is the large number of African-American women enrolled in our nation's community colleges. According to NSF (2013), there has been a 50% increase of African-American females at community colleges. This insinuates that a proportion of African-American female STEM talent will be entering the HBCU environment through the community college environment (Jackson, 2013).

HBCUs have proven to be significant in the education of African-American students since their inception. These institutions continue today to accept students who are the first in their families to attend college (first-generation college students); may lack the academic preparation, initially, to be accepted at other institutions; and may not have

the financial means to support themselves in higher education. Despite these challenges, HBCUs accept these students and manage to successfully prepare them to be as competitive as their White or Asian counterparts.

There has been a decline in the number of African-American students enrolled in HBCUs over the last decade. This is a result of desegregation, rising incomes, and increased access to financial aid, which has created more college options for African-American students.

Recruitment and Retention of African-American Female Majors in STEM

The important challenge is for minority children to be positioned to take advantage of all the educational and career opportunities available in our society. To meet this challenge, underrepresented minority groups must be able to compete academically with their White or Asian counterparts. “Therefore, we must do all we can to strengthen and elevate the academic performance of these students well before they enter college” (Hrabowski et al., 2002, p. 209).

Several studies have been conducted in the quest for finding ways to increase the numbers of women and minorities enrolled in STEM programs at public majority institutions. For example, at the University of North Texas, programs have been introduced or modified to ensure an attraction of women in their CS and engineering disciplines. They designed the following 3-part plan to recruit and retain females in these fields: the sponsorship of portable and mobile summer computer engineering robotics camps geared at middle and high school female students, the creation of an ambassadors program utilizing current CS and computer engineering students at the University of North Texas, and the expansion of their undergraduate mentoring program (Akl et al.,

2005, p. 2). The result of this recruitment and retention effort was an increased student population in computing and engineering by approximately 1.5% from fall 2004 to fall 2005.

Interestingly, Stanford University has taken a more holistic approach in dealing with the challenge of increasing the number of women in their CS program: They considered the barriers to women pursuing CS degrees in an effort to better strategize their recruitment and retention efforts. They found that CS departments face similar challenges as other engineering disciplines, namely patterns of behavior that create a biased and unsupportive learning environment, gender differences that impact how students assess their own performance, a lack of role models/mentors, and a lack of cohorts to maintain a functioning support system (Roberts et al., 2002, p. 84). However, more discipline-specific problems, which may be unique in CS, include the following:

- The level of computing experience that students have prior to college differs markedly with gender [and sometimes race].
- The extraordinary flexibility of software makes it easier to incorporate social biases in the design of computing systems.
- The culture that develops around computer science departments is often unattractive to women. (Roberts et al., 2002, pp. 84-85)

As a result, the initiatives that were developed at Stanford University were as follows:

- the creation of an introductory CS course that is attractive to a wide audience, not just to majors, designed to encourage all students versus a select few, offers several positive role models for women—in addition to female lecturers

there are also teaching assistants and advanced undergraduates, who are female;

- role models are strategically at different levels of the students' matriculation—undergraduates, graduates, lecturers, and faculty are all part of the teaching process; and
- the introduction of "bridge programs" to prepare students for discipline-specific work at the college level (Roberts et al., 2002, pp. 85-86).

As stated previously, the task of improving the recruitment and retention rates of women is an ongoing one; they also recognize that the aforementioned initiatives only address some of the underlying problem. Therefore, the success of these initiatives has been of partial consequence. In addition to the list of discipline-specific problems provided, there may be others that were not included; thus, the initiatives offered, while a good start, should not be considered a "one-size-fits-all" recruitment and retention strategy.

HBCUs are known historically for graduating the largest number of African-American (female and male) STEM students and, in particular, CS majors. While predominantly White institutions (PWIs) that seek to recruit and retain women and minorities in CS should be acknowledged, there exists an added benefit in looking at HBCUs to prepare female undergraduates to fill this void. "Fifty-five percent of Black HBCU graduates were more likely to 'strongly agree' that their colleges prepared them for life after graduation compared to 29% of Black graduates of other institutions" (Prince, 2015, para. 5). This is one of the findings included in the new Gallup-USA Funds Minority College Graduates Report. The report is based on the results from

Gallup-Purdue Index studies in 2014 and 2015 with 55,812 college graduates aged 18 and older, with internet access, who received bachelor's degrees between 1940 and 2015. The study included 520 Black graduates of HBCUs and 1,758 Black graduates of other colleges.

Hrabowski et al. (2002) mentioned the major initiatives of agencies such as NSF, the National Institutes of Health (NIH), and the National Aeronautics and Space Administration (NASA) as specifically focusing on K-16 minority student development programs that connect universities and schools in working with teachers and children to improve performances in math and science (Hrabowski et al., 2002).

NSF, created by Congress in 1950, is a major funding agency for science and mathematics education in the U.S. NSF also coordinates programs that promote STEM with other federal and state agencies. These programs focus on all levels of education from preschool to graduate school and beyond. NSF annually documents the number of science and mathematics degrees conferred to minority students as part of their goal of increasing the number of minorities in STEM.

Its student development programs are grouped into three areas of focus: pre-college, undergraduate, and graduate. Pre-college opportunities that focus on elementary and secondary school students fall under the Urban Systemic Program. The two programs supported under this initiative are the Comprehensive Regional Centers for Minorities and the Partnerships for Minority Students Achievement. Alliances are forged between schools; higher education institutions which include HBCUs; community organizations; and private industry to foster minority student interest in science, math, and technology and to increase minority performance.

In 2000, NSF established the Historically Black Colleges and Universities Undergraduate Program (HBCU-UP) to strengthen HBCUs in their effort to strengthen STEM education and research as a means to widening the pipeline to the nation's STEM workforce.

"HBCU-UP provides awards to develop, implement, and study innovative models and approaches for making dramatic improvements in the preparation and success of underrepresented minority students so that they may participate in STEM graduate programs and the workforce" (HBCU-UP, n.d., para. 3). Examples of the support offered by NSF include the following: implementation projects, broadening participation research projects, targeted infusion projects, and planning grants.

Undergraduate programs provide "outreach assistance and scholarships to increase the number of degrees awarded to minorities in science, math, and technology" (Hrabowski et al., 2002, p. 234). There are two programs supported under this initiative: the Louis Stokes Alliance for Minority Participation Program (LSAMP) and the HBCU Initiative. LSAMP is aimed at increasing the quality and quantity of students successfully obtaining STEM undergraduate degrees and increasing the number of students interested in pursuing graduate degrees. The HBCU Initiative strives to address historical underrepresentation of minorities in baccalaureate and doctoral degree ranks in STEM. The LSAMP initiative is also present at HBCU XYZ and is discussed in Chapter 4.

At the graduate school level, NSF intends to support minority researchers through the Centers of Research Excellence in Science and Technology and the Alliances for Graduate Education and the Professoriate. The intent of both programs is to expand a diverse student presence via several means:

- upgrading the capabilities of the most research-productive minority-serving institutions;
- implementing innovative models for recruiting, mentoring, and retaining minority students; and
- developing strategies for identifying and supporting underrepresented minorities interested in pursuing academic careers (Hrabowski et al., 2002).

NIH, an agency of the U.S. Department of Health and Human Services, is one of the world's foremost research centers. Support is available at the undergraduate, graduate, postdoctoral, and faculty levels, including educational and research infrastructure improvements. One program in particular, Minority Access to Research Centers, is mentioned here. The Minority Access to Research program offers special research training support to 4-year colleges, universities, and health professional schools with substantial enrollments of minority students.

> The goals are to increase the number and competitiveness of underrepresented minorities engaged in biomedical research. These goals are accomplished by strengthening the science curricula at minority-serving institutions and increasing the opportunities for research training for students and faculty at these institutions. (Hrabowski et al., 2002, p. 236)

NASA is in charge of U.S. technology that has to do with airplanes or space. NASA has two programs dedicated to providing minority students with research and educational opportunities.

> NASA's Office of Equal Opportunity Programs established the Minority University Research and Education Division (MURED) in 1990 to increase the

> Agency's responsiveness to Federal mandates related to HBCUs and Other Minority Universities (OMUs)…. Secondly, the National Council for Minorities in Engineers (NACME) has led the national effort to increase the representation of successful African-Americans, Latinos, and American Indians in engineering. (Hrabowski, 2002, p. 237)

These initiatives, while helpful, are not enough to remedy the phenomena of piping more girls and women into STEM fields and, in particular, CS fields. The underlying problem is so subtle and historical—as are other forms of discrimination and racism—that the oppressors (in these cases, males) choose not to acknowledge the unjust playing field of the oppressed (women and women of color); thus, the result is the intrinsic nature of a male-dominated field, which leads to systemic bias.

Systemic Bias in CS Programs and IT Fields

In Chapter 9 of Women's Ways of Knowing, Belenky et al. (1997) began with the reminiscence of an ordinary woman, recalling an hour during her first year at college. The woman, now middle-aged, remembered the first meeting of an introductory science course. The professor marched into the lecture hall, placed upon his desk a large jar filled with dried beans, and invited the students to guess how many beans the jar contained. After listening to an enthusiastic chorus of wildly inaccurate estimates, the professor smiled a thin, dry smile, revealed the correct answer, and announced, "You have just learned an important lesson about science. Never trust the evidence of your own senses" (Belenky et al., 1997, p. 191).

Years later, the woman reflected on that first-year of college experience. She reasoned that the professor had used the experience as a way of inviting the class to

explore the secrets of the universe independently through scientific reasoning. However, at seventeen years of age, she could not appreciate the experience as an invitation. All she understood at the time was that he was denying her sense of knowing and leaving her with no alternative. Consequently, she withdrew from the course that day and abandoned any interest she may have had in science altogether.

Belenky et al. (1997) identified this woman's experience as humiliating rather than humbling, stating that she and other women in their study did not view themselves as thinkers. As a result, "the kind of learning the science teacher demanded was not only painful but crippling" (Belenky et al., 1997, p. 193).

What this suggests is that there are multi-faceted reasons as to why females view science and math differently from males as well as how the various systems (educational, familial, communal, and societal) view the intelligence of females and males. From a very early age, little girls are taught to play with dolls and to be "good girls," while boys are encouraged to build (and break) objects; and they are validated, if not rewarded, for doing so. Therefore, males are encouraged at a very early age to be confident and outgoing—that it is okay to make mistakes—mistakes are part of learning. By contrast, girls are taught to be less aggressive and "nice." Belenky et al. (1997) said it best: "but our interviews have convinced us that every woman, regardless of age, social class, ethnicity, and academic achievement, needs to know that she is capable of intelligent thought, and she needs to know it right away" (p. 193).

Earlier, in this same section, some of the major initiatives of funding agencies such as NSF, NIH, and NASA were discussed. There are additional White House initiatives such as Educate to Innovate and Change the Equation which were started for

the main purpose of providing students at every level the skills they need to excel in STEM fields. Educate to Innovate, launched in 2009 by the Obama Administration, is a collaborative effort along with leading companies, foundations, nonprofits, and science and engineering societies to achieve this goal ("Educate to Innovate," 2009). Educate to Innovate calls for improving the STEM pipeline from an early age to moment of hire with four key points: "focusing on underrepresented groups, exposing girls and young women to STEM fields, setting the standard with exceptional role models, and promoting tech inclusion" (Diversity, Inc. Staff, 2015, para. 3).

One of the objectives of Educate to Innovate is to prepare 100,000 new and effective STEM teachers over the next decade. To reach this objective, Change the Equation was launched in 2010 with the help of the President. Change the Equation is "a new no-profit with full-time staff dedicated to mobilizing the business community to improve the quality of STEM education in the United States" (Sabochik, 2010, para. 1).

Time will surely play an important factor in determining how well and to what extent these initiatives achieve their goals and objectives. Still, while initiatives like Educate to Innovate and Change the Equation are important, for the underrepresentation of women in technology, the issue is further complicated by systemic bias in science and technology fields. Whether it is Microsoft's CEO saying women should rely on karma for raises or women seeing bias in training and sponsorship at tech firms, the issue of systemic attitudes toward gender persists.

There are some scholars who believe that the problem is not so much widening the pipeline as it is addressing the bias that women and women of color are exposed to in science fields such as CS. Williams et al. (2014) conducted a study with 60 women

recruited via the Association for Women in Science by sending emails to the Association for Women in Science members. The participants consisted of 20 each of Latinos, Asian-Americans, and Black women. Additionally, 557 women scientists responded to an online survey. The outcomes of this research were as follows: (a) the data suggest that gender bias is very common in science; (b) 100% of the 60 scientists interviewed reported encountering one or more of these patterns of gender bias; (c) women of color face "double jeopardy" because they encounter race as well as gender bias (as cited by Williams et al., 2014, p. 4); and, (d) Black women were more likely than other women to report a sense of bleak isolation.

Based on the findings, Williams et al. (2014) believed that gender bias today is more subtle, but it is pervasive. Also, statistically, the data indicate that more women and women of color are attending colleges and universities and are graduating from CS fields than are being hired. This would lead one to question whether the problem is really with the pipeline, i.e., the lack of readily available talent from the underrepresented populations or is it something more subtle and systemic such as gender and/or racial bias.

Contributions to the Success of Recruitment and Retention of African-American Females in CS/IT

Hrabowski et al. (2002) provided some key insight into the second part of a study that begin in 1995 as the result of the success of the Meyerhoff Scholars Program at the University of Maryland, Baltimore County. This program, created in 1988, was designed to increase the numbers of minorities, especially African-Americans, who become research scientists and engineers.

Hrabowski et al. (2002) discussed a study that was conducted on raising

academically successful African-American young women. In addition to the students, Hrabowski et al. interviewed the parents of the female students.

> From the daughters' perspective, there were a number of specific factors that contributed substantially to their success and reflected their overall feeling that their parents had been a major resource for them in their upbringing. The following themes were identified consistently throughout our interviews.
>
> 1. The Importance of Reading
> 2. High Expectations Accompanied by Encouragement
> 3. Demonstrating Parental Interest
> 4. Parents' Interaction with Teachers
> 5. Extracurricular Activities. (Hrabowski et al., 2002, pp. 216-217)

Hrabowski et al. (2002) believed that more focus should be placed on the role of families in preparing daughters—in particular, African-American daughters—for success in school. "Both parents and daughters agreed that parental or family support, in addition to natural ability, was a major reason for the daughters' success" (Hrabowski et al., 2002, p. 209).

Hrabowski et al. (2002) stressed the importance of increasing the ways in which to connect parents to the schools. This is necessary in order to attain the goal of not only preparing children to learn but also achieving success in math and science. They agreed with Willie Pearson that

> if Black participation and performance in science is to improve significantly, Black parents…will have to play a more active role in any such efforts. These parents must be made aware of the economic opportunities available in scientific

> and technical fields. (Pearson's *Blacks, science, and American education*, as cited in Hrabowski et al., 2002, p. 222)
>
> In the healthiest of communities, schools have been effective largely because of their ability to sustain ongoing communication between parents and teachers. Parents of girls and young women need opportunities to interact with teachers in order to provide them with additional knowledge about their daughters and to receive feedback from teachers about their daughters' performance and behavior in the school. (Hrabowski et al., 2002, p. 222)

Gender Issues

In the past 20 years, the number of women majoring in CS in college has actually declined, even as the number of women majoring in other fields like biology and chemistry has reached near parity with their male classmates.

"The decline is due in part to the stubborn cultural myth that, as Barbie says, math class is just too tough for girls. These ideas are communicated and internalized from long before birth," said Cordelia Fine (as cited in Hing, 2012, para. 8), an associate professor of psychology at the University of Melbourne: "Gender is absolutely primary; it is the first thing we want to know about a newcomer to the world—'Is it a boy or a girl?'…and as a social division it is emphasized ceaselessly" (para. 8). "When people are reminded of their gender, 'even subtly,' it can influence people's behavior and perceptions of themselves and even change their abilities" (Fine, as cited in Hing, 2012, para. 8).

Collins (2009) defined oppression as, "any unjust situation where, systematically and over a long period of time, one group denies another group access to the resources of society" (p. 6). Although racism consists of many forms including age, class, gender,

race, and sexual orientation to name a few, Collins gave special credence to class, gender, and race. These characteristics were present as early as U.S. slavery and therefore serve as an impetus for the other forms.

Collins (2009) contended that African-American oppression has been shaped by three interdependent aspects: the economic dimension of oppression, the political dimension of oppression, and the ideological dimension of oppression.

