The iAAMCS Ecosystem: Retaining Blacks/African-Americans in CS PhD Programs

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Abstract— A persistent challenge in computer science (CS) graduate education is the lack of representation, retention, and graduation of certain racial and ethnic groups. Despite increased enrollment in computer science departments across the United States, the persistence of Black/African-American students remains primarily unchanged since the mid-1990s, particularly at the doctoral degree level. The Institute for African-American Mentoring in Computing Sciences (iAAMCS) is an NSF Broadening Participation in Computing Alliance (BPC-A) that provides a national ecosystem by connecting students and faculty through short and long-term programmatic activities to build community and advance Blacks/African-Americans in computing research. This paper presents an analysis of admissions and graduation data of Black/African-American CS PhD students from the CRA Taulbee surveys from 1995 to 2018. The findings suggest that less than 50 percent of the Black/African-American students that enter CS PhD programs finish. However, of those Black/African-American CS PhD students that have engaged in iAAMCS activities, 86 percent completed their PhD.

Keywords—broadening participation, mentoring, retention, engagement

I. INTRODUCTION

Between 2005-2006 the National Science Foundation (NSF) launched the Broadening Participation in Computing Alliance (BPC-A) program to address the limited diversity in computing and computationally intensive degree programs across the country. The program was designed to reach students traditionally underrepresented in computing, including women, persons with disabilities, African-Americans, Hispanics, Native Americans, and indigenous peoples as the target population [1]. With a majority of the United States (US) population represented by these categories, the BPC-A program touted the opportunity to prepare the next generation of computing students with the skills and competencies needed for the 21st century workforce [1].

Several BPC-A proposals have been awarded since 2006, and their activities and engagements are designed to reach underrepresented computing students in K-20 pathways. The Institute for African-American Mentoring in Computing Sciences (iAAMCS) was awarded in 2013, and serves as a national resource for Black/African-American computing students and faculty. It began as a merger of several NSF BPC-A awards including: The Alliance for the Advancement of African-American Researchers in Computing (A4RC), The Advancing Robotics Technology for Societal Impact (ARTSI) Alliance, and The Empowering Leadership Alliance, as well as the BPC Demonstration Project entitled, African-American Researchers in Computing Sciences (AARCS) [2]. Each of these projects utilized different strategies toward broadening the participation of African-Americans in computing.

Today, iAAMCS remains a collaborative effort between faculty at several institutions who serve as the leadership team. Originally housed at Clemson University, the award moved in 2014 with the principal investigator to the University of Florida and in its final year involved leaders from Auburn University, University of Alabama, Winston Salem State University, Morehouse College, Morgan State University and an evaluation team from the University of Wisconsin-Madison. And while some institutions are no longer a part of the organization's leadership team, they maintain interactions through the programming and events which take place nationally.

Through the years, iAAMCS events touched the lives of over 649 core participants. This is through a systematic effort to create an ecosystem of resources accessible to students who traditionally exist in isolation on their college campuses.

A. The iAAMCS Ecosystem

One of the initial primary goals of iAAMCS programming was to add more advanced researchers into the advanced technology workforce. To do this, interventions were designed for undergraduate and graduate students that leverage the expertise of faculty and industry professionals. Additionally, programs involved collaboration with complimentary BPC-A's and other national initiatives that focus on diversifying science, technology, engineering, mathematics, and computing (STEM+C) workforce. iAAMCS signature programs have included:

1) Collaborative Research Experiences for Undergraduates (CREU): an undergraduate research program that provides stipends to teams of students working on research projects under the guidance of a mentor at their home institution. Students supported by CREU collaborate with each other and with their mentors during the academic year and, in some cases, the following summer. Students are strongly encouraged to present their CREU research at national or regional conferences. This program is in partnership with the Computing Research Association's Committee on Widening Participation in Computing Research (CRA-WP).

2) Distinguished Fellowship Writing Workshop: a writing workshop that guides undergraduate and graduate students through the process of writing a competitive application for summer internships, graduate school, and/or external funding. The targeted audience are junior and senior-level undergraduates, first- and second-year graduate students, and includes faculty who advise and/or mentor these students.

