DIFFERENTIAL GENDER EFFECTS OF A STEM-BASED INTERVENTION: AN EXAMINATION OF THE AFRICAN AMERICAN RESEARCHERS IN COMPUTING SCIENCES PROGRAM☆

Jerlando F. L. Jackson, Juan E. Gilbert, LaVar J. Charleston and Kinnis Gosha

Although science, technology, engineering, and mathematics (STEM)-related jobs are a growing sector of the United States economy, the nation faces a severe shortage in computer scientists, specifically those that are U.S.-born [Beyer, Rynes, Perrault, Hay, & Haller, 2003; National Science Foundation (NSF), 2009]. This shortage of skilled workers in STEM is one

☆This material is based in part on work supported by the National Science Foundation under Grant Numbers CNS-0540492 and CNS-0837675. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Black American Males in Higher Education: Research, Programs and Academe
Diversity in Higher Education, Volume 7, 317–330

ISSN: 1479-3644/doi:10.1108/S1479-3644(2009)0000007018

that the United States has not seen since the mid-1950s (ACT, 2006; Jackson, Charleston, George, & Gilbert, 2009). Nonetheless, the U.S. Department of Labor projected that from 2000 to 2010, approximately 1.6 million additional workers with degrees in computing sciences will be needed to fulfill workforce demands (Beyer et al., 2003; Hecker, 2001). Although the field of computing sciences has moved to the forefront of this information age, economic and societal ills have played a significant role in the lack of participation among racial and ethnic minorities, preventing many African Americans from productively contributing to the field (Carver, 1994; Gilbert, Jackson, George, Charleston, & Daniels, 2007).

College and university officials have identified sub par teacher quality and poor high school preparation as factors that discourage the overall pursuit and majoring in STEM fields with an effect of further perpetuating decreased participation in computing sciences among African Americans (Gilbert et al., 2007). However, with the promulgation of technology within the national and global economy, and the increasing need for individuals to fill technology-based positions in the workforce, adequate preparation in computing sciences and related disciplines is increasingly becoming a necessary acquisition for access into today's information-based and knowledge-driven society, and this is particularly true regarding underrepresented groups (Gilbert & Jackson, 2007; Jackson et al., 2009; Moore, 2006; Maton, Hrabowski, & Schmitt, 2000).

The federal government has heavily invested in promoting measures to correct the lack of participation in STEM, especially for underrepresented groups. For example, in 2004, the government allocated $2.8 billion to be used toward 200 programs whose aims were to increase the numbers of students in STEM fields, the number of employees in STEM occupations, and to improve STEM-related education programs (Gilbert et al., 2007). The NSF and the National Institute of Health (NIH) account for the funding of nearly 50% of all such programs. To the extent that African Americans are a significant part of the composition of underrepresented groups that have been historically and consistently underrepresented in computing sciences, these populations promise to provide an untapped pool of applicants for current and future computing science-related positions within the U.S. workforce.

The compilation of studies about participation and STEM-related disciplines throughout the last three to four decades has illuminated differences among males and females regarding participation, perception, and attitudes as it relates to STEM fields (Jones, Howe, & Rua, 2000). Although women now outnumber men with regard to college enrollment, and minority students are enrolling in record numbers at the postsecondary level (Beyer et al., 2003), the differences relative to perception and attitude about STEM fields among African American males and females are factors that should be evaluated and addressed when attempting to provide an intervention to foster increased participation. Likewise, data collection within and among intervention recipients may serve to provide additional insight into the necessary features an intervention program should encompass in order to promote optimal results for the targeted population. That said, this chapter examines results from a study of the African-American Researchers in Computing Sciences (AARCS) program in an effort to explore differences regarding the effect of the intervention by gender; namely, whether the effect of the AARCS program differed for male and female participants.

THE COMPUTING LANDSCAPE IN HIGHER EDUCATION

The Computing Research Association (CRA) was formed in 1972 as the Computer Science Board (CSB), which provided a forum for the chairs of Ph.D.-granting computer science departments to discuss issues and share information (CRA, 2009). Since 1989, women have never accounted for more than 24% of the computer science faculty at any given rank (e.g., assistant, associate, or full professor). Currently, women represent 21.7%, 15.4%, and 11.7% of computer science faculty at the assistant, associate, and full professor ranks, respectively. Women have been as much as 24% of the Ph.D. graduates in computing in a single year. Since 1998, African Americans have never accounted for more than 2.0%, 1.4%, and 0.7% of the assistant, associate, and full professors, respectively, in computer science. Furthermore, African Americans have never accounted for more than 2% of the Ph.D. graduates in computer science in a single year over that same time period. It appears women and African Americans overall are under-represented among the ranks of computer science faculty, but to what extent?