The economic dimension of oppression refers to the fact that large populations of Black women in the U.S. hold blue collar jobs and have not been afforded the financial opportunities to pursue their education beyond high school. In a lot of cases, they are living paycheck to paycheck and are locked into a nearly hopeless situation. On the other hand, Whites with the same level of education are able to live in better homes and hold more financially rewarding jobs. That is to say, impoverished Black women have been "ghettoized" (Collins, 2009, p. 6) to certain U.S. cities such as Philadelphia and Detroit.

The political dimension of oppression refers to the fact that African-American women have been refused rights and privileges sometimes routinely extended to White males. These would include "forbidding Black women to vote, excluding African-Americans and women from public office, and withholding equitable treatment in the criminal justice system" (Collins, 2009, p. 7).

The ideological dimension of oppression references the fact that Black women were controlled and oppressed during slavery, which foreshadows how U.S. Black women are viewed and treated today.

From the mammies, jezebels, and breeder women of slavery to the smiling Aunt Jemimas on pancake mix boxes, ubiquitous Black prostitutes, and ever present

> welfare mothers of contemporary popular culture, negative stereotypes applied to African-American women have been fundamental to Black women's oppression. (Collins, 2009, p. 7)

Social theories reflect women's attempts to understand lived experiences within intersecting oppressions of race, class, gender, sexuality, nation, and religion (Collins, 2009). Black feminist thought which is U.S. Black women's social theory, arises because African-American women as a group remain oppressed within a U.S. context characterized by injustice. That is, Black feminist thought's identity as a "critical" social theory "lies in its commitment to justice, both for US Black women as a collective and for that of other similarly oppressed groups" (Collins, 2009, p. 12).

Gaps in the Literature

The purpose of the NSF-funded project, "Inside the Double Bind: A Synthesis of Empirical Literature on Women of Color in STEM," was to gather, analyze, and synthesize empirical research that had been produced since 1970 and 2008. The project team identified 116 works of empirical research literature produced since 1970 on women of color in STEM higher education and careers (Ong, 2011).

They identified 19 sources on women of color in CS—not a lot when one considers that the search covered a nearly 40-year span of literature.

> Studies in computing are relatively new: 16 of the works have been produced since 2002. Most of the literature focuses on higher education, and the research covers an array of topics, including the digital divide that separates girls and women of color from others, social challenges for students who are women of color, the roles of minority-serving institutions, and nontraditional pathways to

CS degrees. (Ong, 2011, p. 33).

Ong (2011) warned that their searches were thorough but not necessarily exhaustive. However, with only 19 identified works, there are obviously many gaps and incomplete descriptions about the status and experiences of women of color in computing.

The literature is clear in declaring there is a shortfall of women and minorities in the CS discipline (National Center for Education Statistics, 2012; NSF, 2012; Ong, 2011; Ong et al., 2011; Weston et al., 2019). The literature is also clear in its evidence that women of color, including African-American, Latinos, and American Indians, are underrepresented in CS and STEM in general (Landivar, 2013; Varma, 2010). What the literature is not clear on is exactly why this is and/or what the solution(s) is. Some researchers believe that the "pipeline theory" still holds true (Camp, 2002; Dillon et al., 2016; Vitores & Gil-Juarez, 2016). Others believe, as do I, that the problem is not *just* in the pipeline but also in the subtle and systemic bias that exists in educational institutions and industry and continues to make it a "hostile" environment for women and minorities. Furthermore, the literature provides very little information on specific underrepresented minorities, such as African-American/Black females pursuing degrees (undergraduate or graduate) in CS. Last, although a few studies have centered on HBCUs and the contributions that they continue to make in producing African-American students who earn degrees in STEM, not many have researched the strategies HBCUs have adopted and/or developed.

Conclusions

My intent was to closely look at the CS program of one HBCU which has had a successful track record of graduating African-American female students in the major as

well as to speak (via interviews) with a representation of those students from the HBCU.

This helped identify the practices and structures that are utilized to recruit and retain Black females in CS as well as student perceptions of these strategies and their effectiveness in empowering and enabling them to persist.

Chapter 3: Methodology

Introduction

This chapter describes the qualitative research paradigm and grounded theory design for this study of the recruitment and retention of African-American females majoring in CS at a coed public HBCU located in the southeastern region of the United States. The chapter describes the methodology for this study, including a description of the participants, how participants were selected, a pilot study that was conducted, my role, and ethical issues. An explanation is included of the data collection tools, how data were collected and analyzed, and threats to data quality**.**

Design of Study

According to Creswell (2014), the qualitative research paradigm should be undertaken based on the following rationales: (a) research questions begin with *how* and *what*; (b) the topic requires exploration because of multiple variables and/or a lack of theory; and (c) a natural setting is required. Therefore, the paradigm of qualitative research was chosen because I wanted to give a voice to this underrepresented group, specifically African-American women in computing.

"In grounded theory, the researcher generates an abstract analytical schema of phenomenon, a theory that explains some action, interaction, or process" (McCaslin & Scott, 2003, p. 449). This analysis occurs mainly by collecting interview data of student participants, the director, and the study HBCU's published documents and website and attempting to develop and combine categories of information through constant comparison and writing a substantive or context-specific theory (Corbin & Strauss, 1990). In simple terms, theoretical sampling can be defined as the process of collecting,

coding, and analyzing data in a simultaneous manner in order to generate a theory. This sampling method is closely associated with grounded theory methodology (Dudovskiy, 2011).

Grounded Theory

This qualitative, exploratory study utilized the grounded theory research paradigm. Grounded theory, developed in 1965 by Barney Glaser and Anselm Strauss, does not begin with a hypothesis that you prove or disprove. Instead, it begins with an area of study and allows what is relevant within that area to emerge (Grounded Theory Tutorial, n.d.).

This theory is ideal for this exploratory study in that I explored the experiences of a particular group—African-American females majoring in CS—and the contextual factors that affected their choice in declaring CS as their major discipline at an HBCU. Study of these contextual factors included brochures, newsletters, reports, websites, and email correspondence. As stated by Charmaz (2011), "Global, national and local social and economic conditions shape and are shaped by collective and individual meanings and actions. Yet when, how, and to what extent these conditions affect specific groups and individuals may not be fully recognized" (p. 359).

The central goal of this exploratory study was to begin building a theoretical framework that would uncover the practices and structures of the effective recruitment and retention of African-American females majoring in CS at HBCUs. Table 2 provides the research questions that guided this study aligned with the data to be collected for each question.

Table 2

Research Questions and Data to be Collected

Research questions	Data to be collected
1. Why do African-American females choose CS as a major?	Student interviews
2. What are the perceptions of African-American female CS majors about their academic preparation ***before*** declaring their major?	Student interviews Director interview
3. What are the perceptions of African-American female CS majors about their academic preparation ***during*** their progression in the major?	Student interviews Director interviews
4. Why do African-American females enrolled in CS programs at HBCUs persist in their major?	Student interviews Director interviews Document analysis
5. What structures and practices are being utilized at HBCUs to recruit and retain African-American females in CS programs?	Student interviews Director interviews Document analysis

Pilot Study

A pilot study was conducted to validate the clarity of the interview protocol questions that would be used in the research study during the student participant interviews. Participants for the pilot study included three African-American female, junior CS majors at my worksite—one of two all-women HBCUs in the U.S. Results of the pilot study uncovered that Interview Questions 3 and 4 were unclear and redundant:

- Why did you choose to major in CS?
- Describe some of the experiences that led to your decision to major in CS.

Due to the small participant size in the pilot, I was reluctant to delete either question and noted the potential ambiguity in my notes and reflections for future consideration during the actual study.

Role of Researcher

According to Creswell (2014), a researcher "supports a way of looking at research that honors an inductive style, a focus on individual meaning, and the importance of rendering the complexity of a situation" (p. 4).

Although I entered the relationship as a researcher, I also emphasized my role as a college professor. I introduced myself as a full-time faculty member and a part-time doctoral student. I did this when I recruited participants and at the beginning of each interview. My hope was that this would help establish more of a collegial relationship which may have been viewed as less intimidating.

My perceptions of HBCUs and CS have been shaped by my personal experiences. I graduated from an HBCU, where I majored in mathematics with a concentration in CS. I spent 10 years employed at a competitive research and development company writing computer programs. As an African-American female who has faced the challenges incurred with gender, class, and race, I believe an understanding of the context and role enhances my awareness, knowledge, and sensitivity to many of the challenges and issues faced by African-American females majoring in CS at HBCUs.

I accepted the ethical responsibility to safeguard the storyteller (research participants) by maintaining the understood purpose of the research. It was important to take the draft findings back to the student participants and the departmental representative to ascertain if the findings were taken to mean what I said they meant. This gave the research participants a chance to further explain or even change the wording of a response. I sought comments on the extent to which findings were consistent with their experiences, and whether the findings assisted in understanding the topic being

investigated. There is, however, a methodological weakness involved with this technique based on the time required to transcribe interviews. I was able to complete the member checking within 2 weeks of each interview and data analysis. Time was needed for the transcriber to type each interview and mail the transcripts back to me. I proofed the transcripts for acronym edits that may have been ambiguous to the transcriber before completing the member checking. It is possible too much time may have elapsed and circumstances may have changed. The participants may also have had too much time for reflection and this might have altered what they initially said. Either of these dilemmas may be a weakness of the study.

Data Collection Procedures

Janesick (2000) revealed that a key issue for qualitative research is developing a shared understanding of appropriate procedures for assessing credibility or trustworthiness. In a broad sense, trustworthy qualitative research needs to be based on a systematic collection of data using "acceptable" research procedures and allowing the procedures and findings to be open to systematic critical analysis from others. Janesick further noted that triangulation refers to comparison of findings derived from two or more data-gathering procedures or sources of information. Using this technique, emerging findings are assessed for the extent of consistency or inconsistency among data derived from different sources. Data in this study were obtained from (a) individual interviews with students, Subquestions 1-5; (b) an interview with the director of undergraduate studies for CS, Subquestions 2-5; and (c) analysis of documents including departmental brochures, CS department undergraduate handbook, newsletters, CS department website, and email correspondence (from director), Subquestions 4 and 5. The findings among

these various data sources were compared to determine confirmation or conflict.

Grounded theory involves multiple stages of data collection and the refinement and interrelationship of categories of information (Charmaz, 2006; Corbin & Strauss, 2007), Data collection occurred in multiple phases: prescreening via initial interview (general background) questions, interviews, and document analysis. However, because the data were limited with regard to number of HBCUs and number of participants, this study can be considered only an initial step in developing theory related to recruitment and retention of African American females in CS at HBCUs.

This exploratory, qualitative inquiry-based study was conducted on the campus of an HBCS. The HBCU in this study (HBCU XYZ), an 1890 land-grant doctoral research university with an emphasis on preeminence in STEM and a commitment to excellence in all its educational, research, and outreach programs, is located in the southern region of the east coast.

In May 2014, when I began the process of identifying potential HBCUs for this research, HBCU XYZ conferred 10 (35%) undergraduate CS degrees to African-American female students of 29 total CS degree recipients. In May 2017, the year I conducted my study at the HBCU, a total of 21 CS degrees were conferred and only four (19%) were African-American females. The lower number of African-American females graduating is indicative of a steady decrease that has occurred over the last 5 years due to a decrease in the number of females enrolling in the university as CS majors and persisting in the major through matriculation.

Despite the lower number of African-American females graduating with an undergraduate CS degree at HBCU XYZ, it is a highly ranked university and still has a

competitive and reputable CS program. The following are a few rankings that have been awarded to HBCU XYZ: It has ranked high among public HBCUs and has been recognized as a producer of African-American STEM majors.

Steps of Data Collection

I collected data through interviews and document analysis. Upon approval by the Institutional Research Board (IRB) of the proposed study of HBCU XYZ, I contacted the CS department chair at HBCU XYZ and provided him with an overview of the study. I requested and scheduled an appointment to present to potential African-American female CS student participants. This initial phone conversation was followed up with an email summarizing the telephone conversation and requesting the chairperson recommend African-American female CS majors (juniors and seniors only) who might be interested in participating in the study and/or encouraging African-American CS majors to participate in the study. I specifically requested junior- and senior-level CS female majors to participate in this study. Most undergraduates do not declare majors until their sophomore year (NSF, 2018); and my objective was to identify strategies used in recruiting and *retaining* African-American females. Therefore, concentrating on CS female majors in their junior year or above ensured a minimal retention rate of 1 year.

I was working with a pool of 14 juniors and seniors who were female and African-American. After obtaining approval from the department chairperson to do a presentation to the female, junior and senior African-American CS majors, I arranged a presentation date with the director of undergraduate studies and emailed her a flier to disseminate to the students. Five students attended the presentation, which was held in the CS department's conference room of HBCU XYZ. Of the five students, three

volunteered to participate. However, one withdrew right before her interview was scheduled.

After consulting with the director, I contacted another CS faculty member at the study HBCU, who provided the name and email address of a third student. She graciously agreed to participate, provided her interview could be done via conference call as she had already left the state for the summer. There were several factors that may have led to poor student participation: participation in the study was strictly voluntary with no incentives; the timing of the interviews happened to occur during the latter part of April, right before final examination period; and last, a possible sense of distrust on the students' part that I was unable to allay.

In addition to the student participants, the director of undergraduate studies, who was recommended by the department chairperson, was interviewed (see Appendix A). Also, I analyzed several documents pertinent to the academic program, department, and university. Once the student participants were identified, I emailed an informed consent form to each. This informed consent form was also sent to the department representative.

The interview questions addressed all of the research questions (see Appendix B). The study was qualitative because I sought not only to capture a clear picture of the perspectives of each participant as to *why* they persisted in a CS undergraduate program but also to glean an understanding of specific strategies and procedures that were being utilized by the HBCU to ensure effective recruitment and retention of African-American female students (that is, *how* they persisted).

During the presentation at HBCU XYZ, I disseminated a brief demographic questionnaire to the student attendees (see Appendix C). The questionnaire was

completed by each interested student anonymously. A number on the top right corner of the questionnaire corresponded to a number on the bottom right corner of the form. The bottom portion or summary was detachable and included the student's email address and telephone number. If they indicated on the form's summary an interest in participating in the study, I knew how to contact them. The forms were then placed in an envelope and sealed; the sealed envelope was held by the departmental representative. At the conclusion of the presentation, the departmental representative detached the bottom portion of the forms and gave them to me. The top portions of the forms were returned to the envelope and resealed. This was done to ensure that I remained objective and unbiased in my selection of research participants.

I modeled initial interview questions for the student participants based on a former doctoral candidate's interview questions, having requested and obtained permission (Ellington, 2006). Ellington's (2006) study sought to understand factors that shaped participant decisions to persist and succeed in mathematics. Her study employed interpretive case study methodology in which interview data from eight high-achieving African-American mathematics majors were collected, transcribed, and analyzed. While Ellington's instrument was consulted for items and structure, it was not replicated.

Data were collected over a 2-month period. Each participant was interviewed, and these interviews were the primary source of data. Guided by the research questions, I created a protocol with general open-ended questions designed to understand the student's background and readiness for college and the pursuit of a CS degree. Appendix B represents the interview protocol for the student interviews. Appendix B also identifies the research question that each interview question addresses.

I contacted each student who completed a form, either by phone or email, to confirm their interest and to schedule the interviews. Each interview lasted approximately 25 minutes and was audio recorded. I met individually with two of the student participants in the privacy of my worksite office. One of the student participants was not available for an in-person interview; therefore, I conducted the interview via conference call. The recorded interviews were transcribed by a paid typist. A draft copy of each transcript was emailed to the student participants for accuracy and validation within 2 weeks from the interview. I instructed the students to make changes or corrections to the transcripts using the track changes feature in Microsoft Word. This helped to ensure that focus was placed on understanding and clarifying my interpretation of student perceptions and experiences that had been shared during the interviews.

The interview questions are found in Appendix B. I analyzed and synthesized the data, using the grounded theory analyzing technique to determine initial themes.

The interview protocols did not change after the first interview. As data were gathered during the interviews, I searched for repetition in the themes of at least two of the three student participants. I triangulated the themes that emerged from the student participant interviews with those of the director of undergraduate studies and the documents that were analyzed. I did not reach saturation—an important element of grounded theory—due to the small number of participants; therefore, these are preliminary findings that can be built on in future work.

Data Analysis Procedures

The qualitative data were analyzed with memos and with categorizing and contextualizing strategies. Memos were written after each interview to facilitate

analytical thinking about the data and to help remember details that may not necessarily have been included in the transcripts.

Recorded interviews were transcribed, coded, and categorized and analyzed on an ongoing basis as a source for further questions, the emergence of themes, and as an eventual source for organizing patterns of response across categories and individuals. Guided by the research questions, I modified Ellington's (2006) protocol with general open-ended questions designed to understand student communal, educational, and personal experiences and their perceived impact on their persistence in CS (see Appendix B for the interview protocol). Each of the questions in the interview protocol was designed to gain information about each student's experiences in the aforementioned areas.