3) Distributed Research Experiences for Undergraduates (DREU): this program accepts applications from both interested students and mentors who are matched based on their interests and backgrounds. During DREU, students complete a 10-week summer research experience that consists of several checkpoints in the process to ensure uniform expectations and outcomes. This program is run in partnership with CRA-WP.

4) Future Faculty and Research Scientist Mentoring Program: a mentoring program which provides guidance and mentorship through the faculty and/or research scientist job search. It is designed for doctoral students who have reached candidacy.

5) iAAMCS Distinguished Lecture Series (DLS): this series of programs features opportunities for Black faculty and graduate students to give lectures at Historically Black Colleges and Universities (HBCUs). The purpose of the iAAMCS DLS is to provide mentoring through role modeling, while also exposing students at HBCUs to faculty and graduate students of Black descent. This program is run in partnership with CRA-WP.

6) iAAMCS MentorNet: iAAMCS established a partnership with MentorNet, a division of Great Minds in STEM, to recruit Black mentors in computing while yielding more opportunities for Black students to receive mentoring. This effort also supports the DREU and CREU programs, along with graduate students connected to iAAMCS programming, while also providing training for participating mentors. Diverse mentors are invited to learn how to effectively mentor Black students through a series of training modules. Mentors are paired with students through a detailed profile matching process.

7) Morehouse-Spelman Virtual Mentoring Program: this program uses an integrated messaging ecosystem to expand mentorship opportunities for Black undergraduate and graduate students in computing through virtual interactions.

8) National Society of Blacks in Computing Conference: this conference provides mentoring and networking opportunities for Black undergraduate and graduate students, faculty, postdoctoral researchers, and research scientists. It is a platform for participants to engage in face-to-face interactions to develop personal and professonal networks, to learn how to identify and develop productive mentoring relationships, and to acquire a productive mentorship that may be lacking from their current environments.

Beyond the signature programs of iAAMCS, efforts to encourage student engagement have also been supported by the organization through scholarships, targeted presentations, and strategies for science communication:

- Travel scholarships: students are sponsored to attend a diverse array of affinity and professional conferences in their discipline to network beyond the confines of their institution.

- The African-American PhDs in Computing Sciences (AAPHDCS) Listserv: a virtual network consisting of more than 490 members. The listserv is a primary source of information sharing for students, faculty, and researchers.

- Modern Figures Podcast: a conversational-style podcast elevating the voices of Black women in computing to inspire the next generation of the advanced technology workforce. The podcast was developed in collaboration with the National Center for Women & Information Technology (NCWIT) and was designed to be understood by everyone, regardless of their experience with computing and technology. Guests from and allies for the Black Women in Computing (BWIC) community are invited to share their stories and perspectives on technical, societal, and personal topics.

- iAAMCS Workshops: these workshops are presented by iAAMCS leadership to target underrepresented students in computing. Topics include methods for successfully applying to graduate schools, how to successfully navigate graduate school, and guidelines for successfully mentoring Black CS PhD students, among others.

- iAAMCS Guidelines: The Guidelines for Successfully Mentoring Black/African-American Computing Sciences PhD Students were released 2018 with the goal to articulate successful strategies for mentoring African-American doctoral students in Computing Sciences (CS).

Along with these efforts, iAAMCS scholarly journal publications and conference proceedings have expanded the literature on Black computing students in the US. Since its inception, iAAMCS has championed new approaches to support Black/African-American students across the country. Yet, while overall doctoral student enrollment in the computing disciplines continues to grow, limited gains have been seen in the recruitment and retention of Black doctoral students on a national scale [3].

II. THE PROBLEM

Black graduate students in computing remain underrepresented in computer science (CS) doctoral programs in the US. Through the interventions provided by iAAMCS, doctoral students are more likely to persist through the completion of their degree program.