According to the 2008 U.S. Census Bureau, women represent 51% of the U.S. population and African Americans represent 12.9%, with African American women and men at 6.7% and 6.2%, respectively, of the U.S. population (U.S. Census Bureau, 2008a). When the CRA Taulbee Survey figures are compared to the U.S. Census Bureau's data, the extent by which women and African Americans are underrepresented in computer science faculty positions becomes clear with significant gaps at all levels. It should be noted that the CRA Taulbee Survey does not report data aggregated by gender and ethnicity; therefore, there are no statistics on African American males or females separated by gender for computer science faculty by rank. However, the NSF's Science and Engineering Doctorate Awards data (NSF, 2009) show that African Americans accounted for 664, or 4.3%, of all science and engineering Ph.D. degrees awarded to U.S. citizens in 2006. Of the 664 science and engineering degrees awarded to African Americans in 2006, African American females and males accounted for 61.4% and 38.6% of those Ph.D. degrees, respectively. African American females accounted for 4, or 0.28%, of the Ph.D. degrees awarded in computer science, with African American males accounting for 10, or 0.69%. These data show that African American females account for the majority of science and engineering Ph.D. degrees versus African American males; however, African American males obtained twice as many Ph.D. degrees in computer science. In spite of the fact that African American males outnumber their female counterparts in computer science, the total number is so small that it is essentially negligible, thus the deficient numbers for both groups are obvious.

In an effort to broaden participation in computing to address these gaps in representation, the NSF created the Broadening Participation in Computing (BPC) program in 2005. The BPC program was designed to increase the number of U.S. citizens and permanent residents from traditionally underrepresented groups in computing at the levels of undergraduate, graduate, and professional (e.g., academic, research, or corporate) (BPC, 2009). However, the BPC program allows for projects that target middle school as well. The underrepresented groups by this definition are women, persons with disabilities, African Americans, Hispanics, American Indians, Alaska Natives, Native Hawaiians, and Pacific Islanders (http://www.nsf.gov/funding/pgm_summ.jsp?pims_id = 13510&org = NSF& from = fund). The BPC program is still very young, but the positive numbers that have been observed in the CRA Taulbee Survey are likely connected with the BPC program. Unfortunately, very few research and evaluation results have been reported on programs or interventions that target African Americans in computer science. Furthermore, very little work has been reported on interventions that benefit women over men in computer science programs at any level. After a thorough review of the literature, no research studies were found that examined the underrepresentation of African Americans in computer science faculty positions as a group or separated by gender.

AARCS PROGRAM DESCRIPTION

The AARCS program consists of three components: (a) targeted presentations, (c) future faculty/researcher mentoring, and (c) an annual AARCS mini-conference. This chapter only focuses on the effect of the targeted presentations component.

Targeted Presentations

The targeted presentations component requires at least one faculty member and one graduate student to travel to a historically Black college or university (HBCU) to give a presentation discussing graduate school, computing sciences research, academic faculty, research scientist, and corporate research employment. These presentations have been designed to address seven identified barriers to the participation of African Americans in computing sciences. The faculty member and the graduate student co-present this information. The content of the targeted presentation can be described as follows with respect to the seven barriers:

1. *Stereotypes:* The negative stereotypes that students typically have of scientists are immediately broken down when the faculty and the graduate students walk into the room. None of those stereotypes fit the presenters. In the presentation, the stereotypes are pointed out and immediately discarded.
2. *Role models:* The presentation explains the importance of role models. At the same time, the presentation reveals the low numbers of African Americans in computing sciences. This approach is taken to help the students realize the slim chances of finding African American role models within computing sciences. However, through AARCS, the students enter a network of African Americans in computing sciences.
3. *Helping professions:* Within the presentation, several links are made to illustrate how computing sciences can be used to "give back" and help others. Specifically, the presentation presents research areas (e.g., artificial intelligence, advanced learning technologies, and human-centered computing) as vehicles that can be used to give back. For example, software developed by the presenters is described in the presentation. This serves as an example of how computing can be used to help others. The presentation itself serves as an example of how the presenters are giving back.

4. *Financial concerns:* The presentation covers graduate school funding opportunities. An explanation of graduate teaching assistantships, research assistantships, and fellowships is provided. Specifically, fellowship opportunities for African Americans are discussed.
5. *Inadequate advisement:* The targeted presentation and the AARCS program at-large are vehicles of proper advisement.
6. *Lack of knowledge regarding the advantages of having a Ph.D.:* The presentation presents several advantages of obtaining a Ph.D. in computing sciences (e.g., tenure and the ability to work on problems you want to address).
7. *Employment opportunities:* Employment opportunities are addressed by providing facts about computing sciences. The presentation addresses outsourcing concerns, corporate employment options, government research opportunities (e.g., NSF and DARPA), faculty employment options, and research scientist options.