To verify findings and themes, I undertook extensive member checking of new findings and transcripts on an ongoing basis. To further contrast and compare interview data with other sources, I attempted to collect and inventory relevant documents on an ongoing basis throughout the study. Relevant documents included college catalogs and any additional records and documents that pertain to the recruitment and retention of CS majors (departmental, operational, and strategic plans). Triangulation was used to validate the methodology by an examination of the results from several perspectives, namely student interviews, the department representative's interview, and document analysis (see Appendix D for a list of documents analyzed).

Methods for Verification

A significant attraction to the grounded theory research paradigm is that the analysis makes use of constant comparisons. "Making comparisons assists the researcher

in guarding against bias, for he or she is then challenging concepts with fresh data" (Corbin & Strauss, 1990, p. 9).

Furthermore, to deal with bias, I exercised extensive reflection and reflexivity as I proceeded through interviews and document collection, bringing attention to my own awareness. Verification techniques that were performed included

- member checks of interview transcripts and documents;
- actively sought discrepant evidence by using informed interviewing techniques, emphasizing discrepant evidence in member checks; and
- sought informed input from colleagues and committee members while undertaking reflection and analysis of interview transcripts and documents.

Member Checks

I employed member checking which allowed participants to review and edit transcribed data. After each interview and preliminary analysis, a copy of the transcript and my preliminary assertions were given to the participants. The participants were asked to review the manuscripts and interpretations and to make any corrections they saw fit.

Summary

This exploratory study utilized a grounded theory qualitative inquiry approach for the purpose of identifying practices and structures that are being implemented at one HBCU in its effort to recruit and retain African-American women in the CS program. Unlike quantitative research, which is based on calculation and comparison of numbers and generalizations, qualitative, grounded theory research requires a check and balance system because it is based upon interpretation of words and pictures.

This chapter described the methodology for this study, including a description of

the participants, how participants were selected, and a brief description of the pilot study, my role, and ethical issues. Also, an explanation was included of the data collection tools, how data were collected and analyzed, delimitations, limitations, and threats to data quality. Chapter 4 presents the findings of the study, and Chapter 5 presents conclusions and recommendations.

Chapter 4: Results

The purpose of this study was to identify practices and structures to increase the number of African-American female students in the CS discipline at an HBCU. It is worth noting that the college housing the CS department at HBCU XYZ has high national rankings with regard to STEM disciplines.

This exploratory study sought to address this phenomenon by interviewing three African-American female CS majors attending an HBCU located in the southeastern region of the United States. Chapter 3 provides detailed information pertaining to methods for this study. Three African-American female students participated in the study. One, beyond her undergraduate program and pursuing a PhD in CS at the HBCU of this study, had also obtained her BS and MS in CS from this HBCU. Additionally, the undergraduate director of the CS program was interviewed, and I was provided access to documents for review and analysis. Table 3 shows the breakdown of the three student participants of this research study.

Table 3

Student Participants

Student Alias	Classification
Katherine	Junior
Dorothy	Junior
Mary	Graduate Student

Fictitious names were used to protect the identities of the student participants in this study. I chose to use the first names of three African-American women scientists whose story is focused on in the book *Hidden Figures* (Shetterly, 2016). Mary Jackson, Katherine Johnson, and Dorothy Vaughan were three

> brilliant African-American women working at National Aeronautics and Space Administration [NASA] who served as the brains behind the launch into orbit of astronaut John Glenn, a stunning achievement that turned around the Space Race. The visionary trio crossed all gender and racial lines and inspired generations. (Gigiliotti et al., 2017, para. 1)

Using these three scientists' names—of African-American women who were actually referred to as "computers" during the Word War II time period (1939-1945)—provided a logical rationale for pseudonym selection. This chapter begins by providing a brief description of each student participant. Research questions guiding the study with themes and descriptions developed through data analysis follow. A summary of the study findings concludes this chapter.

Description of Student Participants

Katherine

Katherine is a full-time CS major in her junior year. She self-identifies as Black. Her high school grade point average was 3.6 of 4.0 and her current college grade point average is 3.9 of 4.0. She is a traditional student (that is, her current age is between 18-22 years). Katherine is from New Jersey and attended a PWI for her first year of college prior to transferring to the HBCU in this study her sophomore year.

Dorothy

Dorothy is a full-time CS major in her junior year. She self-identifies as African-American. Her high school grade point average was 4.3 of 5.0, and her current college grade point average is 2.3 of 4.0. She is a traditional student (that is, her current age is between 18-22 years). Dorothy is from a suburb in central North Carolina. Dorothy

entered this HBCU as a freshman.

Mary

Mary attained both her undergraduate and graduate degrees from the HBCU serving as the focus of this study. She earned both a Bachelor of Science degree and a Master of Science degree in CS. At the time of this study, she was enrolled in the CS doctoral program. She self-identifies as African-American and Black. Her high school grade point average was 3.75 of 4.0. She did not provide her college or graduate school's grade point average. She is a traditional student (although her current age is 23 years or older). This is traditional based on her matriculation of all degree programs up to this point. Mary grew up in a city in central Virginia.

Research Questions

The data collected for this exploratory, qualitative study are thoroughly described in Chapter 3. To summarize, by interviewing these three students as well as the director of undergraduate studies for CS and reviewing pertinent documents at the HBCU as well as online, I was able to gather information to support deeper understanding of my primary research question:

> What practices and structures are used to increase the number of African-American females in the CS major at HBCUs?

To explore the primary question, this study examined data related to the following subquestions:

1. Why do African-American females choose CS as a major?
2. What are the perceptions of African-American female CS majors about their academic preparation *before* declaring their major?

3. What are the perceptions of African-American female CS majors about their academic preparation *during* their progression in the major?
4. Why do African-American females enrolled in CS programs at HBCUs persist in their major?
5. What structures and practices are being utilized at HBCUs to recruit and retain African-American females in CS programs?

Findings

It is reported in multiple outlets that numbers are low for women and women of color majoring in the CS discipline (Landivar, 2013; Ong, 2011; Saulsberry, 2012). "Women's representation in STEM occupations has increased since the 1970s, but they remain significantly underrepresented in engineering and computer occupations, occupations that make up more than 80% of all STEM employment" (Landivar, 2013, p. 2). Furthermore, it is reported that women's representation in computer occupations has declined since the 1990s (Landivar, 2013). For example, in 1985, 37% of CS bachelor's degrees were awarded to women; however, in 2010, only 18% of such degrees were awarded to women (Sax et al., 2017).

This exploratory study included interviews with three African-American females at a prominent HBCU in the southeastern region of the United States. Their respective backgrounds and reasons for pursuing a CS degree varied to some degree; therefore, major themes, in most cases, evolved individually for each participant. I developed themes that were directly chosen from the words of the student participants. The findings of this study are organized by research question with individual participant responses summarized. Then, the responses are discussed across participants as broader themes.

Selecting CS as a Major

The student participants were asked why they chose CS as their major. Each student had a different high school experience, and it was during their high school tenure that each first thought about pursuing a CS degree. Although none of the three student participants' high schools offered computer programming courses, in two cases, the students had been enrolled in a computer class. Consequently, that brief and broad encounter with computers was impactful enough to pique their interest in CS as a major field of study in higher education.

Katherine

Katherine spoke of a web design course that she had taken in high school. Specifically, Katherine discussed using HTML (Hyper-Text Markup Language) and CSS (Cascading Style Sheet) in the course. Hyper-Text Markup Language is the software used to create the content of web pages. It became the official markup language in 1991, and it was created by Tim Berners-Lee, who is also the creator of the World Wide Web (Fisher, 2019). Cascading Style Sheet is a feature used to modify the aesthetics of a web page (Berners-Lee & Jaffe, n.d.).

Katherine admitted that prior to taking the web design course, she was unclear on what she would pursue in college. She stated specifically that she liked the coding (programming) aspect of the class.

Dorothy

Dorothy's decision to major in CS was based more on her arriving at the conclusion that she did not like engineering. She had attended an engineering high school where more emphasis was placed on aerospace, chemical, and automotive engineering.

She stated that she knew she wanted to do something in technology, and CS is a growing field. For her, it was a choice between CS and computer engineering: "I didn't want to go into computer engineering actually. You know, actually setting something on fire…I'll just go into computer science." Because the school Dorothy attended focused more on chemical and automotive engineering and less on computer engineering, her faulty assumption that computer engineering would result in setting something on fire can be understood through her experiential lens. Perhaps, if it had been made clear to Dorothy—that a computer engineer usually refers to one of two cases: (a) a professional who has software, systems, or network engineering experience or (b) a professional with an electrical engineering background, who is also proficient in CS—then her decision to major in CS would have been a more informed one (Sommerville, 2016).

Mary

Mary's decision to pursue a CS major consisted of several factors: her strong background in mathematics, her enjoyment of programming in Visual Basic in high school, and "out of the guidance and recommendation" from her computer teacher in high school. She attributes all three factors as having impacted her decision to pursue CS. Visual Basic, a programming environment created by Microsoft, allows a programmer to "use a graphical user interface to choose and modify preselected sections of code written in the BASIC programming language" (Rouse et al., n.d., para. 1). BASIC or Beginner's All-purpose Symbolic Instruction Code is an early programming language and still considered one of the simplest because it can be learned quickly, its statements are easy to read by other programmers, and support is available on most operating systems (Rouse et al., n.d.).

Selecting CS as a Major Themes

In all three cases, the participants identified events or experiences that occurred while they were in high school as the reason(s) for their choosing to major in CS. In Katherine's and Mary's cases, they were introduced to a computer course (Web Design and Visual Basic respectively) that influenced them to some degree. Additionally, Mary felt that her strong math background and the support of her computer teacher influenced her decision to pursue CS. Themes that evolved from Katherine's and Mary's responses are as follows: first encounters with programming, strong math background, and teacher encouragement. Dorothy, who had had a totally different experience than either of the other two, seemed to base her decision to pursue CS in college on her own personal research on the field. Thus, the theme that emerged here is individual interest.

Perceptions Before Declaring CS Major

To address the second research question, the student participants were asked whether they felt prepared for their CS courses when they first entered the program in college and to explain their responses.

Katherine

Katherine stated that she had no previous experience with CS prior to college; also, she had no problems adjusting to the major in college. She explained that having transferred from a PWI to this HBCU had given her an advantage.

"I felt like I kind of had more of an advantage, like I really knew a lot of things that students here didn't know yet." To gain an accurate understanding of her viewpoint, I visited the PWI's website to view the curriculum pattern for a CS major. Table 4 provides a listing of courses offered at both institutions for first-year CS majors. At the PWI, there

are a total of five courses that a first-year student who plans to major in CS is required to take: Calculus I for Physical Science Majors, Calculus II for Physical Science Majors, Introduction to Computer Science, Data Structures, and Introduction to Discrete Structures I. Furthermore, the prospective CS major must earn a grade of C or better in each course. Since Katherine transferred after her first year from the PWI to the HBCU, she was able to transfer the credits for the three CS courses, namely Intro to CS, Data Structures, and Discrete I. This was confirmed by the undergraduate director at the HBCU. The Introduction to Computer Science course would have exposed her to problem-solving, analyzing, debugging, and writing programs in Java. Additionally, she would have been introduced to data structures in this course. The Data Structures course covers the two most important concepts necessary for one to become competent in programming—algorithms and data structures. Both are powerful tools required to design and implement programs that will solve real-world problems. Last, Introduction to Discrete Structures I, as Katherine stated, "introduced me to the mathematical tools of logic and induction."

Table 4

CS Course Comparisons for First-Year Majors

PWI ABC	HBCU XYZ
Intro to CS	Intro to Comp Programming GEEN 163
Data Structures	Comp Program Design GEEN 165
Discrete I	Discrete Structures COMP 180
Calculus I	Calculus I MATH 131
Calculus II	Calculus II MATH 132

The most significant difference between the first-year CS experiences at the PWI versus the HBCU is the fact that Data Structures is offered during the first year at the PWI, while it is offered later (during the second year) at the HBCU. Therefore, this alone

would have given Katherine a clear advantage over the other sophomore CS majors at the HBCU.

Katherine went on to explain,

> So at our school [the HBCU], it's like two basic coding classes. We have 163 and then we have 165, and that's often because the professors are much harder so people have a harder time transitioning, but it was really easy for me to go into 165.

The two courses Katherine referenced are GEEN 163 and GEEN 165 respectively. GEEN 163 is a three-credit hour course, Introduction to Computer Programming. GEEN 165 is a four-credit hour course, Computer Programming Design. GEEN 163 is the first programming course that CS majors take, followed by GEEN 165. In Katherine's case, she was able to transfer credit for the Intro to CS course she took at the PWI, enabling her to have incoming credit for GEEN 163.

I was informed by the participants as well as the undergraduate director that Java is the high-level programming language currently taught in these two programming courses.

Dorothy

Dorothy readily admits that she did not feel prepared for her CS courses when she entered the program. She explained it this way: "I did not feel prepared. I found that out on my first day of class. I was just so lost…it was because I had never been exposed to it [computer science] before I came to college." She believes that she would have benefited from having had pre-college exposure to CS, and then she would not have been as stressed out.

Mary

Mary chose CS as a major based on the one computer course (Visual Basic) she had taken in high school along with the encouragement of her high school computer teacher. When she began work in the major at the HBCU, she realized that what she had learned in high school did not fully prepare her for what she was about to undertake in college. In other words, her perception had been that her academic preparation was adequate for her to pursue a CS major at the HBCU; however, the reality was that her academic preparation was not as strong as she had initially thought.

Mary admitted that she was confident in her math skills but did not feel the same level of confidence in her programming skills: "So, from the math perspective, I did feel comfortable, but within the programming side, it took some concentration. It took some hard work to get really comfortable with things."

Perceptions Before Declaring CS Major Themes

With regard to academic preparation for the CS major, two of the three participants did not feel prepared for their CS courses when they first entered the program in college. Katherine, who had transferred from a PWI to the HBCU in this study, stated that although she had no other experience with CS, she did not find it hard to adjust to the CS program while at the PWI. She even felt that her time (1 academic year) at the PWI gave her an advantage when she came to the HBCU. On the other hand, Dorothy, who had attended an engineering high school, still felt underprepared for the CS discipline when she first enrolled at the HBCU. In her words, "I was so lost. I don't know; it was because I never was exposed to it before I came to college."

Finally, Mary thought she was prepared because of the Visual Basic she had been

exposed to in high school. However, she quickly learned that Visual Basic was elementary in comparison to higher-level programming languages like C and C++.

The theme that emerged here is CS readiness gaps. In two of the three cases, the participants perceived that they were prepared by their pre-college experiences for the CS program in higher education. In other words, the level of experience provided to them in high school was sufficient for them to feel prepared for in-depth study of CS. In those two cases, the participants described minimal pre-college exposure to what computer programming actually is. Exposure they did have, specifically Web Design and Visual Basic courses, contributed to a misconception of the skills and knowledge required for computer programming.

Perceptions During Progression in CS Major

To better explore the subquestion, "What are the perceptions of African-American female CS majors about their academic preparation *during* their progression in the major," I posed specific questions to the participants. First, the participants were asked to reflect on the best and worst assignments or experiences they had as part of their CS coursework. Next, participants were prompted to tell me about any other experiences related to their academic preparation they had as a CS major.

Best Assignment/Experience

Katherine

Katherine seemed excited about a particular programming assignment. She briefly explained that during her sophomore year, the class created space invaders. This was an individual assignment; however, she stated that the students worked together to complete the assignment. She admitted that it was challenging; but once it was completed, she

realized, “it was fun. It was cool; it was like, I did this!”

Aside from her reflection on this one assignment, Katherine seemed most impacted by a summer internship experience. She interned at a major company in Florida during the summer of 2016. She was one of two interns in a division that made radios that allowed soldiers out in the field to communicate back to base. Her job was to write code that would correct radios that did not work properly. Katherine remarked that she felt a sense of accomplishment after completing the task and seeing the result—radios that worked properly. Additionally, she attained firsthand experience as to how computers are programmed to solve real-world problems.

Dorothy

Dorothy described her favorite programming assignment of creating an algorithm to decipher a password. She admitted that it had been challenging to develop the program; however, after the program was successfully implemented, the experience itself proved to be enjoyable. Developing a program involves creating an algorithm that will solve the problem and then translating the algorithm into a particular programming language which can be run on the computer. Dorothy stated that she had coded the program in C++. She also mentioned a research opportunity: “Another experience I had in the CS Department was when I was able to actually start research. It was really fun doing that.”