III. RESEARCH APPROACH

iAAMCS leadership maintains data from each of its signature programs on the participants reached by the intervention. Researchers from the iAAMCS evaluation team collaborate with these iAAMCS stakeholders to manage the quantitative data collection of participants as well as non-participants. The iAAMCS evaluation team designed the evaluation instruments to capture data that respond to iAAMCS needs and general national questions in computing sciences. Additional data is collected by the evaluation team through a comprehensive research and evaluation plan, which includes participant tracking. The objectives of the iAAMCS research and evaluation plan are as follows:

1) To measure the effect of iAAMCS on increasing the number of students pursuing and completing PhDs in computing science in comparison to control group;

2) To assess the feasibility of iAAMCS as an effective national mentoring intervention for potential and declared African American majors in computing science; and

3) To examine whether the iAAMCS interventions changes attitudes of African Americans toward computing science majors and careers.

This work aims to address, in part, the first and second aims of the iAAMCS research and evaluation plan. For the purposes of this research the information presented focuses on portions of the quantitative data collected, as they relate to graduation and retention rates, and time to degree for computing graduate students who participated in iAAMCS activities. This data is compared to national data from the CRA Taulbee survey on students pursuing doctoral degrees in CS in the U.S.

The CRA Taulbee survey is the leading source for data on enrollment, production, and employment of PhDs in information, CS and computer engineering in North America [3]. Each year, surveys are administered to all academic units that grant doctorates in the disciplines previously mentioned. Analysis of the historical CRA Taulbee data will be presented and discussed in the following sections. However, to compare the iAAMCS and CRA Taulbee data, it is important to note that since the survey is voluntary, some iAAMCS participants were excluded from the analysis as a result of their institution not being represented in CRA Taulbee survey data to provide an accurate comparison.

IV. Data Analysis

Data from 2008-2018 were analyzed from CRA Taulbee surveys. These years were chosen to understand the impact of the funding period (2013-2018) of iAAMCS on graduation and attrition rates of Black/African-American computing doctoral students. Due to the small numbers of participants in iAAMCS, some data was restricted from publication to reduce risk of identifying individuals who participated in iAAMCS activities.

A. Graduation Rates

iAAMCS data presented in this paper include the number of students who participated in any iAAMCS program during their doctoral degree attainment. Year of enrollment, graduation year, and inherently, their time to degree attainment are recorded for each participant. From 2013-2018, there were 42 Black/African-American CS PhD students that participated in iAAMCS activities that ended their PhD program. Of those 42, 36 completed their PhD and 6 left the PhD program. The overall average to degree attainment for iAAMCS participants is 5.5 years, while the median time to degree completion is 5.0 years. According to the 2017 Survey of Earned Doctorates, the median time to degree completion for any doctoral degree is 5.8 years [4]. The authors chose to use a 6-year graduate rate to better compare with CRA Taulbee survey data.

Data was attained from CRA Taulbee surveys from 2008-2018 for US CS departments [3]. Data on newly admitted PhD students, the number of PhD graduates, and the percentage of PhD student enrollment were extracted from relevant tables. For each variable, the data by ethnicity and overall were recorded. Table 1 reports the number of Black/African-American CS PhD graduates from 2013-2018

with the number of iAAMCS PhD students that graduated. Notice that iAAMCS impacted 36% of those graduates during those 5 years.

TABLE I. BLACK DOCTORAL GRADUATES FROM CRA TAULBEE AND IAAMCS

Year	Black CRA Taulbee graduates	iAAMCS graduates	Percent iAAMCS graduates
2013	22	5	23%
2014	17	6	35%
2015	15	10	67%
2016	17	2	12%
2017	10	5	50%
2018	19	8	42%
Total	100	36	36%

The CRA Taulbee survey does not report newly admitted PhD students by ethnicity, so this value was calculated by using the percentage of enrollment by ethnicity, and the total number of students admitted. Thus, the calculated enrollment by ethnicity is an estimate, since there is no accurate measure of this provided in the survey. For example, in 2013 the Taulbee Survey reported 145 Black/African-American PhD students enrolled, which was 1.3% of all the CS PhD students enrolled. The 2013 Taulbee Survey also reported 2,010 students were admitted into CS PhD programs. Therefore, to estimate the number of Black/African-American CS PhD students admitted in 2013, the percentage of Black/African-American CS PhD enrolled was used to calculate the number admitted as follows: 0.013 * 2,010, yielding an estimate of 26 Black/African-American PhD students were admitted. This calculation was selected because overtime, the percentage of Black/African-American CS PhD students enrolled didn't change much over the entire time the CRA Taulbee survey has been reported. The estimated admitted PhD students was then used to calculate a 6-year graduation rate by dividing the students who graduated 6 years in the future, by the estimated admitted students. Similarly, the 6-year graduation rate overall was calculated.