The presenters have Ph.D. degrees in computing sciences; therefore, they seek to build confidence in students by serving as living examples of African Americans that obtained the Ph.D. in computing sciences and have successfully obtained tenure track appointments. At least one African American graduate student attends the targeted presentation. The graduate student also seeks to build confidence in the undergraduates by serving as a living example of an individual not far removed from the current status of the undergraduates.

Currently, there are 194 African Americans in computing sciences doctoral programs (CRA, 2009). These data are reported from 151 computer science Ph.D. programs. This is an average yield of less than two African American Ph.D. students per department. The targeted presentation aims to increase that ratio.

METHOD

Student Sample

The student sample consisted of 232 students who attended an AARCS targeted presentation at an HBCU between 2006 and 2009. The participants consisted of 55.5% male and 45.5% female as well as 95.7% African American/Black, 0.4% Hispanic, 1.7% Asian/Pacific Islander, 1.7% White, and 0.4% American Indian/Alaskan Native. The majority of the participants were from low-income, single heads of households and

middle-income households (both single and dual). Approximately 60% of the participants were involved in extracurricular activities emphasizing computing sciences or undergraduate research programs. Likewise, by all measures those participants had a very high level of contact with faculty.

Data Analysis

Means and standard deviations were reported, by pre- and post-test scores, for each of the following AARCS program outcomes: (a) graduate school interest, (b) interest in applying for graduate school within five years, (c) negative views of computer scientist, (d) apprehensions regarding graduate school, and (e) interest in becoming a computer science professor/researcher. The difference between the pre- and post-test means (i.e., mean difference) was also reported for each outcome. Notably, all statistical differences were reported at the $p < .001$ level. Effect size estimates were reported to provide a sense of the practical significance[1] of any observed mean differences.

FINDINGS AND DISCUSSION

Table 1 shows that pre- and post-test responses differ for male and female participants at HBCUs with regard to the AARCS program outcomes. Male participants showed a medium effect size for a positive change in attitude regarding graduate school interest, whereas female participants showed a small effect size. Female participants began and finished with a higher interest in graduate school, while male participants realized a larger gain from the AARCS program. Male and female participants recorded a large effect size for a positive change in interest in applying for graduate school within five years.

Female participants began with a higher interest in applying to graduate school, and realized a similar gain as male participants, although slightly higher. Male participants showed a huge effect size for change in negative views of computer scientist for the better. However, female participants showed a very large effect size for change in negative views of computer scientist for the better as well. Female participants began with a higher level of negative views about computer science, but realized comparable gains to the males, although slightly lower.

Table 1. Means, Standard Deviations, Mean Differences, and Effect Sizes of Program Outcomes for the African American Researchers in Computing Sciences Intervention (HBCUs).

AARCS Program Outcomes	Males (N = 127)						Females (N = 102)					
	Mean		Standard deviation		Mean difference	Effect size	Mean		Standard deviation		Mean difference	Effect size
	Pre-test	Post-test	Pre-test	Post-test			Pre-test	Post-test	Pre-test	Post-test		
Graduate school interest	3.36	4.11	1.44	1.10	−.75*	.59	3.50	4.02	1.44	1.21	−.52*	.39
Interest in applying to graduate school in > 5	3.36	4.34	1.44	.96	−.98*	.81	3.650	4.56	1.44	.85	−1.06*	.90
Negative views of computer science professor/researcher	.10	.60	.30	.47	−.57*	1.46	.16	.74	.37	.44	−.58*	1.43
Apprehensions regarding graduate school	.55	.90	.50	.30	−.35*	.84	.60	.85	.49	.37	−.25*	.57
Interest in becoming a computer scientist	.55	.61	.50	.49	−.06	.13	.60	.43	.49	.50	.17	.34

*$p < .001$.

Male participants showed a large effect size for a positive change in attitude regarding apprehensions about graduate school, whereas female participants showed a medium effect size. The topics discussed in the targeted presentations facilitated a larger reduction for males in apprehension regarding graduate school than for female participants. Male participants showed a negligible effect size for change in attitude regarding interest in becoming a computer science professor/researcher, whereas female participants showed a small effect size. Although the effect of the AARCS program on interest in becoming a computer science professor/researcher was minimal, the effect was larger for female participants.