Dorothy was an undergraduate research assistant from February 2017 through June 2018. She described her research experience as follows:

> My research at that time involved investigating different cybersecurity incidents and determining the cause of them and if those incidents were something that

could've been prevented. My research was conducted on campus where I was the only researcher/investigator. With the information that I collected I was able to write an article and present my findings at a student research symposium.

Mary

Mary was candid in stating that it was hard to come up with just one "best assignment or experience," since she considered no assignment or experience as bad or the "worst." She settled for speaking of two "good examples" she had experienced. Mary's first example was challenging because of the grade she received rather than the assignment itself. She explained that the first example was to write a program to create a vending machine. She understood and implemented the program based on the requirements; however, she failed to include the customer's (in this case, the professor's) input as part of the solution. "So even though I had everything that should be there for the end result, because I didn't ask additional questions to really actively engage the customer, I didn't receive the highest grade—and for me, it was always about the highest grades." This experience taught her to always engage the customer, "Because I can design all day, but what is it that the customer wants?"

Mary's second example took place in a different CS course with a different instructor: For this assignment, the students had to design an animation through programming. She had a chance to incorporate her math skills in designing a swing set. However, this professor's approach was to give the students (they worked in groups/teams) just enough information so they would work independently of the professor. Mary's impression of that experience was, "it was neat, because it was like a group project, so we all worked together to actively build a sound solution. So that was

awesome!"

Best Assignment/Experience Themes

Themes from these positive experiences include relevant, problem-based learning; challenging assignments; collaboration; and internship opportunities.

Relevant, Challenging, Problem-Based Learning

The programming assignments (both in-class and during the summer internship experience) were real-world problems that needed to be solved by developing an algorithm and then executing it on a computer. This made the application relevant and worthwhile to the student participants. All three participants exuded pride in having completed their assignments and having produced working programs. In all three cases, the participants seemed to enjoy the computer programming assignments, especially in the cases where the assignments were challenging.

Challenging Assignments

In the case of challenging assignments, both Katherine and Dorothy felt that the programming assignments were challenging. It seemed that the initial challenge may have come from not having a clear understanding of exactly what the problem was. Additionally, in Katherine's case, she was in her sophomore year when she encountered this particular assignment (creating space invaders). Therefore, she had not had a lot of programming experience at that point. In either case, my impression was that the challenge was a "good challenge." In other words, the end result of having successfully completed and executed their programs gave each confidence in their programming abilities.

In the case of Mary, there were some additional lessons that she learned beyond

the finished program. She discovered the importance of assessing the customer's needs and when to solicit input from the customer.

Collaboration

Collaboration evolved from Mary's experience in one of her classes where she worked in a group with two other students. The assignment was to design an animation via programming. Mary was able to incorporate her strong math skills into the project when considering the degree measurements (for the swing set, in this case) as well as the problem-solving skills acquired. For this project, the students were given the autonomy to complete the programming assignment with little or no direction from the instructor (or customer). This experience also adds to the challenging assignments theme. The challenge for Mary was in knowing how much customer (that is, instructor) input was needed to complete the assignment successfully.

Internship Opportunities

Perhaps more so than the in-class programming assignments, Katherine was enthused with the opportunity to participate in summer internships. It was there that she was able to fully understand and see firsthand how computers are utilized to solve real-world problems. Further discussion of summer internships will be addressed in the section Other Experiences to follow.

Worst Assignment/Experience

The participants were also asked to describe a worst assignment or experience they had as part of their CS coursework.

Katherine

Katherine stated that no specific assignment came to her mind as being the worst;

however, she was adamant in stating her dislike for group projects:

> I feel like in college, group projects don't really work because I feel like I end up doing all the work. And, I know in the workplace it's supposed to be about collaboration, but in college it just doesn't work out that way.

Dorothy

One of Dorothy's worst experiences occurred during her first year when she was given a programming assignment, but the instructions were unclear to her. She stated that she had asked several of her peers, and they had responded that they did not understand it either. For Dorothy, the worst part of the experience was trying to find someone to help them. Another worst experience for Dorothy was that she had to repeat a programming course because she did not initially pass with the mandatory grade.

Mary

Mary had not experienced a worst assignment.

Worst Assignment/Experience Themes

Themes that evolved from the negative experiences were collaboration and lack of assignment clarity. Katherine felt that her experiences of working in a group for class projects had not had a favorable outcome. Specifically, she felt that she ended up doing all the work. Although she understood that working on teams is common in the workplace, she felt unsupported in collaboration in the college environment.

Lack of Assignment Clarity

Dorothy's worst experience was described in terms of a programming assignment with little to no instruction provided. Although she sought help from classmates, they, too, were puzzled and unable to provide her any guidance.

Other Experiences

The participants were asked to reflect on other experiences related to their academic preparation as a CS major.

Katherine

Katherine showed excitement when discussing her internship opportunity during the summer of 2016 at Harris Corporation in Sunrise, Florida. She explained that she was one of two interns in her assigned division. “They made radios so that soldiers, who were out in the field, could communicate with people back at the base.” She continued, “There were things the radios were supposed to do, but they didn’t work correctly. So, it was my job to go into the code and fix it.” This was an invaluable experience for Katherine, as stated in her words, “It was pretty cool because after you had fixed the code, you could load up the radio with your code and actually see how the software connects to the hardware.” This is an experience that she believes she has not encountered in her college classes. She ended by stating that she would be interning at Bank of America this summer (2017).

Dorothy

Dorothy responded that what has helped her in her major has been “finding people in my major who didn’t mind working with me, especially in study groups.” She attributes passing the programming class, which she had repeated, by way of a study group. She explained her experience this way:

> Like when I first came in, there weren’t really as many girls in my major, so I would just hang out with the boys…. Then there started to be more girls who transferred in and then I started to meet them, and then my grades went up, and

I'm learning stuff.

Mary

Mary was able to reflect and summarize her CS major experience in this way: "One is given the essentials needed to create a program or to solve a problem but the expectation is that the student will figure out how to solve the problem." Her undergraduate experiences at the HBCU taught her that the professors are there to prepare the student with the basic skills they will need to solve problems, whether in writing programs or other real-life applications. Mary surmised this to be "learning or acquiring the skill set to figure out how to come up with a sound solution."

Other Experiences Themes

Several themes emerged from this additional discussion with participants. The themes introduced included the following: internship opportunities, study groups, application to real-world examples, and faculty mentors**.** At least two of these themes (namely study groups and faculty mentors/advisors) coincide with the discussion that I had with the director of undergraduate studies:

> I think the retention of the African-American females as well as the retention of our students in general is that we develop a family atmosphere within the Computer Science Department. Many of the faculty have an open-door policy and are eager to help the students, not only in the class setting but, one-on-one…. Students' willingness to help each other attributes to the retention of many of our students. Most of our students develop friendships for life among their peers who are majoring in Computer Science.

Persistence in a CS Program

To better explore the subquestion, "Why do African-American females enrolled in CS programs at HBCUs persist in their major," I posed specific questions to the participants. First, the participants were asked to describe a challenge they had encountered and to explain the outcome of the challenge. Each student's reflection around this topic is presented and then the emerging themes are summarized.

Challenges as a CS Major

Katherine

Katherine could not think of any challenges she had had.

Dorothy

Dorothy stated that when working with a group member on coding projects, the challenge of making decisions on how to complete the project, initially, becomes a debate. The conflict may arise due to scheduling conflicts, for example. The resolution was to find alternate ways to communicate, if they were unable to meet at mutually agreeable times. Alternatives included email and text messaging each other to obtain updates on each other's progress.

Mary

Mary considered it a challenge when her 4.0 grade point average was jeopardized. She explained that she had been a 4.0 student in undergrad until she encountered her Physics I course with a separate lab. She had assumed that since she was doing well in Physics I, the instructor would be lenient with the lab and perhaps even curve the class averages. However, he did not curve, and her grade for the semester was a B. She met with the instructor and attempted to persuade him to change her grade, to no avail. This

was her first and only B; and the experience taught her "that sometimes in life you're just given what you worked for." Mary felt that was one of the best educational lessons she learned.

Challenges Encountered Themes

The themes that emerged from the discussions with Dorothy and Mary were as follows: collaboration and life lessons.

Professor or School Support

Next, I inquired as to any support the student participants may have been provided by their professors or the school.

Katherine

Katherine felt that the school was supportive in establishing local chapters of student organizations on campus such as the Association for Computing Machinery (ACM) and the CS club. She mentioned that she was a Students in Technology, Academia, Research, and Service (STARS) mentor. During a freshman colloquium, students can sign up for a STARS mentor. The STARS Mentorship Program serves two main purposes. First, it assigns a peer mentor, a junior or senior, to first-year students. As the acronym implies, first-year students may be supported on any or all of the major foci of the CS experience at the HBCU, namely academic community, research, service, and technology. Additionally, upperclassmen are given the opportunity to develop leadership skills while serving as mentors. The aim of the program is to give guidance and support to first-year CS majors supporting their transition from high school to the university environment.

Katherine sees her role of mentor as someone who encourages the mentee(s)

(first-year students) to stay in the CS program, especially if they become overwhelmed. The STARS mentor gives them someone to talk to who can better relate to their experiences. Katherine also thinks that the mentor could help the new students with their programming assignments. Last, Katherine mentioned that she is serving as the vice president of the ACM, and all of her mentees (STARS) are female.

Dorothy

Dorothy felt that the professors are supportive in open office hours, and they (professors) ensure that the teaching assistants (TAs) are knowledgeable and available to the students. According to Dorothy, "I look to TAs a lot more, because when I go into the study room, they're always there and I can say, 'I need you.'"

Mary

Mary stated that she had been an athlete (a swimmer) while in the undergraduate program; and study hall was built into athlete schedules. Her goal was to utilize the department's TAs to avoid study hall with the other athletes. In other words, Mary had discovered that it was more beneficial for her to receive one-on-one attention from the TA versus being in a classroom filled with other athletes, while trying to focus on her studies. By utilizing the TAs, she was able to "study and actually get something accomplished."

Mary also cited the professors' interest in developing students as a positive means of support. During her senior year in the undergraduate program, Mary was unsure of what she would pursue after graduation. She applied to an MBA program at Wake Forest, and she had an internship offer with Raytheon Missile Systems. It was while she was enrolled in an information assurance or security course with the graduate director for the

master's program that the graduate director questioned Mary about her future plans. The graduate director encouraged her to consider pursuing her master's degree in CS and invited her to interview with the NSF during a campus recruitment session. After the interview, Mary was informed that she had received a fellowship to attend graduate school in CS. Mary felt that this was divine intervention, and she felt relieved because of her prior uncertainty. Subsequently, she enrolled in the master's program in CS at the HBCU.

Professor or School Support Themes

The following themes emerged from the discussions with the students: participation in CS-related clubs, student mentoring, available and supportive faculty, knowledgeable TAs, and financial support.

Wish List for CS Majors

I asked the student participants if there was anything they wished their professors or school would do to support them as CS majors.

Katherine

Katherine mentioned that "more scholarship opportunities" would be beneficial to her. She stated that she had one of the highest GPAs in the CS department; however, she was not provided any scholarships. In addition to that, she was an out-of-state student, which means that her tuition is higher than that of in-state students. As she summed it up, "That's a lot to handle." The director of undergraduate studies also mentioned scholarships as one of the most effective ways of recruiting students into the CS major.

Dorothy

Dorothy felt that it would be helpful to send the entering students (first-year

students) a package which includes information on what they would be studying as a CS major.

> Because when I came into computer science, I really didn't know…. And so, like send out a sample to show this is what you're going to do, starting the first day of class. And, it's going to be a whole different ballgame than it was in high school.

Mary

Mary wished that the HBCU in this study had already had a PhD program, "because I feel—I know—I would have at least applied sooner to pursue my PhD." Her point was that she would have opted to go directly into the doctoral program after undergraduate had the PhD program been an option at that time. Mary admitted there were advantages to having work experience prior to pursuing a PhD: "However, I did know the importance of working, like getting some field experience before pursuing my PhD. So, it was sort of like a catch-22 with that one." The PhD in CS began at HBCU XYZ in 2014.

Wish List Themes

The student participants in this study gave varied responses to this subquestion. Themes that evolved from this discussion were as follows: scholarship opportunities and a CS majors' what-to-expect information packet. I did not include Mary's suggestion as a theme because the PhD in CS now exists at the HBCU in this study.

Mary's comment in respect to the graduate program not being available during her matriculation at the HBCU in this study after obtaining her undergraduate degree was based on a specific timeframe and is no longer applicable. A doctoral program in CS was introduced while she was completing her master's degree. Her point was that she would

have opted to go directly into the doctoral program after the undergraduate had the PhD program been in place.

Satisfaction with CS Major Decision

The student participants were in agreement that they were satisfied with their chosen major. Two of the participants expounded on their reasons for feeling satisfied.

Katherine

Katherine's response was, "I am very satisfied. I feel like it's a field that will be relevant for a long time, so I will always have a job, and I generally like it, so I also will be happy."

Dorothy

Dorothy explained that the CS major allowed her to develop her critical-thinking and logic skills more fully. "So I am very satisfied with my major because it allows me to actually use my brain a lot more than I used to. Like, I mean [I] think deeper, if that makes sense." She also believes that her formal training in computer programming has exposed her to several applications:

> And plus, it just allows me to do a lot more things that I want to do, like actually going into hacking, and being able to understand these program algorithms, or eventually, I am going to be able to use programming—I know how to teach and explain it, and use the applications with it, and stuff like that.

Satisfaction with CS Major Themes

The three student participants were in unanimous agreement of their overall satisfaction in choosing CS as a major. The director of undergraduate studies concurred with the overall CS majors' satisfaction with the discipline, per the results of the Senior

Exit Surveys. Themes that evolved were job security, improved critical-thinking and program development skills, and diversity of the CS field.

Summary of Research Question 4

The three participants spoke of STEM relationships and having a supportive environment as they pursued their CS degrees. In Katherine's case, her involvement in the ACM and CS clubs as well as the STARS Mentorship Program evolved into the themes of participation in CS-related clubs and student mentoring. Furthermore, she was an active participant in each—vice president of the ACM chapter and a mentor in the STARS program—signifying the development of leadership skills.

Themes that emerged from Dorothy's reflection include available and supportive faculty and knowledgeable TAs. Both of these factors are important to build a supportive climate. Dorothy felt confident in going to her instructor's office for assistance as well as going to a TA for tutoring or supplemental instruction because she knew that the faculty had selected TAs who were conversant with the subject matter.

During Mary's discussion, several themes emerged. In addition to supportive faculty and knowledgeable TAs, she also spoke of collaboration, family mentors, internship opportunities, and scholarship opportunities.

Based on where the most agreement occurred, the themes were narrowed to the following: relationships; financial support; knowledgeable TAs; and relevant, challenging, problem-based learning. Generally speaking, the role of the individual faculty member (who was also the graduate director), the rapport that developed between she and Mary, and all of the previously stated themes dealing with faculty mentoring or interactions could be included with relationships. Financial support is a more specific

theme, and it compares Mary's options to pursue an MBA with no financial assistance versus pursuing a master's degree in CS funded by an NSF fellowship.

Last, in all three cases, the notion of family or community within the CS department at the HBCU seemed to be prevalent—whether peer-to-peer, student-to-faculty, or both. It is apparent that the participants believed that these relationships enabled them to persist in the CS program. Additional discussion is included in the next section with regard to Research Question 5.

Structures and Practices Used at HBCUs

The final research question explored structures and practices implemented at HBCUs to recruit and retain African-American women in CS programs at HBCUs. Specific interview items addressing this question included the following:

- What types of academic activities have you participated in or are currently participating in?
- Did the university do anything specifically to encourage your decision to major in CS?
- What does the university do to support you as a CS major?
- What types of professional conferences or internship opportunities have you been exposed to?
- Looking towards the future, what would you like to see put into place to recruit and retain students into the major?

I examined responses for each student participant. Additional data informing my findings for this question included the interview of the undergraduate director and my review of specific documents such as departmental brochures, the CS undergraduate student

handbook, and the university's and CS department's web pages. Each data item discussion will be followed by a summary of the themes that emerged from the discussion. The chapter will conclude with a final analysis (i.e., triangulation) identifying similarities and differences of all the data in relation to each other. Collectively, these three sources of data inform my understanding of the practices and structures that are being utilized at the HBCU to recruit and retain African-American females in the CS program.

Current Efforts

The first four interview items in the protocol focused on asking students to consider structures and practices that are currently being utilized to recruit and retain African-American females in the CS program. This is followed by the undergraduate director's description of structures being utilized for recruitment and retention. Next, I discuss the analysis of pertinent documents reviewed in this study.

