Creating a Pipeline for African American Computing Science Faculty: An Innovative Faculty/Research Mentoring Program Model

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African Americans represent 1.3% of all computing sciences faculty in PhD-granting departments, underscoring the severe underrepresentation of Black/African American tenure-track faculty in computing (CRA, 2012). The Future Faculty/Research Scientist Mentoring (FFRM) program, funded by the National Science Foundation, was found to be an effective strategy in increasing the number of tenure track faculty hires by 11% (Charleston & Jackson, 2011). This manuscript describes a new program, the Institute for African American Mentoring in Computer Sciences (iAAMCS), which capitalizes on the successes of the FFRM and other mentoring models. The iAAMCS endeavors to improve faculty representation through a national mentoring model.

Innovation in computing drives economic growth and underlies many scientific advances. Unfortunately, although considerable growth in computing jobs is expected in the next decade, students are not majoring in computing in sufficient numbers to meet this demand. These impending workforce shortages will require a range of solutions, one of which includes developing the skill sets of racial and ethnic minorities who are underrepresented in computing related fields (Charleston, 2012).

While there are many theories (e.g., social disparity theory, social stratification theory, self-efficacy theory, viable social identity theory) to explain disparities in representation and participation in higher education and particular fields therein, it is also the case that representation of traditional minority groups in the computing sciences are disparate and are at especially low levels. According to the most recent Computing Research Association (CRA) Taulbee Survey (2012), nationwide there are merely 56 Black/African American computer science tenure-track faculty members at PhD-granting institutions, which includes 12 (or 0.6%), 21 (or 1.4%), and 23 (or 3.0%) Full, Associate, and Assistant Professors, respectively. This compares to approximately 3.4%, 5.4% and 6.4% of all Black/African American Full, Associate and Assistant professors, respectively, across all degree-granting institutions in the U.S. – which includes Historically Black Colleges and Universities (HBCU). These figures illustrate the severe underrepresentation of Black/African American tenure-track faculty members in computing. This disparity will not change unless there are more Black/African Americans obtaining PhDs in computing related disciplines. The CRA Taulbee Survey also reports that there are just 172 Black/African American PhD students currently enrolled in computer science PhD programs (1.6% of the total number of doctoral students enrolled in the discipline). These figures indicate a 3:1 disparity for Black/African American PhD students to faculty versus 1:1 for White PhD students and faculty.

In an attempt to reduce this disparity, the National Science Foundation (NSF) established the Broadening Participation in Computing (BPC) Alliances between 2006-2009. Currently, there are 13 BPC Alliances nationwide. These Alliances – national and regional collaborations of academic institutions, educators, professional societies, community organizations, and industrial partners – aim to increase the number and diversity of college graduates in the computing disciplines. They establish best practices, provide educational resources, and offer advocacy networks and forums needed to transform computing education. Under the BPC's auspices, the Alliance for the Advancement of African American Researchers in Computing (A4RC) and the Empowering Leadership (EL) Alliances are merging to form a new mentoring program, the Institute for African-American Mentoring in Computing Sciences (iAAMCS, pronounced "I am C.S."). The new program

seeks to increase the number of African Americans pursuing and completing the PhD in computing fields through the implementation of a national mentoring program that builds on a proven precursor, the Future Faculty/Research Scientist Mentoring Program, shown to be an effective method of broadening participation for faculty in STEM fields (Charleston & Jackson, 2011). Under the new iAAMCS program, mentoring will serve as the unifying framework for all interventions and activities within the alliance.

This manuscript presents an overview of relevant research, followed by, a detailed description of the iAAMCS mentoring program and how it may serve as a model for career and faculty development programs in computing science and other STEM-related areas. Lastly, the manuscript concludes with a discussion of how the program can be used as a resource for research, researchers, and practitioners.

The Role of Mentoring in Cultivating Success: An Overview of Research

Higher education in the United States has often been held up as an exemplar as one of the few industry sectors to take diversity initiatives seriously—an attitude most evident in post-affirmative action admissions policies in the 1970s. However, despite these efforts, a severe underrepresentation of African Americans in doctoral programs persists, and the imbalance is particularly glaring among faculty on the tenure-track (Davidson & Foster-Johnson, 2001). This underrepresentation is exacerbated in the context of STEM fields and even more so with respect to computing sciences (Charleston, 2012; Jackson, Gilbert, Charleston, & Gosha, 2009). Historically, studies have undertaken the challenge of exploring this phenomenon, arriving at various explanations for the low enrollment levels of African Americans in doctoral programs (e.g., Boykin, Franklin, & Yates, 1979; Brazziel, 1988). Some reasons include the high costs associated with graduate education, limited financial aid, and the existence of better and more lucrative career alternatives for students with STEM training. However, more recent studies have identified a lack of high quality mentorship and positive faculty-student relationships and posited that these factors may be a more impactful determinant of students' career trajectories and likelihood of graduation (Davidson & Foster-Johnson, 2001).