CONCLUSION AND IMPLICATIONS

The results from our analysis strongly suggest differential effects of the AARCS program by gender. Although it is clear that both male and female participants benefit greatly from the AARCS program, males seem to experience slightly enhanced benefits. To be sure, male participants appear to have larger gains regarding change in attitudes with respect to the five AARCS program outcomes. The results of our analysis revealed several key areas that should be more specifically addressed when contemplating and organizing an intervention program. First, the differential effect by gender on graduate school interests suggests a need to target African American males with programs such as AARCS. According to the 2008 U.S. Census (U.S. Census Bureau, 2008b), African American females accounted for 55% of the master's, professional, and doctoral degrees awarded to African Americans. Furthermore, females accounted for 61.4% of all the science and engineering degrees awarded to African Americans in 2006 (NSF, 2009). This may explain why female participants began and finished with a higher interest in graduate school. African American females are already realizing graduate education at higher rates than their male counterparts; therefore, as recorded, their interests are already higher than the males'. Programs like AARCS can be specifically designed to target African American males in an effort to remedy this effect.

Second, the differential effect by gender regarding graduate school apprehension is likely a signal that African American males lack exposure and information regarding graduate school requirements and expectations. African American males appear to be more apprehensive and less informed about graduate school and related fields in the computing sciences. As a result, the number of African American males pursuing graduate degrees in science and engineering are lower due to apprehension and other factors that are not equally shared by females. In an effort to address this lack of information and apprehension, the AARCS targeted presentation addresses common miscues about graduate school. For example, the targeted presentation addresses the fact that, overwhelmingly, first-generation college students do not have mentors within the family to tell them about college, let alone graduate school. Therefore, when those students do attend graduate school, they establish a perception of graduate school based on their undergraduate experience. In the AARCS presentation, the differences between graduate and undergraduate school are clearly distinguished. This may explain the differential effect by gender regarding graduate school apprehension for the males that are most likely less informed versus the females.

Third, the low effect in general, and differential effect by gender regarding interest in becoming a computer science professor/researcher may be identifying that participants find the master's degree more appealing than the Ph.D. degree. Therefore, such an interest would privilege a career in industry, opposed to a research or academic focused career. The AARCS targeted presentation discusses employment compensation by degree (e.g., B.S., M.S., Ph.D.) and the amount of time spent in school earning the corresponding degree. For example, it is thoroughly explained that salary differences between a computer science graduate with a bachelor's, master's and a Ph.D. degree will increase by $11,000 from the bachelor's to the master's degree and by $15,000–20,000 from the master's degree to Ph.D. degree. This explanation also includes the fact that a master's degree will take approximately two additional years of study beyond the bachelor's degree, and the Ph.D. will take approximately five years beyond the bachelor's degree. The presentation also discusses the fact that if the student was to accept a job with a bachelor's degree, it is highly unlikely they would increase their annual salary by $11,000 within two years. Conversely, they would likely receive a cost of living increase, which would be significantly less than $11,000 over two years. Given this information, the students would presumably see a cost benefit in the short term for the master's degree over the Ph.D. with respect to workload, salary, and time to earning a salary. Concurrently, we must also consider that a one time intervention may be more successful with altering attitudes about graduate school and less effective with regard to changing attitudes about career options. In turn, it appears that more engagement is necessary to alter career choice decisions in an upward direction.

Fourth, males and females demonstrate comparable program benefits regarding applying to graduate school and change in negative views of computer scientists. This is likely due to the design and content of the targeted presentations. The majority of the targeted presentation focuses on addressing the identified barriers that deter African Americans from pursing advanced degrees, as well as careers in computer science. Additionally, the presentation gives a detailed description of the differences between graduate and undergraduate school. The expressed differences between graduate and undergraduate schools likely present graduate school in a light that is more attainable to those students who do not have any concept of what graduate school involves. These two program outcomes are reflective of AARCS's aims to address these barriers and the differences between graduate and undergraduate schools.

The differential effects by gender within this study provide a unique lens in which to view intervention programs. It indicates the necessity of tailoring programs like AARCS not only to a racially demographic group, but also by gender. The data expose the varying needs of African American males and females, which in turn expose the necessity of additional features that should be included in an effort to provide the optimal outcomes for both African American males and females. Although the AARCS program indeed produces positive outcomes within its targeted population, fine tuning the program to address the needs of African Americans by gender has the propensity to foster even greater gains.