Participants' Experience with Structures

Katherine

Katherine is a member of three student chapters of the following professional organizations: ACM, the National Society of Black Engineers (NSBE), and the Society of Women Engineers. Katherine has seen numerous companies visit the campus as the result of her involvement with the ACM. Specific companies include Microsoft, Bank of America and Google, Inc. She believes that this network provides CS majors with employment opportunities at these companies. Although she had not attended any professional conferences, she has participated in a couple of summer internships at Harris Corporation in Florida (2016) and Bank of America in North Carolina (2017).

Dorothy

Dorothy is also a member of the ACM, which has allowed her to participate in hackathons and professional development with other CS students. Although she was aware of other organizations like the Black Engineer Awards Conference, National Society of Black Engineers, and Society of Women Engineers, she was not a member. Additionally, during her freshman and sophomore years, she was in a Cyber Defense Club and she concluded that that is "where I was exposed to hacking because of the classes that we had." She stated that she had attended a leadership development conference (on campus), but it was not CS related.

Dorothy feels that the university has made it possible for students to connect with different companies that often visit the campus to recruit new hires and discuss summer internships and/or permanent job opportunities. Additionally, she reported that industry employees come and teach courses to help students improve their technical skills.

Mary

As part of her undergraduate experience, Mary participated in a programming competition held at Spelman College in Atlanta, Georgia. Several schools participated in this event, and she learned a lot from the competition as well as the experience itself. The programming competition involved robotics, so she was exposed to concepts like computer vision and topography. Computer vision is used in the navigation of robots and consists of information about the environment received by one or more video cameras (on the robot) and processed by computers (Rock Holdings, n.d.).

Mary believes that the university was supportive of decisions she made pertaining to her educational experience. In her own words,

> So being an athlete, my coach knew that education was important. She was a real big advocate for education. So like I said, because I didn't think that study hall was beneficial, she let us make minor adjustments that fit our needs from an educational perspective.

Mary was referring to the fact that she was able to utilize the CS department's TAs for tutoring as needed in lieu of study hall with the other athletes.

Mary also believes that it was a concerted effort consisting of the school itself, the internships, networking, the supervisors she's had, her academic advisor, and her teammates which were all instrumental in her development as a CS major and graduate. She explained that when she had mentioned to a high school teammate that she was considering attending an HBCU, their response was, "Well, as long as you go to class, and you're participating, your professors will help you get an internship." She admitted that she did not really know what the statement meant at the time, "but I thought that must be pretty good." Listening to this advice, Mary landed her first internship as an undergraduate with IBM.

Mary, having worked at IBM, the Navy, Eli Lily, and Raytheon Missile Systems, has had a vast array of internship opportunities. She had an opportunity to work with the FBI. Also, she attended an NSF conference; Mary mentioned that due to the extensive travel requirement of her employment, she is unable to travel to other conferences.

Participants' Experience Themes

Both Katherine and Dorothy agree that the university has enabled corporate industry to have a visible presence on campus. Several of the corporations mentioned are leading in the field of research and development (for example, Google and Microsoft).

Research and development companies seek students who are majoring in CS and technology disciplines. Therefore, a strong industry presence at the university provides opportunities for students to attain summer internships and permanent positions. In addition to job opportunities, corporate representatives do guest lectures and serve as judges for programming competitions. The participants all agreed that they had access to visiting corporate representatives on several occasions; for example, via the ACM network. In addition, two of the three participants were active members in one or more professional organizations. The emerging theme is professional development for students. The remaining themes emerged from a single participant discussion and do not represent the collective results of the experiences of two or more participants.

Director's Description of Structures

The interview items in the protocol for the director focused on asking her to consider structures and practices that are currently being utilized to recruit and retain African-American females in the CS program.

According to the director of undergraduate studies for CS, in addition to the activities and programs sponsored by the Office of Admissions, the CS department also provides their own recruitment activities. She explained that the department conducts outreach to local high schools. For example, a couple of faculty members along with a couple of CS majors arrange to visit several high school classes and tell them about the CS program. The university students are there to interact with the high school students and give their individual testimonies of their experiences as college students and CS majors. Other strategies cited included maintaining the reputation of promoting an excellent CS program that produces graduates who are equipped for industry and

graduate and professional schools; utilizing current students to recruit new students—these include siblings and other family members and friends they come into contact with; and providing scholarships to as many students as possible. Faculty are actively involved in securing funding for scholarships—applying for grants through funding agencies and partnering with industry for corporate sponsorships are the two main sources. The director stated, "In many cases, it's the money that makes a difference as to whether or not they are going to come here or go to another university that will offer them money. So we're very conscious of the money factor."

The director cited providing scholarships as the most significant strategy they have utilized within the department. She explained,

> The activity that probably brought in the most students was a scholarship opportunity we had which went on for several years. It provided students with in-state tuition for 4 years. And so for that group of students we recruited, 95% of them were retained and graduated.

Director's Description Themes

Themes that emerged from this interview item were as follows: career opportunities, precollege connection, excellence in CS program, and financial support.

Director's Experiences in the CS Department

According to the director, most of the CS majors who graduate from the HBCU go on to work in computing positions in industry or government. A smaller number of students will enter graduate school programs in CS. Some will pursue their graduate degrees at HBCU XYZ, since it offers both master's and doctoral degree programs in CS.

The director shared with me that one area of retention that she believes could be

improved upon was faculty advising. A faculty member, generally, will not be assigned as an advisor until after they have 1 year of employment in the department. During that first year of employment, they attend an advising meeting and are walked through the advising process. Periodically, advising meetings are conducted within the department. The CS Undergraduate Student Handbook is easily accessible from the CS web page and will be discussed in the next section. However, the director feels that this process could be improved upon for more effective results.

In addition to relevant student tutors, a study room located in the department is available and easily accessible to the CS majors. Students may come for supplemental instruction and tutoring throughout the day. The tutors are upperclassmen with a strong academic standing in the CS program, and they are paid to tutor. The tutors also possess excellent people skills.

In concluding the interview, the director was asked to reflect on what she feels has played a significant role in the recruitment and retention of African-American females in the CS program at the HBCU in this study. In her words,

> I think the retention of the African-American females as well as the retention of our students in general is that we develop a family atmosphere within the Computer Science Department. Many of the faculty have an open-door policy and are eager to help the students not only in the class setting but one-on-one. I have noticed that some young ladies may be less expressive in class than some of the males. But those more quiet young ladies will come to the instructor's office hours for one-on-one assistance. Also, within this family atmosphere, students have the tendency to develop good relationships with each other. Students willing

to help each other attributes to the retention of many of our students. Most of our students develop friendships for life among their peers who are majoring in computer science.

Director's Experience Themes

The director emphasized several practices that indicate an impact on the retention of CS majors. Themes that emerged from these practices include the following: knowledgeable TAs, a study room/space dedicated to CS majors to meet with the tutors, STEM scholarships, family atmosphere, and faculty's open-door policy. Also, improved faculty advising is an important practice the director believes needs attention. Although new faculty members are not assigned advisees until after their first year in the CS department, the director believes that additional training during that time period as well as ongoing training is needed. Initially, the new faculty attend an advising training session where they are walked through the advising process. However, this is a one-time training session; the CS department meets periodically to discuss advising within the department, but this is in no way intended to substitute as additional advising training.

There is an overlap of thematic concepts between the director's responses and those of the student participants. In particular, the following intersections were identified: knowledgeable TAs, available and supportive faculty, and financial support/STEM scholarships.

Program Document Analysis of Structures

In a review of the CS program overall, the student participants and the director identified some of the structures that are in place at the HBCU and utilized to recruit and retain African-American women. In this section, additional data—my review of specific

documents related to the CS program—informing the findings for this question are discussed.

The director of undergraduate studies provided documentation related to the program during our interview and through email correspondence. In addition, I accessed information through the university's website. The following is a summary of the analysis of the documents that identify structures and practices utilized at the HBCU in this study to recruit and retain African-American females in the CS program.

General Description of Study HBCU and CS Department

The HBCU in this study is one of the largest HBCUs in the U.S. and it is located in the southeastern region of the country. It is a public, coed institution with a population of approximately 10,000 students. In the 2016-2017 academic year, there were 163 CS majors enrolled in the CS department. Table 5 provides a breakdown of the CS majors by classification and gender. Interview data were collected in 2017, so the data related to student population are based on that time period.

Table 5

HBCU XYZ CS Majors Fall 2016-Spring 2017

Classification	Females	Males	Total
Freshman	14 (39%)	22 (61%)	36
Sophomore	6 (19%)	27 (81%)	33
Junior	8 (19%)	34 (81%)	42
Senior	11 (31%)	41 (79%)	52
Total	39 (24%)	124 (76%)	163

Table 5 shows that there were a total of 20 junior and senior female students during the academic year 2016-2017. Of the 20, 14 were African-Americans, which is the pool used to solicit participants for this study.

Table 6 provides the breakdown of the total enrollment of females by

classification and number of African-American females majoring in CS.

Table 6

African-American Female CS Majors Fall 2016-Spring 2017

Classification	Number of females	Number of African-American females
Freshman	14	6
Sophomore	6	5
Junior	8	7
Senior	11	7

Table 6 is shown to further indicate that the junior and senior classes for academic year 2016-2017 consisted of 14 African-American female CS majors. The data for both Tables 5 and 6 were provided by the director of undergraduate studies for CS.

The dean of the college where the CS program is housed is an African-American female with a STEM (mechanical engineering) doctoral degree. Her picture and vita appear on the college's website.

The CS department consists of 19 personnel: a department chairperson who is female and a woman of color, 12 full-time faculty members, four adjunct faculty members, and two staff members. When this study began, the chairperson was an African-American male with a PhD in CS; however, he left the HBCU before the start of the 2018-2019 academic year. It is worth noting that the director of undergraduate studies for CS is an African-American female who earned a BS degree in mathematics at the study HBCU and an MS in CS at a PWI. She also did additional graduate work at a second PWI.

The HBCU's website in this study is the first place prospective students and their families will go to find out as much as they can about the university and CS program. The site is extremely user-friendly and arranged in such a way that one may easily find and

access the information needed or of interest. Throughout the website, one encounters many colorful and diverse faces of the student population. For example, African-American females with school paraphernalia are featured in videos, each representing the diverse group of students attending the university. A one-word adjective, for instance, "independent," pops up on the screen with a direct quote from the student in smaller print: "There are too many opportunities available for us not to do things."

CS Department Website

The CS department's website consists of ample pictures of African-American women and women of color. At the website, a rolling screen is featured, highlighting student-driven activities in the department. For example, a group of students, mainly African-American females, are featured with the subtitle, "STARS Mentorship Program Leaders." From the department's website, there are also links to other areas of interest and significance: corporations, research, and student development, to name a few. The corporations' link takes one to a web page where corporate sponsors are invited to participate in several ways, including to schedule a visit to the university and CS department; to showcase their organization, its products, and services as well as employment opportunities throughout the academic year; to partner with the CS department in solving their engineering problems while exposing the CS majors to real-world problems; to provide financial support to assist the professors with providing students a more relevant classroom experience; and to establish scholarship opportunities that will not only support the education of deserving CS students but also provide a lasting presence of the organization within the department.

Research conducted within the CS department includes but is not limited to the

following: A4RC–Alliance for the Advancement of African-American Researchers in Computing, CASIS–Center for Academic Studies in Identity Sciences, and BEACON–Bio/computational Evolution in Action CONsortium (A National Science Foundation Science and Technology Center for the Study of Evolution in Action). All research programs including those previously mentioned are aligned with the overall goal of increasing the number of African-American and other underrepresented minorities in STEM. These research programs increase African-American student awareness of and entry into computing research; provide a means of networking by collaborative research with other HBCUs; increase the pool of talented researchers in STEM fields; and expound upon student classroom experiences by providing real-world applications.

The college that houses the CS department at HBCU XYZ hosts over 20 student organizations. Student development within the CS department consists of the two major professional organizations: ACM and Upsilon Pi Epsilon (UPE), the CS honor society. ACM, "the world's largest educational and scientific computing society, delivers resources that advance computing as a science and profession" (White et al., 2011, p. 4). This nonprofit, professional organization was founded in 1947 and exposes CS students (and faculty) to current and future research in computing as well as application- and technology-based challenges that computer scientists and scholars encounter.

UPE is the first and only international honor society for the computing field in the world. UPE started at Texas A&M University, College Station, Texas in 1967. Currently there are chapters in various colleges and universities in North America and overseas. The mission of UPE is to recognize academic excellence at both the undergraduate and graduate levels in the computing discipline.

Additionally, there are several student organizations that were mentioned during the student participant interviews, namely the National Society of Black Engineers, Institute of Electrical and Electronics Engineers, and Society of Women Engineers.

Professional Faculty Development Conferences

Funding is provided each year for faculty members to attend professional development conferences on the Scholarship of Teaching and Learning and Learning Communities. Participation in the conferences is fully funded by the Center and provides the following: opportunities for faculty to increase their abilities to teach, mentor peers, establish learning communities, and contribute to the scholarship on teaching and learning. The faculty members apply to attend these conferences on an annual basis.

Scholarships and Fellowships

Per HBCU XYZ's website, 140 endowed scholarships are listed. Of the 140 scholarships, 65 are open to any and all majors; five are designated specifically for STEM majors; and two are designated for CS majors. "Endowed scholarships are privately donated funds that are given to the University students each year from private gifts made by individuals, groups, and organizations."

Corporate Sponsors

The CS department of the HBCU in this study encourages and welcomes corporations that are interested in visiting the department, providing exhibits (for example, at career fairs), partnering with the department/university for research/teaching and summer internships, and financial support/scholarships.

As recently as August 2018, a partnership was established with Google, Inc. "A Google engineer with 28 years of experience taught classes, shared insights with students

and traded ideas with faculty as part of the Google in Residence program." The Google in Residence Program began in 2013, and its aim is to improve diversity in the tech industry "by embedding engineers at historically black colleges and universities and Hispanic serving institutions."

> Expanding the pool of technologists is core to Google's strategy to have representation of Black and Latinx Googlers in the United States reach or exceed the available talent pool at all levels of the company and is one way the company is looking to attract and hire more Googlers to truly reflect the diversity of their users.

The Google resident engineer received his PhD and MS in CS from Stanford University and his BA in mathematics from Yale University. He taught COMP 163—Introduction to Computer Programming, the first required course for CS majors at this HBCU. Additionally, he assisted with COMP 120—Freshman Colloquium seminar and held office hours and assisted in tutoring and career counseling (helped students prepare for internship interviews).

Other more recent visits and/or partnerships include a visit by Mark Zuckerberg, the founder and CEO of Facebook, who presented at an hour-long town hall at the HBCU in the spring semester of 2017. During his talk, "he addressed diversity in the tech industry, fake news and the importance of Facebook Live as a tool for transparency."

The chancellor of the HBCU was quoted as saying, "creating opportunities for senior executives of major corporations and global leaders to engage with students is part of [this HBCU's] strategy." He went on to explain,

> We want our graduates to see themselves as big thinkers, leaders and focus on

global issues so that they cannot just ask smart questions, but frame in their mind how they see themselves being a part of the solution or being successful in the community.

CS Programming Activities

HBCU XYZ provides for several opportunities throughout the academic year for CS majors to compete on programming teams—coding programs to solve real-world problems. The programming contests consist of local high school and college teams of three students per team. Students are allowed to program in any high-level programming language of their choosing and are encouraged to bring their own computers to the contest. Students also have access to a computer lab to ensure computer access. The contest lasts approximately 4 hours and faculty judges determine the winners based on the number of programs each team successfully designs and executes as well as the correctness and efficiency of the programs. I was invited to and attended such a contest in the spring of 2017.

Additionally, for the second consecutive year, a team of HBCU XYZ CS students took home the top prize for Black Enterprise's TechConneXt Summit BE SMART hackathon in Silicon Valley. Each team consisted of four students for a total of 60 students from 15 HBCUs. Team HBCU XYZ consisted of three male and one female CS major. The female CS major was one of the three participants in this study.

Toyota, the hackathon sponsor, "charged the teams with developing an innovative in-store retail experience that would incorporate the newest technologies and invigorate the car-buying experience."

Toyota provided a first-place prize of $40,000—$10,000 to each student on the

team; Samsung Tablets were awarded to the second-place winners; and Galaxy Notebooks to the third. The hackathon was a 2-day (24 to 36 hours) experience, and the top three winning teams presented in front of the TechConneXt Summit attendees. Each school team "learned about collaboration, innovative thinking, working with mentors, and public thinking."