This vein of research concludes that formal and informal avenues for mentorship provide important environmental conditions for success among African American students and that, as a result, positive environmental conditions fostered by multifaceted mentorship should be more prevalent during the educational process. Davidson and Foster-Johnson (2001) asserted that mentoring relationships serve to "(a) integrate a student into the fabric of the department, (b) cultivate essential professional and social networks, (c) aid students in acquiring core research competencies, and (d) pave the way for placement in the work force upon matriculation from graduate school" (p. 549-550). Overall, the literature calls for more mentoring programs and initiatives if a greater number of African American students are to attain faculty positions within STEM.

Although there is no consensus definition of mentoring, Healy and Welchert (1990) offer a broad understanding on the concept rooted in observations across multiple studies of mentoring relationships. They define mentoring as:

> A dynamic, reciprocal relationship in a work environment between an advanced career incumbent (mentor) and a beginner (protégé) aimed at promoting the career development of both. For the protégé, the objective of mentoring is the achievement of an identity transformation, a movement from the status of understudy to that of self-directing colleague. For the mentor, the relationship is a vehicle for achieving midlife' generatively' [or passing along a legacy]. (p. 17)

Numerous studies emphasize the impact of mentor-protégé relationships (Carden, 1990; Cox & Nkomo, 1990; Dixon-Reeves, 2003; Ensher & Murphy, 1997; Harley, 2005; Smith, Smith, & Markham, 2000; Stanley & Lincoln, 2005; Waitzkin, Yager, Parker, & Duran, 2006). Earlier studies (Burke, 1984; Jennings, 1971; Phillips-Jones, 1982, 1983; Roche, 1979) highlighted how mentors could be helpful in facilitating the personal development and organizational advancement of their mentees by serving as role models and providing challenging assignments, guidance, and counseling, as well as increased exposure and visibility to the mentor's peers. In mentoring relationships between doctoral students and faculty advisors, many studies describe how mentorship can significantly influence students' professional development (Charleston & Jackson, 2011; Jacobi, 1991; Merriam, 1983; Phillips, 1979; Rawles, 1980). Additionally, a study of graduate students concentrating in science at one large Midwestern university found that students who were highly competent and highly committed to science at the time of starting graduate school reported, one year later, that they had received good mentoring (Green & Bauer, 1995).

Within higher education, mentoring has become an increasingly popular method for addressing recruitment and retention issues for women and ethnic minorities (e.g., African Americans, American Indians or Alaskan Natives, and Hispanic Americans). It is often regarded as an essential factor in helping women and ethnic

minorities successfully matriculate in non-traditional undergraduate programs (e.g., engineering, computer science, and the natural sciences) and prepare students for graduate training in these academic disciplines (Charleston, 2012; Graham, 1997). The literature provides extensive documentation that women and ethnic minorities consistently do not receive adequate mentoring in IT fields (Moore, 2000; Moore, Madison-Colmore, & Smith, 2003), particularly at the undergraduate level. For example, Jacobi (1989) found that regardless of one's academic discipline and/or demographic characteristics, undergraduate students rarely experienced mentoring relationships. For women and ethnic minorities, Johnson (1989) concluded that the mentoring process was even less likely to occur. Where mentoring relationships tend to be more common is at the graduate stage of the educational process (Jacobi, 1991), but here too the disparities are reproduced. LeCluyse, Tollefson, and Borgers (1985) found that a significant number of the female graduate students who enrolled in education or liberal arts degree programs did report having a mentor. Other scholars, such as Cronan-Hillix, Gensheimer, and Davidson (1986), have produced similar findings with respect to graduate students in psychology. Cusanovich and Gilliland (1991) argue that mentoring is not only an essential part of the educational process for graduate training, but the crux of graduate education. In sum, these findings suggest that a strong mentoring component at the undergraduate level may lead more underrepresented students to pursue graduate education and better prepare them for the graduate school experience, which ultimately relies heavily on mentorship relationships.