Table 2 shows the 6-year graduation rates by ethnicity of all the data analyzed from the CRA Taulbee survey from 2013-2018. The average rate of graduation over these 6 years was calculated for each category. The Black graduation rates from the CRA Taulbee survey indicate that 50% of the students who entered into PhD programs in CS completed their degree within a 6-year period. This is the lowest rate of all demographics, with nearest demographic of White, and Hispanic students graduating at a rate of 59% and 63% respectively. All other demographics meet or exceed the overall 6-year graduation rate of 76%. Of particular interest is the multi-racial demographic, which is not defined by the Taulbee survey in great detail. These students complete their degrees in twice the time as their ethnic counterparts at a rate of 165%. This is likely due to the low numbers of these students and a longer than 6-year graduation rate where a cluster of them graduated in a single year to significantly increase the calculated graduation rate.

B. Attrition Rates

As iAAMCS tracks all of its participants, data is readily accessible on students who choose to leave their doctoral programs. This is not true of the CRA Taulbee survey data.

TABLE II.   6-YEAR GRADUATE RATES BY ETHNICITY FROM 2013-2018

Year	Inter-national	White	American Indian	Asian	Black	Hawaiian/ Pacific Islander	Multiracial	Hispanic	All CS PhDs
2013	72%	57%	76%	81%	57%	47%	23%	59%	76%
2014	81%	61%	76%	72%	47%	28%	118%	39%	76%
2015	82%	66%	74%	60%	37%	95%	520%	84%	74%
2016	84%	63%	81%	68%	52%	246%	33%	53%	81%
2017	69%	47%	72%	107%	31%	46%	62%	69%	72%
2018	74%	61%	76%	68%	73%	0%	236%	73%	76%
Average:	77%	59%	76%	76%	50%	77%	165%	63%	76%

In order to calculate the loss of students, the graduation rate was subtracted from 1.0. For example, in 2013, the 6-year graduation rate for Black/African-American PhD students was 57%; therefore, the attrition rate was calculated as 1.0 - 0.57, yielding 0.43, or 43%. The calculated attrition rates from the CRA Taulbee Survey are in Table 3. As previously noted, iAAMCS had 42 Black/African-American CS PhD students complete their PhD program or leave the PhD program. Overall, there 36 out of the 42 that completed their PhD. This yields an 86% graduation rate or 14% attrition rate. From Table 3, the average is attrition rate is 50% for all Black/African-American CS PhD students versus the 14% for iAAMCS. In other words, iAAMCS participants have an 86% graduation rate versus a 50% graduation rate for all Black/African-American CS PhD students. Note that the overall graduation rate includes the iAAMCS graduates.

TABLE III.   BLACK DOCTORAL ATTRITION RATES FROM CRA TAULBEE

Year	Attrition Rate
2013	43%
2014	53%
2015	63%
2016	48%
2017	69%
2018	27%
Average:	50%

V. CONCLUSION

iAAMCS has established a national ecosystem of activities that fosters community and shares information through mentoring. The quantitative data presented here suggest that iAAMCS is having an impact on Black/African-American CS PhD students versus those that are not connected to iAAMCS. And according to this analysis, iAAMCS has reached 36% of the Black/African-American doctoral CS graduates from CRA Taulbee survey institutions. It is our hypothesis that isolation, lack of community and lack of strategies regarding the PhD program, career options, etc. are significant factors in the attrition of Black/African-American CS PhD students. The results of this may be manifested in the difference in attrition rates for iAAMCS participants (14%) versus the attrition rates of Black/African-American students from the CRA Taulbee survey institutions (50%). In moving forward, qualitative analysis will be conducted to explore this hypothesis.

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