Mentorship Programs

The mentoring program within the college and the CS department at HBCU XYZ has been described as a "family affair," according to the director. The director and one of her student mentees were highlighted in a campus newsletter. In the article, the director explained her philosophy when forming relationships with students:

> Kindness shows students that we care… It opens them to positive influences. It causes a struggling student to have hope, and for a motivated student, it gives them direction. In the CS department, we develop an atmosphere that's conducive to mentoring.

Her student mentee at the time of the interview was an African-American female CS major who initially had been her freshman advisee. In addition to maintaining a 4.0 GPA, she is "the first [HBCU XYZ] student to be named a University Innovation Fellow at Stanford University, one of only 150 students chosen from 52 colleges and universities across the country." She has also been recognized as a White House HBCU All-Star and an inaugural Apple HBCU Scholar with two other XYZ students.

The University Innovation Fellows program at Stanford University empowers students around the world to be change agents in higher education. The fellows work closely with faculty, administrators, and community representatives at their respective

schools. Fifteen hundred students from 185 schools have served as fellows. This program was initially part of the NSF-funded National Center for Engineering Pathways to Innovation (Epicenter) from 2011 to 2016 (Greenberg, n.d.).

The White House HBCU All-Star Program is a 1-year appointment that recognizes and promotes HBCU excellence at the undergraduate, graduate, and professional levels of students for their accomplishments in scholarship, leadership, and civic engagement. The appointees serve as ambassadors by "providing opportunities and communications to their fellow students about the value of education and the initiative as a networking resource" (U.S. Department of Education, 2017, para. 2).

The Apple HBCU Scholars Program is a partnership with the Thurgood Marshall College Fund. The program is open to all full-time students at a 4-year accredited HBCU or predominantly Black institution. The goal of the program is to increase the talent pool of students in STEM fields. Students are selected—mainly those pursuing a degree in STEM—to participate in a 12-week summer internship before their senior year and receive up to $25,000 in scholarship funding (Thurgood Marshall College Fund, 2019).

In her closing statements in the article, the director summarized the CS experience in the following manner:

> In the computer science department, we've developed an atmosphere that's conducive to mentoring said [the director], who noted that 20 percent of undergraduates in the department are working with faculty members on research projects. We try to create a warm, friendly atmosphere. We want to be approachable and have an open-door policy.

Summary and Themes of Program Document Analysis of Structures

While it is the overall effort of the study HBCU to recruit and retain African-American students, more of the responsibility to increase the number of African-American females in CS lies in the CS department itself. For it is at the departmental level that faculty and student relationships are developed and nurtured. The director of undergraduate studies referred to this as "an atmosphere conducive to mentoring" and cited this as one of the reasons she feels the majors tend to matriculate and complete the CS program successfully. This mentoring atmosphere enables faculty to reach students beyond the classroom setting and provides the students direct access to the faculty members; for example, "the open-door policy." As a further illustration, one of the faculty members, who is Caucasian and male, advises four (the largest number as compared to other faculty at HBCU XYZ) African-American female graduate students. The director of undergraduate studies also has mentored several African-American female majors, including the student who was highlighted in the campus newsletter (see the Mentorship Programs section in this chapter). While it is true that faculty members who are of the same gender and race may be effective mentors, supportive male faculty of a different race can be just as effective (Margolis et al., 2000).

Two of the student participants also referenced CS faculty members who had provided them with information pertaining to summer internships or scholarship opportunities in addition to career and graduate school opportunities. There is a vital role faculty serve in taking a personal interest in mentoring students as well as fostering a sense of belonging to African-American female students. The theme that emerges is mentoring programs.

Additional themes that emerged from document analysis and coincide with the student and director interviews are as follows: public image, corporate sponsors, research opportunities, and scholarships/financial support.

Future Ideas

One of the aims of this exploratory study was to continue the conversation that has already begun in regard to increasing the number of underrepresented African-American females in the CS discipline. In conducting a qualitative study, I hoped to provide insight from the student participants as to not only why they persist in the CS discipline but also what practices and structures they believe would enable other women students like them to persist. The following section details their responses.

Participants

The participants were asked, "Looking towards the future, what would you like to see put in place to recruit and retain students into the major?"

Katherine

Katherine thinks it is important to expose students to CS before they enter college. Therefore, she suggested implementing a "boot camp" to allow them to develop and practice their coding skills. Also, she believes that students do not always see the relevancy of the coursework, so making the programming assignments more applicable to the "real world" and/or the interests of the students would be effective.

Dorothy

Dorothy stated that she would like to see summer camps geared toward high school students that would expose them to computer programming: "That's one thing I didn't have." She justified her suggestion by explaining, "Because if I had been exposed

to this when I was in high school, I think I would be a lot better." Dorothy suggested that perhaps agencies would fund the programs if the school was unable to cover the costs of such a program.

Mary

Mary believes that higher education and, in particular, this study HBCU need to be more synchronized with corporate America. She explained it this way:

> So, I would say making sure that what we're learning is still [relevant]…we can still apply that knowledge in the workforce. I was under the impression that I could do IA (information assurance) and [write] programs. Then, when I got into the work environment, it was a little different. You had to pick one or the other.

The director also mentioned a domestic exchange pilot program that was scheduled to begin in 2017 of which HBCU XYZ had been invited to partner. The Google Tech Exchange Program was initially with Howard University, another HBCU, and is one way Google makes long-term investments in student education in order to increase pathways to technology for underrepresented groups. Since that time, Tech Exchange has grown to include 11 HBCUs and Hispanic-serving institutions hosted by Google at its Mountain View location in California.

The program is geared to rising juniors who must have a cumulative GPA of 3.0, a 3.2 GPA in a CS or computing-related major, and basic programming concepts and introductory data structures mastered in order to apply. Accepted students will pay their tuition for spring semester to their respective universities, and Google will provide funding for each student to cover costs for room and board. HBCU XYZ's first participant was selected for the spring 2020 semester, and she is a junior CS major.

Tech Exchange engages the students in applied CS courses, including machine learning and product management, all co-taught by HBCU/Hispanic-serving institution faculty and Google engineers. Student participants have given testimonies of their experiences: finding confidence, learning the value of a network, and gaining insight into specific careers in IT (Brown, 2018).

Future Ideas Themes

Two of the student participants mentioned programs that would expose students to CS (in particular, computer programming) before they enter college. Katherine referred to boot camps and Dorothy mentioned summer camps geared to high school students that would expose them to programming. The theme that emerges is pre-college or K-12 experience.

Mary mentioned the importance of CS programs being more integrated with industry. The director described the Google Tech Exchange Program, in which HBCU XYZ has now partnered, that will make the pathway to technology more direct for junior and senior CS majors. In addition to taking CS courses in a corporate environment, the students are co-taught by Google engineers. This permits Google to provide direct input to the CS curriculum as well as to give students a more realistic view of how the major is utilized in corporate America. Themes that emerged are industry partnerships and relevant and challenging experiences.

The above section addressed the fifth and last research subquestion for this exploratory study, “What structures and practices are being utilized at HBCUs to recruit and retain African-American females in CS programs?”

Conclusion

In this chapter, findings related to each research question were explored. Three sources of data were utilized, namely the transcribed interviews of the student participants, the transcribed interview of the director, and university and CS departmental documents that were analyzed by me. Major themes cutting across multiple interview questions and sources of data include K-12 experiences, industry partnerships, supportive relationships among students and faculty, and relevant and challenging experiences. Table 7 shows emerging themes based on the three sources of data utilized as well as instances of cross-cutting themes derived.

Table 7

Validated Themes

Research question	Major themes	Cross-cutting themes
Why do African-American females choose CS as a major?	First Encounters with Programming Strong Math Background Teacher Encouragement Individual Interest	First Encounters with Programming
What are the perceptions of African-American female CS majors about their academic preparation before declaring their major?	CS Readiness Gap	CS Readiness Gap
What are the perceptions of African-American female CS majors about their academic preparation during their progression in the major?	Relevant, Problem-Based Learning Challenging Assignments Collaboration (good and bad) Internship Opportunities Lack of Assignment Clarity Application to Real-World Examples	Relevant, Problem-Based Learning Challenging Assignments Collaboration Internship Opportunities
Why do African-American females enrolled in CS programs at HBCUs persist in their major?	Participation in CS-Related Clubs Available and Supportive Faculty Knowledgeable TAs Financial Support	Participation in CS-Related Clubs Available and Supportive Faculty Knowledgeable TAs
What structures and practices are being utilized at HBCUs to recruit and retain African-American females in CS programs?	Professional Student Development Career/Summer Internship Opportunities Exposure to Visiting Professors Financial Support Competitive Programming Activities Knowledgeable TAs Student Testimonies/CS Majors as Recruiters Family Atmosphere Available and Supportive Faculty	Public Image Corporate Sponsors Research Opportunities Scholarship/Financial Support Mentorship Programs

In Chapter 5, a summary of findings, implications of findings for practice, limitations and delimitations of the study, and recommendations for future research are included.

Chapter 5: Discussion

The purpose of this study was to explore procedures and strategies for recruiting and retaining African-American female students in CS. This study was guided by the following central research question, "What practices and structures are used to increase the number of African-American females in the CS major at HBCUs?" There were five research subquestions: (a) Why do African-American females choose CS as a major; (b) What are the perceptions of African-American female CS majors about their academic preparation *before* declaring their major; (c) What are the perceptions of African-American female CS majors about their academic preparation *during* their progression in the major; (d) Why do African-American females enrolled in CS programs at HBCUs persist in their major; and (e) What structures and practices are being utilized at HBCUs to recruit and retain African-American females in CS programs?

In response to the purpose of this study, the central research question, and subsidiary research questions, I administered an exploratory qualitative study to examine the factors that impact African-American female students as they matriculate through a CS undergraduate program at an HBCU. Three African-American female undergraduate students were invited to participate in the study. Two of the three students were classified as juniors at the time of the interviews. The third student had completed her BS and MS degrees in CS at the HBCU and was about to begin a doctoral program in CS at the same HBCU.

Additionally, I interviewed the director of undergraduate studies for CS at the HBCU as well as analyzed documents (brochures, departmental, college and university websites, and reports made available to me). Results from these additional sources were

used to triangulate data garnered from the student interviews.

The data collected for this study consisted of transcribed interviews of the student participants and of the director and the analysis of documents garnered from the university website and the CS department where this study was conducted. All of the collected data were analyzed by reading and writing notes in the margins and utilizing thematic code highlights. Furthermore, I analyzed the data for patterns and similarities in the experiences reported by the participants. Analysis of the three sources of data allowed me to triangulate categories or emerging themes. The significance of the themes was determined by me based on whether more than one participant or document analyzed provided the same or similar responses. A detailed analysis of the data pertaining to the five research questions was presented in Chapter 4. The study's findings are summarized here by the research questions guiding this study.

After the summary of findings, the remainder of this chapter briefly reviews the findings of the study. This will be followed by a discussion of findings organized around four major themes: K-12 experiences, industry partnerships, supportive relationships among students and faculty, and relevant and challenging experiences. These themes were derived based on the intersections of the student participant responses, those of the director of the undergraduate studies for CS, and document analysis, where applicable.

Summary of Findings

Findings are reported in research question order.

Choosing CS as a Major

The first research question explored why African-American females choose CS as a major. The findings reveal that there are various reasons for African-American female

students to choose to major in CS: first encounters with programming, a strong math background, teacher encouragement, and individual interest. Each of the three student participants had a different experience that led them to pursue an undergraduate degree in CS. It is interesting to note that in all three cases, the earliest precollege encounter that they had in computer programming occurred during their high school years. Since children as young as 4 years old (kindergarten) are exposed to computer programs and technology in classrooms (Ellington, 2006), this point is particularly salient as it emphasizes that inequitable first encounters with computing at the high school level place many students and particularly African-American female students at a disadvantage (Google, Inc., & Gallup, Inc., 2015). While we cannot assume that all children have access to computers and the internet in their homes, we must do better to ensure that our schools (private and public) provide access to the technology students will need to advance and pursue careers in CS and other STEM fields (Ellington, 2006; Google, Inc., & Gallup, Inc., 2015; Hrabowski et al., 2002). Literature reports that Black students are at a disadvantage as it pertains to high school CS course offerings. Black students are less likely to have access to computer courses at the schools they attend (Google, Inc., & Gallup, Inc., 2015).

First Encounters with Programming

"There are over 42,000 high schools in the United States. But only 2,100 of them were certified to teach the AP CS course in 2011, and only 21,139 students took the AP exam" (Goode & Chapman, 2015, para. 2). According to a multiyear, comprehensive study among seventh- to 12th-grade students; parents of seventh- to 12th-grade students; and elementary through high school teachers, principals, and superintendents conducted

by Google, Inc. and Gallup, Inc. (2015), Black students are at a disadvantage as it pertains to high school CS course offerings. Google, Inc. commissioned Gallup to conduct the study, which investigated structural and social barriers underrepresented groups (female, Black, and Hispanic students) face at home, in school, and in the community. One of the key points uncovered as a structural barrier was, "Black students are less likely than the White students to have classes dedicated to CS at the school they are attending (47% vs. 57%, respectively)" (Google, Inc., & Gallup, Inc., 2015, p. 4). Structural barriers such as this one could influence the likelihood of Black/African-American students entering the CS field.

The Advanced Placement (AP) CS course is taught with a high-level programming language (currently Java) that is also recognized and taught as a first programming course at the university level (College Board, n.d.). Offering the AP CS course to interested high school students would provide them a more realistic view of what CS is. Two of the three student participants in this study took a computer course in high school but not AP CS; both Katherine and Mary were enrolled in a computer class that indirectly exposed them to programming (Web Design in Katherine's case and Visual Basic in Mary's). However, they found they really had not been exposed to computer programming until after they entered their first year of college.

A Strong Math Background and Teacher Encouragement

Several factors led Mary to her decision to pursue CS in college: her strong mathematical background, her enjoyment of programming in a Visual Basic course she took in high school, and the encouragement and guidance she received from her high school computer teacher. Hrabowski et al. (2002) identified several reasons for the lack

of “either initial or enduring interest in the sciences among girls and African Americans in the precollege years” (p. 148). The reasons included the following: (a) teachers’ low expectation for success and related differential treatment; (b) perpetuation of the myth by teachers, parents, and peers that math and science are “White-male” areas; (c) inability of girls and African Americans to see themselves as scientists based on a lack of exposure to role models, advanced courses, and career opportunities; (d) overall lack of encouragement to succeed in the sciences from parents and teachers; and (e) doubts about their ability to succeed at higher levels in math and science. Fortunately for Mary, not only did she have supportive parents/family members, she also had a computer teacher who encouraged her to pursue a STEM profession.

More recent studies, such as the Google, Inc. and Gallup, Inc. (2016) multiyear, comprehensive study supports this earlier research. In regard to social barriers to learning CS, such as the continuing perception that CS is only for certain groups, namely White and Asian males, the study results included the following:

1. Despite presumably equal access to CS learning opportunities in [middle and high] schools, female students are not only less aware but also less likely than male students who have learned CS to say they learned it online (31% vs. 44%) or on their own outside of a class or program (41% vs. 54%). Female students are also less interested (16% vs. 34%) and less confident they could learn CS (48% vs. 65%).
2. Black students are more confident than White and Hispanic students (68% vs. 56% and 51%, respectively)--so to the extent that Blacks are underrepresented in CS, lack of confidence would not appear to be the cause. (Google, Inc., &

Gallup, Inc., 2016, pp. 5-6)

Thus, the results of this study in regard to social barriers would suggest in the case of African-American females that lesser awareness, exposure, and interest could be preventing them from considering learning or pursuing CS.

Additionally, Mary had a solid foundation in mathematics, affording her the confidence and determination needed to decide to major in the CS program at HBCU XYZ. This needs to be more of the norm as it pertains to girls and African Americans alike. Children are never too young to be encouraged to take challenging courses or to be exposed to people who can serve as role models in STEM fields. This idea will be explored further in the Implications for Practice section.

Individual Interests

While the other two student participants were exposed to a computer course in high school, Dorothy had no such experience. In Dorothy's case, she attended an engineering high school, and there seemed to be some ambiguity in the way she was introduced to the field of engineering. During the interview with me, she stated that she knew she did not wish to pursue computer engineering because she thought this would entail "setting something on fire." Although computer engineering and CS are quite different in practice, people usually equate them as being synonymous. Computer scientists are responsible for producing electrical and software systems; that is, developing and writing programs for computer systems. Computer engineers are responsible for designing software and integrating that software with hardware components. Dorothy attended an engineering school; however, there are many disciplines that fall under engineering (computer, electrical, chemical, and industrial, to

name a few). Therefore, it could be deduced that this high school may have emphasized more of a chemical engineering curriculum since that would involve the mixing of compounds and materials to produce a product.