Throughout the literature, mentoring is often proposed as a mechanism to provide women and ethnic minorities with "support, socialization, and direct assistance they need to succeed in an environment they may experience as alienating and hostile" (Jacobi, 1991, p. 518). Additionally, existing scholarship indicates a strong correlation between mentoring and academic success for women and ethnic minorities (Charleston, 2012; Frierson, Hargrove, & Lewis, 1994; Jacobi, 1991), particularly at predominantly White colleges and universities. "Because the leadership and faculty of these colleges and universities are traditionally White and male, students of color and women may have less access to informal networks and other sources of support" (Jacobi, 1991, p. 518). Mentoring relationships may be critical in overcoming this lack of support particularly where students have difficulty adjusting and acclimating to a predominantly white male, educational environment (Charleston, 2012; Graham, 1997; Jacobi, 1991; Moore & Flowers, 2003).

Previous studies have indicated that African Americans receive inadequate mentorship during their doctoral training and lack good advising upon graduating (Charleston & Jackson; 2011; Davidson & Foster-Johnson, 2001). A study conducted by Deborah Harley (2005) found that African American protégés and their mentors usually have differing, if not conflicting, perspectives about the terms of the mentoring relationships. A study by Smith and Markham (2000) found that same-race and same-gender mentorship provide more psychosocial support than cross-racial relationships, but they also found that minorities were not as successful in finding mentors, particularly if they wanted same-race pairings.

Charleston's (2012) study specifically examined contributing factors to computing science aspirations among African Americans and found that mentorship served as a positive social interaction that played a significant role in socializing the study participants to the world of computing. These interactions ultimately contributed to degree attainment among the participants. Mentoring was particularly significant as it related to participants' aspirations and trajectories toward the highest levels of degree attainment (e.g., Ph.D.) in computing. In many cases, mentors introduced study participants to the field of computing sciences. These mentors most often came in the form of professors and more senior students (e.g., advanced graduate students). Additionally, some participants' parents served as mentors. In many cases, the participants' interests in mathematics served as a catalyst for professors and advanced students to provide mentorship in the field of computing. For example, as there is a direct relationship between computing sciences and mathematics, an interest in mathematics among the participants often led them to seek out the input of individuals with more depth of knowledge regarding the relationship of mathematics to computing. However, although many study participants attributed their persistence at least partly to good mentorship, most study participants expressed that a lack of mentorship remained a significant problem in the field of computing (Charleston, 2012).

The Institute for African-American Mentoring in Computing Sciences (iAAMCS) Model

The iAAMCS is a new mentoring program that combines efforts from multiple NSF BPC Alliances and Demonstration Projects that utilized different strategies towards broadening the participation of African Americans in computing sciences. Although these previous alliances and demonstration projects differed

with respect to implementation strategies, they all had a strong emphasis on mentoring. The iAAMCS emphasizes mentoring as the primary strategy for increasing African American's participation in computing, specifically at the PhD level and beyond by targeting the leak in the pipeline between the bachelors degree and graduate school pursuits and degree attainment. The larger number of African Americans at the bachelor degree level provides evidence of a sufficient pool of talented African Americans that could possibly pursue graduate education in computing, if made aware of the values and benefits thereof. Therefore, the iAAMCS aims to instill in undergraduate students an understanding of graduate-level expectations, increase interest in graduate school, support the development of research skills, retain undergraduates in their computing sciences programs, and strengthen graduate school applications. In doing so, the iAAMCS will serve as a national resource that will emphasize successful mentoring activities in conjunction with programmatic interventions to increase the number of African Americans pursuing graduate degrees in computing.

With access to a significant number of African American PhDs in computing, the iAAMCS is well positioned to assist the necessary broad range of current and future scholars, expanding upon other models such as MentorNet founded in 1997 to assist women engineers. The iAAMCS offers summer and academic year research experiences, robotics competitions, and research training to provide authentic opportunities for participating in computing. However, because providing research experiences for students is a necessary but not comprehensive method for ensuring success, the program also offers professional training and career development through conference attendance, writing workshops, targeted presentations, and technical web-based seminars (webinars). These opportunities for professional training and career development have been successful in a number of the alliances. The goal of these interventions include: increasing exposure to role models, demonstrating the benefits of a doctorate in computing sciences, increasing the successful placement of new PhD students, providing training to students, increasing their future employment opportunities, and expanding networking opportunities for African American Students in the computing sciences. In addition, one new intervention not part of previous alliances, the Distinguished Fellowships Writing Workshop (DFWW), endeavors to guide undergraduate and graduate students through the process of writing a competitive application for summer internships, graduate school, and/or external funding. The DFWW will be an annual working three-day workshop organized and managed by faculty from Bowie State University, IBM Research, and Spelman College.