Consequently, the engineering high school helped Dorothy determine what she did not wish to pursue and prompted her to take some initiative in researching other educational interests. After conducting her own research into the field of CS, Dorothy decided she would pursue a CS degree in college.

It can be concluded from Research Subquestion 1 that first encounters with programming, a strong math background and teacher encouragement, and individual interest are some of the factors contributing to African-American female decisions to major in CS.

A commonality among the aforementioned themes is that the three participants cited experiences associated with K-12 schooling; that is, no one had family members or friends or experiences outside of high school that they discussed. This could point to an overall theme of the importance of intentional early and repeated exposure to the CS field, to coding and African-American female role models, and to encouragement by teachers and mentors within K-12 settings.

Perceptions of Academic Preparation Before Declaring Major

The second research question explored what perceptions African-American female CS majors have about their academic preparation *before* declaring their major. Data indicated that aside from their experiences in high school, the student participants had no other pre-college experiences in the CS discipline. Despite this fact, two of the three participants felt they were prepared to pursue a CS degree in college. Katherine

stated that she had had no problems adjusting to an undergraduate CS program at an HBCU, having transferred from a PWI. In fact, the PWI had offered major courses during her first (freshman) year that HBCU XYZ expected students to take during their second (sophomore) year. Thus, she was able to get transfer credit for two courses, enabling her to advance in the program. Although Katherine stated that she had encountered no challenges in transferring from a CS program at a PWI to a CS program at an HBCU, I failed to probe her for more details regarding her transition from high school directly to the CS program at the PWI. Therefore, it may not be safe to assume that her perception of her academic preparation before declaring her major at the PWI had been as favorable.

Mary's preparation was founded on her strong mathematical background. This strength helped compensate for her unpreparedness in CS. She quickly realized that the Visual Basic course she took in high school did not provide an accurate description of what constitutes programming as a CS major in college. However, she was able to make the adjustment, accepting the fact that she would need to apply more and "work hard to get really comfortable with things."

Dorothy realized from the beginning of her academic year at the HBCU just how unprepared she was. Having had no exposure to computer courses in high school, she felt stressed and uncertain of her choice to major in CS.

It can be concluded for Research Subquestion 2 that the student participants perceive that there is a degree of unpreparedness (CS readiness gap) after completing high school and before declaring a CS major in college. This perception underscores findings from Research Question 1 that this kind of instruction should be early, repeated, and intentional in K-12 experiences.

It stands to reason that if K-12 students have not been exposed to computing prior to entering college, they might have a distorted view of what CS is in addition to an unrealistic measure of preparedness for the major. The CS field is attractive, partly because of its end results (that is, what I refer to as the "bells and whistles"). For instance, careers in CS are very lucrative. However, to obtain a CS degree and a rewarding career, students must be first taught the design (algorithms) and computer programming (coding) that are implemented in the background, resulting in the bells and whistles. Thus, it is this technical component that students need to see early and repeatedly. This exposure may come in different forms: computer (science) classes taught in middle and high school, afterschool or summer programs focusing on computing, or community or family mentors who are already working in the CS field (Google, Inc., & Gallup, Inc., 2016).

Perceptions of Academic Preparation During Progression in Major

The third research question explored what perceptions African-American female CS majors have about their academic preparation *during* their progression in the major. This research question was posed to the student participants in two parts: What was one of the best experiences they encountered as a CS major at HBCU XYZ? What was one of the worst? The themes resulting from student participant responses to Research Subquestion 3 regarding best experiences were as follows: relevant, problem-based learning, challenging assignments, collaboration, and internship opportunities. Themes resulting from student participant responses to Research Subquestion 3 regarding worst experiences were as follows: collaboration, lack of assignment clarity, study groups, and application to real-world examples.

Data indicated that the female student participants favor programming courses

with challenging assignments and real-world problems. The literature has shown that women are concerned with the usefulness of computers (Davis, 2019; Weston et al., 2019). It is important to note that "students adept in technology in pursuit of other projects (for example designing a web page to illustrate a history paper), may not be interested in technology as a field of study" (Weston et al., 2019, p. 13). Therefore, a clear distinction between students who pursue more technical aspects of computing (usually in AP courses in CS) and students who use computers as a means to an end to other activities must be made.

As a professor and founding chair of Whitman College's (in Walla Walla, WA) new CS department, Janet Davis (2019) advised female and minority students to see "computing not purely as a toy, but as a tool for solving problems that matter" (p. 4).

The collaboration theme serves both as a best experience and as a worst. Participants appreciate when the group is able to work together and meet all goals in a timely fashion; however, in the case where this does not happen, it may be viewed with a negative connotation. Dorothy experienced such a case earlier in the CS program when there were very few female CS students in her programming course. Her only option was to work in male-dominated groups. She mentioned that it took longer to actually stick to the assignment and, as a result, she did not learn a lot. Later, in another class where there were more female CS students, she was able to team up with some of them and noted two things: (a) there was less startup time in working in the female group; and (b) she learned more and immediately saw an improvement in her grades. This finding corroborates research literature that suggests the presence of more female peers creates a female-friendly environment that encourages women to persist (Bostwick & Weinberg, 2018).

This finding also supports the research literature pertaining to the assertion that female scientists collaborate differently than male scientists (Zeng et al., 2016). One study conducted at Northwestern University looked at the collaboration patterns of approximately 4,000 STEM faculty members in six STEM disciplines at top research universities across the U.S. The findings noted the following: (a) female scientists have a lower probability of repeating previous collaborations than males; and (b) female faculty have significantly fewer distinct coauthors over their careers than males.

African-American Females Who Persist

The fourth research question explored why African-American females enrolled in CS programs at HBCUs persist in their major. In order to more effectively answer this research question, I created four subquestions for data analysis.

Challenges Encountered Since Declaring CS Major

The theme that evolved from the student interviews was collaboration/teamwork. Dorothy's reflection on her experience in collaborating with a peer provides some insight as to how she viewed collaboration or teamwork. She mentioned several issues that arose when working on a team: deciding on strategies to take, course/schedule conflicts, and allotting time to complete the assignment. These challenges—though seemingly overwhelming to either student at the time—are necessary for growth to occur and the development of communication and personal interaction skills. Cohoon (2002) suggested that "promoting interaction among classmates, and developing learning communities and other forms of peer support" (p. 51) could foster the peer support that all students find essential to succeed in a computing major but that women usually have more trouble finding.

Mary also took CS courses in which she worked collaboratively. In one class, they designed and coded a vending machine program; and in the other, they designed and coded an animation (a swing set). Mary's experiences in working collaboratively taught her that the focus was not merely on completing the assignments but rather to extend one's self beyond just getting the program to execute successfully. In the first case, the team learned the importance of seeking customer feedback throughout the process to ensure product satisfaction and reliability. In the second case, Mary learned that team members could design a better program, working off of each other's strengths. For example, in Mary's case, her strength was her strong mathematical background.

Literature suggests that two reasons for the small number of women in CS are negative stereotypes regarding the field (Sax, 2013; Beyer et al., 2003) and low confidence (Beyer et al., 2003; Margolis et al., 2000). Researchers have "repeatedly found that females have inaccurately low confidence in masculine domains, including mathematics, chemistry, and CS" (Beyer et al., 2003, p. 49).

An example of a negative stereotype would be as follows: A computer scientist is assumed to be a White male with a long ponytail and potbellied who eats pizza and drinks sodas constantly. This could give an African-American female the impression that someone who looks like her would not be expected to become a computer scientist or to work in computing. Another stereotype involves an unattractive description of CS majors—often described as really intelligent but lacking interpersonal skills. This has been termed the "computer nerd syndrome" or "geek mythology" (Beyer et al., 2003, p. 49).

Adequate peer support is essential to retain women in computing programs. This

support allows women to have access to other female classmates. It also makes them aware that other students struggle with computing and provides them a sense of belonging. Having a support system will lead to increased confidence in their social as well as academic development.

According to the director of undergraduate studies for CS at HBCU XYZ, the department has developed and nurtures a family-like atmosphere. This atmosphere includes faculty members exercising an open-door policy and enables students to develop good relationships with each other. The director summarized the effect of such an environment: “Most of our students develop friendships for life among their peers who are majoring in computer science.” The literature suggests that supportive faculty provides a means for retaining students; in particular, female students (Cohoon, 2002). The conclusion of this study question is that students need to encounter computer programming as early and often as possible. Exposure to programming at an early age will help to build confidence in African-American females. “Students with increased exposure to computer technology are more confident in their own skills and more likely to consider learning computer science in the future” (Google, Inc., & Gallup, Inc., 2015, p. 6).

Additionally, faculty and student relationship are perhaps the best way to not only recruit but also retain African-American female CS majors. Again, peer support is a very effective means; however, if that is not feasible (due to low female enrollment in the major), faculty also have a strong impact on students (Astin, 1993).

Instructor or School Support for Major

Themes that emerged from this discussion with the students were as follows:

participation in CS-related clubs, available and supportive faculty, and knowledgeable TAs.

Participation in CS-Related Clubs

Katherine stated that she was active in two clubs made available to her through the CS department: ACM, the world's largest educational and scientific computing society; and STARS, a mentoring program that connects upper-level classmen in the CS department with freshmen CS majors to help bridge the transition from high school to the college environment. Dorothy described her role in this way:

> Students are allowed to sign up for mentors [in the freshman colloquium]; the mentor is someone that encourages them to stay in computer science because when students first come they're very overwhelmed. So, it's like someone they can talk to.

Dorothy stated that all of her mentees are female.

One cannot emphasize enough the importance of peer-to-peer support in a CS program, especially for African-American women. Women tend to think they are individual "misfits" when it comes to doing well in CS. Therefore, there is a need to promote social bonds that protect women from their individual comparisons with computer geeks or nerds (Margolis et al., 2000). Involvement in organizations such as ACM and STARS provides African-American female students with some resources and support systems beyond the classroom experience.

Available, Supportive Faculty and Knowledgeable TAs

Two of the participants stated that the CS faculty members are supportive and the TAs are knowledgeable. Dorothy felt that the faculty provided "open office hours,"

making it easy for students to access them. She emphasized that the faculty ensure the TAs are knowledgeable and are actively assisting students during their scheduled tutorials.

Mary had also found the TAs helpful during her undergraduate experience; as an athlete, she opted to utilize the TAs instead of study hall. She liked the direct attention she received and felt that it allowed her to accomplish her study goals. Additionally, she felt that one of her professors played a key role in her decision to pursue her master's degree immediately after completion of the undergraduate program. That same professor facilitated Mary receiving a graduate fellowship through NSF.

Two of the student participants in this study and the director for undergraduate studies agree that available, supportive faculty and knowledgeable TAs play a significant role in the retention efforts of African-American females in the CS program in this study. Through observation, the CS department recognized the need for improvement in the TA program. Additionally, a couple of problems arose, namely (a) popular TAs were being overloaded with students needing assistance while the less popular were undisturbed; and (b) the students needing help were relying too heavily on the TAs to complete their assignments. Consequently, the CS department began in the fall of 2009 conducting mandatory TA training sessions at the beginning of each semester. A challenge with the TA program was lack of attendance of students needing assistance. The CS faculty members decided on specific strategies to overcome this challenge: (a) make study sessions mandatory for all freshmen and sophomore level courses, (b) ask professors to take a more active role in encouraging students to attend study sessions, and (c) develop ways for TAs to work with students online.

Literature suggests that what really matters in college is the environment created by the faculty and students (Astin, 1993). Relationships can be vital to the learning process, especially as it pertains to African-American female students and the STEM disciplines. “Relationship between teachers and students is particularly significant for female students. We’ve observed more women than men arrive in college with the expectation of establishing a personal relationship with faculty” (Seymour & Hewitt, 1997, as cited by Fisher & Margolis, 2002, p. 81).

CS Major Wish List

The student participants in this study gave varied responses to this subquestion. Themes that evolved from this discussion were as follows: more scholarship opportunities, a what-to-expect information packet (or student mentoring), and to offer a PhD in CS at HBCU XYZ. Mary made this comment in respect to the graduate program not being available during her matriculation at the HBCU after obtaining her undergraduate degree; however a doctoral program in CS was introduced while she was completing her master’s degree. Her point was that she would have opted to go directly into the doctoral program after undergraduate had the PhD program been in place.

One of the student participants in this study mentioned “more scholarship opportunities.” The director of undergraduate studies also mentioned scholarships as one of the most effective ways of recruiting students into the CS major. In addition to CS faculty actively seeking funding through grant writing, there are corporate sponsors willing to partner with the department and university. “In many cases,” added the director, “it’s the money that makes a difference as to whether or not they are going to come to XYZ. So we’re very conscious of the money being a part of recruitment.”

CS Student Satisfaction with Major Decision

The three student participants expressed being very satisfied with the selection of CS as their major. Reasons they gave were its relevance and high job market demand, it enables one to think critically, and the diverse career options the major offers. Per the director of undergraduate studies, the results of the 2017 Senior Exit Surveys corroborate this finding of student satisfaction with their CS major.

In all three cases, the participants used adjectives or phrases like "challenging," "hard," "fun," and "actively engage the customer" in describing their best assignments or experiences they had as part of their CS experience. Literature (Buse & Bilimoria, 2014) has shown that female engineers are more apt to persist in a major or career if they find it meaningful and challenging.

Structures and Practices Utilized at HBCU XYZ

The fifth research question explored what structures and practices are being utilized at HBCU XYZ to recruit and retain African-American females in CS programs. The main themes, which evolved from the document analysis (and the intersection of information gleaned from the director of undergraduate studies and the student participant interviews), that could be effective in the recruitment and retention of African-American females in CS are as follows: public image information, corporate sponsors, research opportunities, scholarships/financial support, and mentorship programs. A brief discussion of each theme follows.

Public Image Information

An institution's public image is important because it gives the external community a glimpse of what the institution is and the kinds of activities in which the

institution and department are involved. It also informs prospective students and their parents of pertinent information and instructions needed for tasks such as scheduling a campus tour, applying for admission, or providing the appropriate contact information if warranted. Public image information of HBCU XYZ was viewed and analyzed by me and included the following: the institution's website, the college's website, the CS department's website, brochures, newsletters, and reports. I investigated the websites for answers to questions such as, "Do printed information and other media that represent the department and its programs portray women as passive observers? Do they portray women at all?" (Cohoon, 2002, p. 50). It would not be attractive to portray the CS department as one consisting of geeks or nerds, if the goal is to attract females into the department. Cohoon (2002) suggested, "Overcoming negative stereotypes is an important step toward drawing more women into computing majors. Projecting an inclusive image of the discipline contributes to accomplishing this task" (p. 50). The institutional and CS department websites of the HBCU in this study meet all of the positive criteria recommended to attract more African-American female majors into the CS program.

Corporate Sponsors

Two of the student participants mentioned corporate visibility on the campus of the HBCU in this study. They associate this presence with opportunities for CS majors at HBCU XYZ to acquire summer positions as well as career positions. The director of undergraduate studies stated during her interview that corporate sponsors also provide funding for student scholarships. Raising funds for scholarships can be a daunting task for some HBCUs. Both the student participants and the director have three significant reasons to partner with corporate sponsors: summer intern and/or career opportunities and

support with funding (for example scholarships or other activities the CS department may wish to render to groom and guide students for real-world experiences). HBCU XYZ has access to a plethora of Fortune 500 companies such as Facebook and Google. It has afforded students the opportunity to conduct a town hall meeting with Mark Zuckerberg, Chief Executive Officer of Facebook, and exposure to a Google engineer with 28 years of experience via the Google in Residence Program, a partnership established in 2018 with Google, Inc. Additional information can be found in Chapter 4 in the Corporate Sponsors section. HBCU XYZ has partnered with several Fortune 500 Companies over the years, sending a positive message to the CS students—one of diversity, inclusion, and possibility.

Research Opportunities

"Student engagement in faculty research has a strong positive effect on student retention in undergraduate science, mathematics, engineering, and technology majors" (Cohoon, 2002, p. 51). HBCU XYZ provides research opportunities throughout the university. The CS department has at least three major research opportunities. One of the student participants in this study, Dorothy, was very excited about her summer research experience. Her research involved investigating different cyber security incidents and determining the cause of them and whether they could have been prevented. Dorothy learned a lot about how to conduct research; and she wrote a paper that she presented at a student research symposium. Literature reports that engaging in research has positive effects in undergraduate persistence (Cohoon, 2002).

Scholarships/Financial Support

Historically Black colleges, after generations of inequitable funding, lack

> substantial endowments to provide generous scholarships but serve a population in dire need of financial support. Without that assistance, their students rely heavily on loans that can exacerbate racial wealth disparities by making it more difficult to save and invest. The financial instability also places students at great risk of dropping out. (Douglas-Gabriel, 2020, para. 6).