At the center of these efforts is an underlying appreciation for the importance of mentoring. Dixon-Reeves (2003) expanded the definition of mentorship to include peer advisors, counselors, role models, sponsors, and/or guides. Under the expanded definition, 97 percent of the student participants reported having a mentor compared to the 12 percent of African American faculty in previous studies reflecting the more traditional definition. The iAAMCS utilizes the Dixon-Reeves (2003) definition of mentoring as this definition includes all the major roles that are incorporated into the Alliance's interventions.

This broader range of mentors will serve participants through a scalable web-based application. This new effort builds on earlier work offered by the Academy of Courageous Minority Engineers (ACME), a group of PhD students at MIT, who offered a model for efforts aimed at retaining minority graduate students and enhancing their educational experiences through peer mentorship geared toward completion of graduate degrees in multiple disciplines including electrical engineering, computer science, media arts and sciences, biology, and urban studies. While support or accountability groups are not new, ACME makes this process more systematic and streamlined through the use of a web-based system, ACME Online, which allows members to post and track their personal goals and comment on the goals of other members. Weekly forums are held to discuss and provide constructive feedback on the content of and progress toward research goals as well as discussion topics related to graduate school success including time management, preparing for qualifying exams, and advisor-advisee relationships. The use of such tools will help facilitate deeper mentorship relationships among peers and contribute to greater academic and career success.

As the previous descriptors indicate, iAAMCS employs the type of mentorship the literature (e.g., Charleston, 2012) demonstrates would be beneficial to the targeted population. This type of mentorship enables a multilayered relationship between mentors and mentees that utilizes modern technology, self-accountability and ownership, face-to-face mentoring and academic development activities, as well as distance learning and technological tools to enhance the educational computing related outcomes of iAAMCS participants. Additionally, participants will not only be exposed to more senior leadership and mentoring, they will also benefit from peer modeling and mentoring through collaborative components embedded within iAAMCS.

The iAAMCS Model as a Resource for Research, Researchers and Practitioners

The total sample of iAAMCS participants across each of the 31 institutions (approximately 1,600 students per year) will be recruited from two institutional types: (a) historically Black colleges and universities (HBCUs) and (b) predominantly White research institutions (R1s). As a result, it is possible to study inter- and intra-institutional dynamics. The inter-institutional dynamics will focus on established peer group institutions for the HBCUS and the R1s. The intra-institutional data collection will focus on non-participating students at iAAMCS institutions using survey instruments developed by project evaluators, and will be collected through focus groups, individual interviews, and data tracking. Although this data will primarily be used to study the effectiveness of the iAAMCS interventions, it may also prove helpful in evaluating the computing sciences pipeline from undergraduate education, through graduate degree pursuits, towards faculty and research careers at the highest levels of degree attainment for computing (e.g., the PhD).

Major findings from Charleston's (2012) study suggest that the decision to pursue computing sciences degrees (particularly graduate degrees) among African Americans is dependent upon factors that are mainly socially constructed. Although some study participants were found to have demonstrated high levels of ambition and self-initiative, these were not salient contributing factors to their actual degree attainment. What proved more salient were the positive social influences that were often the catalyst for not only the introduction to computing sciences among study participants but also the underlying rationale for their persistence in the field through graduate degree completion. The iAAMCS promotes and utilizes six core factors found to significantly contribute to sustained interest and success in computing sciences through graduate degree completion for African Americans. These factors are: (a) early advanced engagement with computers and computing; (b) technology nourishment; (c) significant science and mathematics exploration; (d) cohort modeling and influence; (e) knowledge of the scope of versatility in computing sciences; and (f) advanced mentorship (Charleston, 2012). These factors are deeply embedded in the program components that make up the iAAMCS and assists in producing educational and occupational decision-making that facilitates advanced degree pursuit and completion in the computing sciences among African Americans.

Informed by previous research studies related to broadening participation in the computing sciences (e.g., Charleston, 2012; Charleston & Jackson, 2011; Jackson, Gilbert, Charleston, & Gosha, 2009), the iAAMCS utilizes and cultivates a multifaceted mentorship model. As African Americans who participate in the field of computing sciences are an anomaly, which in turn necessitates the need to socialize aspirants to the field, the iAAMCS establishes a socialization process in the field of computing that employs robust and multilayered mentorship experiences for participants. The iAAMCS multifaceted mentorship in computing model serves to: (1) assist in the academic preparation of African American students; (2) provide social contacts to enhance experiences through the educational trajectory (e.g., computing organizations); (3) provide educational and occupational career advice; (4) provide apprenticeship opportunities; (5) acquire or refer sources of funding; and (6) assist in job search and acquisition, directly correlating with previous successful strategies (e.g., NSF BPC Alliances; Charleston, 2012). Although these mentorship responsibilities are vast and in-depth, the elite field of computing sciences requires such measures if it hopes to broaden participation beyond its currently miniscule numbers of African Americans. Doing so is important not only for the field itself but needed to assist the U.S. in maintaining an economically viable workforce and its global competitiveness.

Conclusion and Implications

In light of prior research indicating the importance of mentorship relationships, it is pertinent to explore programs such as iAAMCS in which African American students may emulate and closely shadow faculty as role models within the field of computing. In a field like computing sciences, in particular, which rarely acknowledges the contributions of African American participation, programs such as iAAMCS are critical in order to cultivate the ranks of people of color in faculty and research scientist positions. With national efforts underway to increase the participation of underrepresented populations in the field of computing sciences, the iAAMCS, like its precursor FFRM, serves to further this mission. The program aims to help African American computer science aspirants reach their professional goal of attaining tenure-track faculty positions as research scientists. In the past, progress toward attaining these goals was facilitated successfully through the Future Faculty/Researcher Mentoring (FFRM) program (see Jackson & Charleston, 2011), the former mentoring model described within this paper in which African American PhD computing science students receive mentorship through electronic correspondence, con-

ference calls, conference meetings, as well one-on-one meetings and professional development/networking conferences. Additionally, in order to reach these goals, students (particularly African American students) rely on a wide-ranging team of mentors in an effort to fill all of the necessary roles related to educational and occupational decision-making and success. Furthermore, the iAAMCS asserts that mentorship need not be confined to the specific locality of the particular individuals. With modern technology and the continual advancement thereof, some aspects of mentorship can be accomplished via electronic means. The iAAMCS believes that it is the role of mentors to assist African Americans in their navigation of the computing sciences landscape, and, the institute is well positioned to do just that.

Within the academy, we tend to think of faculty development as institution-specific, placing sole responsibility for preparing future faculty and graduate student development on faculty within each individual department, institution, or other higher education entities. However, faculty/research mentoring programs such as iAAMCS described herein, serve as an innovative model of mentorship that goes beyond the campus walls. Indeed these efforts are not confined to a single institution but require collaboration across institutions. These collaborative efforts provide, in a sense, a virtual hub of resources for faculty development and mentorship. To be sure, this mentoring program is intended to supplement, not replace, existing institutional and departmental mentoring programs, particularly, as it relates to the STEM fields where underrepresentation is commonplace. The faculty/research mentoring program (e.g., iAAMCS) serves as a vehicle of change, linking together individuals in a professional network of peers and scholars with either the same, or sensitivity to, particular ethnic backgrounds (African Americans in this case) and a shared sense of educational and occupational goals. The emergence of the iAAMCS will also give teachers, scholars, practitioners, and funding agencies innovative ways of thinking about and understanding the way mentorship impacts the success of students in the STEM pipeline in general, and the computing pipeline in particular.

Programs like iAAMCS do not simply have the potential to positively affect the development of mentees or future faculty; mentorship programs can also benefit faculty who serve in mentorship roles. For example, particularly as it relates to computing and modern technology, mentees can provide an extra set of eyes that, in turn, can provide innovative perspectives and approaches to the research studies or projects at hand. Additionally, there are generational advantages in working with mentees who may be younger or exposed to diverse experiences due to their diverse backgrounds. Working with mentees has the potential to positively affect the following for faculty/researchers: (1) the research questions being asked; (2) the research problems being solved; and/or (3) the new and innovative technological solutions that are being developed. Additionally, faculty/researcher mentors can increase their own productivity (e.g., manuscripts, funded grants that require student involvement, academic presentations), which will in turn help to augment their professional and academic dossiers. In addition to the positive benefits mentors gain through embarking upon joint discoveries and learning from their mentees, faculty mentors can also be rewarded indirectly through observing students' growth under their guidance and leadership. In this manner, mentored students may serve as a vessel for passing on knowledge and skills related to teaching and learning.

In review, iAAMCS is a unique national mentorship program targeted to increase African American computing scientists in tenure-track faculty and researcher positions. If this program achieves the levels of success similar to the gains experienced by other individual BPC Alliance programs, which in many ways serve as a foundation to this program, it is poised to provide a replicable model for effective mentoring strategies and relationship-building that is immediately transferable to other STEM disciplines and other targeted populations. Furthermore, as this program achieves a measure of success with participants from all across the U.S., more programs with similar components could be developed to help build and sustain a viable and thriving community among a targeted group, providing the support needed to broaden participation in fields like computer sciences that remain dominated primarily by White men.

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