Many HBCUs struggle to stay afloat and not lose sight of their central goal: to produce graduates with bachelor's degrees.

Fortunately, HBCU XYZ is one of a few HBCUs that has been able to flourish despite the financial struggles that tend to challenge most HBCUs. The HBCU in this study has a total of 140 endowed scholarships. Of the 140 scholarships, 65 are open to any and all majors; two scholarships are designated for CS majors only. The director of undergraduate studies stated during her interview that faculty members take an active role in locating funds for scholarships; for instance, industry partners provide scholarships and faculty write grants. During her interview, one student stated the need for more scholarships. I failed to ask her if she was aware of any additional scholarships outside of her department. Although the CS department only has two scholarships specifically designated for CS majors, the fact that the university has 65 scholarships available to any and all majors positions HBCU XYZ to support as many students as apply, meeting any academic requirements, if applicable.

Mentoring Programs

Peer groups or peer-to-peer support has been found to be the most effective form of retention of women in CS programs (Astin, 1993; Margolis et al., 2000). Women pursuing CS degrees, especially, need a support system for several reasons: (a) women

may decide later (postsecondary school) to major in CS, and therefore they may have had no prior exposure to computer courses and/or computer programming; (b) their confidence level in their technical ability may not be that high due to a lack of support from friends and family, and they may detach themselves and think that they are the only ones struggling in the CS class or program. There is a need to promote social bonds that protect women from dissuasions.

In addition to peer groups, faculty mentoring can help retain women (Cohoon, 2001). Oftentimes, women may not enter higher education as prepared in the STEM fields as their male counterparts; however, they may decide to pursue a CS degree. Studies have also shown that when they have the preparation, they still may not have the confidence needed to persist in the CS discipline. This may lead to thinking that they are individual "misfits." If these feelings or misconceptions go unchecked, they are more likely than men to leave the CS program (Margolis et al., 2000). Faculty-student relationships are important. This mentoring can involve faculty women and supportive male faculty. It is possible to build up someone's confidence by believing in their ability, initially, more than they do. The CS department at HBCU XYZ has demonstrated the positive outcomes of retaining African-American female majors through their mentoring programs such as STARS.

Theoretical Influences: Reflection

This study explored practices and strategies used at HBCUs to recruit and retain African-American females in CS. To inform my understanding, I was influenced by critical theory and Black feminist thought. One of the goals of critical theory is "to understand and to help overcome the social structures through which people are

dominated and oppressed" (Encyclopedia Britannica, n.d.). Supplemental to critical theory, Collins (2009) described Black women as unique beings with intersecting processes of race, gender, class, ethnicity, and sexual orientation. Both theories provide insight into inequalities that exist for marginalized and oppressed populations. For example, in K-12 experiences, it is more likely that African-American and Hispanic children will not be exposed to computer science classes (Google, Inc., & Gallup, Inc., 2016). Additionally, teachers who are already underpaid and may have little to no experience in computer programming may be expected to teach CS courses with limited resources. None of the three student participants in this study had been exposed to computer programming courses prior to entering the university and declaring their major. Supportive relationships among students and faculty provide African-American female CS majors with not only a support system but also a sense of belonging and help build their confidence to do the work and to persist in the program. Industry partnerships with the HBCU provide African-American female CS majors entry into corporate America via summer internships as well as permanent employment. Relevant and challenging experiences heighten African-American female CS majors' interest and ownership of the major.

Implications for Practice

The purpose of this exploratory study was to identify practices and procedures for increasing the number of African-American females in CS at an HBCU. Based on the limited results of this study, I offer four broad practical suggestions to increase the number of African-American females majoring in CS. First, the findings suggest the importance of K-12 experiences in order for students to develop knowledge of computing

and to build confidence in their ability to code. Second, the study shows that supportive relationships among students and faculty are necessary for women to persist in a CS discipline. Third, providing students exposure to industry partnerships can lead to summer internship opportunities as well as career opportunities. Fourth, these findings emphasize the necessity of relevant and challenging experiences. These experiences can occur inside the classroom (programming assignments that are assigned and implemented collaboratively) or outside of the classroom (summer research opportunities with CS faculty).

The first suggestion is the need for K-12 experiences. Literature supports that the best way to equip students with these needed skills is to teach them at an early age in school.

> One way to accomplish this: More code. By learning to code, kids use the analytical left-brain skills in combination with their imaginative right-brain skills. Collaboration, hands-on and project-based learning with the right coding instruction emphasizes whole-brain thinking, enhancing students' creativity and interpersonal skills. ("Cracking the Code: Six Keys to Better Coding Instruction in K-12 Education," 2018, para. 4).

The second suggestion is to develop supportive relationships among African-American women and faculty. A support system can consist of peer-to-peer support and/or faculty-student relationships. Peer-to-peer support can include knowledgeable TAs who assist students in course recitation. Faculty-student relationships can include faculty serving as student academic advisors and/or mentors.

As found in the study, African-American women may not come to college having

been exposed previously to computer programming. If they do not know any family or friends who work in the CS field, they may not have family and friends to support them in this endeavor. Women who have a support system are more likely to persist in the major (Cohoon, 2002; Margolis et al., 2000). It is important to note that the peer-to-peer support may consist of bonds between women and between women and supportive male peers (Margolis et al., 2000).

The third suggestion is to provide industry partnerships to CS students, which will enable students to network with corporate representatives and be provided opportunities for summer internships and career employment. Encounters with corporate America will expose African-American females to applications of which their formal training in the classroom is applied to real-world settings.

These findings emphasize the need for supporting relationships in corporations that include CS professionals (Cohoon, 2002). Corporate sponsors are an asset to any program in higher education. In particular, corporate sponsors play a key role in CS. The student participants in this study noted that the corporate sponsors were very visible on the campus in this study and would attend some of the CS student organizational meetings; for instance, the ACM. The student participants felt confident that the corporate sponsors would provide summer internships as well as full-time employment for students after they graduated. The director of undergraduate studies also noted corporate sponsor visibility on campus as well as their support in scholarship funding. The corporate sponsors have access to the campus via the university's website where they may register for campus visits, career fairs, or other activities they might wish to host.

The fourth suggestion is to provide relevant and challenging experiences that will

cultivate student critical-thinking and problem-solving skills. During the interviews with the student participants, it struck me that not one of them ever complained about a course or subject matter being ‘too difficult.” Instead, they seem excited about the “challenge” of first understanding the problem and then writing a computer program to solve the problem. In all three cases, they made remarks similar to this: “It was a lot of work, but I felt so proud afterwards, when I had successfully completed it!”

Another relevant and challenging experience can be offered in summer research opportunities with CS faculty members at the HBCU. Cohoon (2002) recommended student engagement in faculty research has a positive effect on student retention in undergraduate STEM majors.

This study aligns with the work of other researchers who suggest that the ways in which to recruit and retain women in CS is to expose students to precollege experiences while they are in K-12 (Google, Inc., & Gallup, Inc., 2016) and to provide a support system (Cohoon, 2002; Margolis et al., 2000). Universities should provide women with benefits of industry partnerships and the opportunity for supporting relationships in corporations that include CS professionals. Universities should provide relevant and challenging experiences (Cohoon, 2002). This study suggests that universities wanting to recruit and retain African-American women in CS should provide K-12 experiences, supportive relationships among students and faculty, industry partnerships, and relevant and challenging experiences.

The last suggestion is a pre-college suggestion to empower young girls (middle school to high school) to believe they can code and pursue careers in CS. To accomplish this, it will definitely take a village, which means parents will need to offer

encouragement to their young daughters just as they do their young sons. Females need encouragement starting from a younger age up to young adulthood. Certified and experienced CS teachers should not only serve as educators but as mentors for female students. Family and friends should offer support—this does not require them to know how to code or know what CS is. It suggests that they will be "cheerleaders," offering positive feedback and other resources that will allow girls to feel free to explore computing. All of these interactions will build up their confidence and self-efficacy, which will give them more options in determining their own career aspirations.

Limitations and Delimitations of the Study

The purpose of a grounded theory study is to derive a general, abstract theory of a "process, action, or interaction grounded in the views of the participants" (Creswell, 2014, p. 14). This study focused on the intersectional factors (namely class, gender, and race) influencing the recruitment and retention of African-American females currently enrolled in a CS program at an HBCU in the eastern region of the United States.

There were several delimitations to this study. The first delimitation was the time of year in which the study was conducted, mid to late March through June. I did not take into consideration the amount of time it would take to invite students to participate and to finalize the selection process. This proved critical because two students backed out of the study prior to the interviews (data gathering), and it was challenging to find replacements as most students had already left or were in the process of leaving the campus for the summer. Additional time should have been allotted for occasions such as this. I suggest beginning such a study at the beginning of the semester (August 1, if in fall semester or January 1, if in spring semester).

The second delimitation was the possibility that I was not clear enough in my questions to the student participants during the interview sessions or did not follow-up certain questions with probing questions as an experienced researcher would have. Time was spent contacting student participants for more information during what should have been the analysis phase. I would suggest that some student participant responses would have been different had the questions been posed differently or followed up with probing questions.

Last, one of the student interviews was conducted via FreeConferenceCall.com, whereas the other two student interviews were conducted face to face in my worksite office. Although the interview was recorded with the student's permission, I may have missed the opportunity to witness verbal cues from the participant by not being face to face.

The study has several limitations. First, the scope is limited in that I only examined practices and procedures influencing African-American female CS majors classified as juniors or higher at one specific HBCU; thus, the findings may not be generalizable to all junior and senior African-American female CS students or to all HBCUs.

Second, personal biases may have arisen in that I am an African-American female who graduated from an HBCU and currently teach CS courses at an HBCU—not the HBCU in this study. To deal with biases during the study, I exercised extensive reflection and reflexivity (through journaling) as I proceeded through the interviews and document collection, which helped to bring these biases to my own awareness. In addition to journaling, I engaged in different conversations with colleagues, peers, and

accountability partners to prevent my biases from influencing the process and the results of this study. Despite taking many precautionary steps to avoid implicating my own assumptions and biases on the findings, I could have inadvertently influenced the results of this study.

Another limitation was that I was not able to get multiple HBCUs (at least one additional HBCU) to participate in the study; therefore, I had a very small number of participants.

Fourth, I collected and analyzed data through student interviews; the director interview; and reviewed documents, brochures, newsletters, websites, and email correspondence between the director and me. I was able to triangulate my data and identify emerging themes across the three data sources. However, due to the small number of student participants, I was unable to reach data saturation.

Suggestions for Future Research

The purpose of this exploratory study was to identify practices and procedures for increasing the number of African-American females in CS at an HBCU. In addition to the suggestions made based on study delimitations and limitations, there are numerous ideas for future research to build on this initial study. Future research could be conducted on the experiences of African-American junior and senior female CS students from at least two different HBCUs. Perhaps one HBCU could be a private institution and the other public. Since it would be a qualitative study, five to 10 students per college would be adequate.

Further research could explore the lived experiences of other ethnic and marginalized student populations; for instance, African-American male CS majors or

Hispanic female CS majors. It would be interesting to compare how different or similar their experiences are. From the literature, the Hispanic and Native American populations are also underrepresented in CS (Ong, 2011; Ong et al., 2011).

Further research could focus on the content of computer/media classes in elementary schools (or K-12). It would be interesting to see how much students are being exposed to actual computing skills and knowledge.

Finally, further research could follow up with each of the three student participants in this study: Katherine, Dorothy, and Mary. I found them to be phenomenal individuals who are destined to make significant contributions to the CS field and to society. Their stories are yet to be told, just like in *Hidden Figures* (Shetterly, 2016).

Conclusion

The purpose of this chapter was to present the summary of findings, implications for practice, limitations, and suggestions for future research. The focus of this exploratory, qualitative study was to investigate procedures and strategies utilized at an HBCU to recruit and retain African-American females in an undergraduate CS program.

The low numbers of women and, in particular, African-American women pursuing CS degrees and careers, gives cause for concern. If the U.S. intends to maintain a level of competence and competitiveness, this disparity will need to be dealt with sooner rather than later. In light of real-world problems we currently face—the COVID-19 pandemic as well as a racial pandemic—competent, critical thinkers who are able to solve problems in imaginative and unprecedented ways are needed. One way to develop such real-world problem solvers is to widen the pipeline and encourage more African-American females to pursue CS majors.

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Appendix A

Questions for Department Chair Interview

QUESTIONS FOR DEPARTMENT CHAIRS

(Interviewer note: These questions can also be addressed to Administrative Officers who are closely involved with the CS program.)

Recruitment

1. What is your current student population in the CS Department by classification, gender, and race?

2. What activities do you currently have in place to attract students into your program?

3. Which recruitment procedures or strategies if any have proven to be successful in the past five years in your department's efforts to attract African-American female CS majors?

4. What are the procedures for a student to follow in declaring their major as CS? Where (in what documents) are these procedures located?

5. What do CS majors who graduate from your university generally do: pursue a graduate or professional degree in CS, began a CS career in industry, or something else?

Retention

6. What percentage (or number) of total African-American females who enter the CS program graduate within four to six years?

7. What is the procedure for faculty advising to occur, for example, when does a new faculty member become an advisor? To what degree does faculty advising encourage retention of African-American female students in your department?

8. Does the department offer tutoring or supplemental assistance for the CS majors? If so, is it being utilized by the students?

9. Based on student evaluations, how satisfied are the students with the CS program overall?

10. What strengths would you identify that have played a significant role in the retention efforts of African-American females in your CS program?

11. Is there anyone else I should speak with to understand these practices and procedures better?

Appendix B

Initial Interview Protocol

Initial Interview Protocol

Research Question:	**Interview Questions:**
General Introduction	1. How do you like college? 2. Tell me a little about yourself.
Why do African-American females choose CS as a major?	3. Why did you choose to major in CS?
*What are the perceptions of African-American female CS majors about their experiences **before** declaring their major?*	4. Describe some of the experiences that led to your decision to major in CS. 5. Did you feel prepared for your CS courses when you first entered the program? Why or why not?
*What are the perceptions of African-American female CS majors about their experiences **during** their progression in the major?*	6. What is one of the best assignments or experiences you have had as a part of your CS coursework? What is one of the worst? 7. Tell me about any other experiences you have had as a CS major.
Why do African-American females enrolled in CS programs at HBCUs persist in their major?	8. Describe a challenge you've encountered since declaring your major. What was the outcome of the challenge? 9. Is there anything your professors or the school does to support you as a CS major? 10. Is there anything you wish they would do? 11. How satisfied are you with your decision to major in CS? Explain your answer.
What structures and practices are being utilized at HBCUs to recruit and retain African-American females in CS programs?	12. What types of academic activities have you participated in or are currently participating in? 13. Did the university do anything

	specifically to encourage your decision to major in CS? 14. What does the university do to support you as a CS major? 15. What types of professional conferences or internship opportunities have you been exposed to? 16. Looking towards the future, what would you like to see put in place to recruit and retain students into the major?

Appendix C

General Student Demographics

General Student Demographics

INSTRUCTIONS:
The demographic information requested above the perforated line should be placed in the envelope labeled 'Demographics' and will be collected by the visiting researcher. Demographic information is requested for the purpose of ensuring that I interviews a broad mix of students. Individual demographic information is confidential, will not be shared with others, and will not be identifiable from the aggregate analysis.

1. What is your age?
   - 18 – 22 years old
   - 23 years and older
   - Under 18 years old
2. What is your race? Are you African-American, Black, or some other race?
   - African-American
   - Black
   - Other (please specify) _____
3. Are you a full-time student?
   - Yes
   - No
4. What was your high school grade point average? _____
5. What is your current grade point average? _____
6. What is your classification?
   - Freshman
   - Sophomore
   - Junior
   - Senior
7. What is your major?
   - Computer Science
   - Other (please specify) _____
8. Would you be willing to participate in at most two interviews with the visiting researcher? The interviews will take approximately 30 – 45 minutes and will be scheduled with little to no interruption in your academic schedule.
   - Yes, I would like to participate.
   - No, I would not like to participate.

Thank you for completing these questions!

(Tear off the strip below the line and place in envelope labeled 'Contacts.')

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Student's Name (please print clearly): _____
Phone number: _____ E-mail: _____
Note: You will be contacted to participate in the interviews *only* if you have agreed to do so (question #8 above), and you are selected by the visiting researcher.

Appendix D

Documents to be Analyzed at the HBCUs

Table 8. *Document Analysis*

Types of Document	Recruitment	Retention
Strategic Plan (University)	X	X
Operational Plan	X	X
Department Plan	X	X
CS Majors Demographics		X
CS Faculty Demographics	X	X
Course Catalog		X
Student Evaluations		X