Implications for Program Design to Eliminate Differential Gender Effects

Program design recommendations that aim to achieve equitable benefits with respect to gender include ensuring the presentation (a) has gender neutral language, (b) contrasts the gender of the presenter versus the graduate student attendee, and (c) establishes a common experience baseline. Computer science is filled with acronyms and other male dominated jargon. It is important to adjust the language to be more inclusive of females and males that do not possess a working knowledge of computer science jargon. This facilitates better communication between the program managers and the students, as students may shutdown if they do not understand the terms. Additionally, students may not ask for clarification for fear of being labeled as an outsider or a slacker. Breaking down the stereotypes of computer science as an Asian or White male dominated discipline is critical. One mechanism to achieve this goal quickly is to visually contrast the presenter and the graduate student attendee with respect to gender. If the presenter is an African American male, then the graduate student should be a female and vice versa. This provides the students with a tangible example of who they could be someday. Lastly, it is essential that a baseline rooted on common experiences is established. If the targeted group is African Americans from HBCUs, the program should begin with shared experiences among members from this group. Making a connection to common experiences shared by males and females at HBCUs is an indispensable measure in the effort to address differential gender effects.

Implications for Future Research

There is a great deal of knowledge yet to be uncovered with regard to differential gender effects as it relates to intervention programs. Although there are some targeted programs that are gender specific, there are numerous programs that broadly target minority populations without respect to gender. The findings in this study illuminate the necessity of evaluating current as well as future intervention programs that aim to increase participation among underrepresented populations for differential gender effects. As this particular study demonstrates, differences between males and females have the propensity to cause variation with regard to program outcomes to a greater or lesser degree based on gender. It is necessary for researchers to take these differences into consideration, not only when evaluating programs, but also when working to develop new programs and initiatives.

As the United States and key entities therein (e.g., NSF and NIH) continue to financially support programs to increase participation in STEM-related disciplines, researchers, grant writers, and program developers and facilitators must pay close attention to the varying needs of males and females in an effort to maximize the reach of federal dollars. Addressing differential gender effects has the potential to increase the number of males and females within the STEM workforce by enabling us to address their needs in more specific ways, thereby enhancing the effectiveness of current and future intervention programs. Additionally, future research should include an assessment of gender-based constructs within the scope of the program that enhance or impede participation by gender, wherein the results thereof can be used to supplement current and future intervention programs. If the goals of

our programs are really to diversify and broaden representation, a more expansive approach that includes gender analysis may prove to expedite the goal of increased participation rates among the underserved.

NOTE

1. For this study, the following scale was used for the relative size of Cohen's *d*: negligible effect, ≥ -0.15 and $< .15$; small effect, $\geq .15$ and $< .40$; medium effect, $> .40$ and $< .75$; large effect, $> .75$ and < 1.10; very large effect, > 1.10 and < 1.45; and huge effect, > 1.45.

REFERENCES

ACT. (2006). Developing the stem education pipeline. Available at http://www.act.org/research/policymakers/pdf/ACT_STEM_PolicyRpt.pdf. Retrieved on December 1, 2008.

Beyer, S., Rynes, K., Perrault, J., Hay, K., & Haller, S. (2003). Gender differences in computer science students. In: *Proceedings of the 34th SIGCSE technical symposium on computer science education* (pp. 49–53).

Carver, B. A. (1994). Defining the context of early computer learning for African American males in urban elementary schools. *The Journal of Negro Education, 63*(4), 532–545.

Computing Research Association (CRA). (2009). *CRA Taulbee Survey* [Online]. Available at http://www.cra.org/statistics/

Gilbert, J. E., & Jackson, J. F. L. (2007). Introduction and state of the stem world. In: J. E. Gilbert & J. F. L. Jackson (Eds), *M7 stem white paper: Final report* (pp. 7–13). Milwaukee, WI: Marquette University.

Gilbert, J. E., Jackson, J. F. L., George, P. L., Charleston, L. J., & Daniels, B. D. (2007). SWOT analysis of stem education: A study of the M7 region. In: J. E. Gilbert & J. F. L. Jackson (Eds), *M7 white paper: Final report* (pp. 38–66). Milwaukee, WI: Marquette University.

Hecker, D. E. (2001). Occupational employment projections to 2010. *Monthly Labor Review, 124*, 57.

Jackson, J. F. L., Charleston, L. J., George, P. L., & Gilbert, J. E. (2009). Factors that attract African American males to computer science: A study of aspiring and current professionals. Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Jones, M. G., Howe, A., & Rua, M. J. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. *Science Education, 84*(2), 180–192.

Maton, K. I., Hrabowski, F. A., & Schmitt, C. L. (2000). African American college students excelling in the sciences: College and postcollege outcomes in the Meyerhoff Scholars Program. *Journal of Research in Science Teaching, 37*(7), 629–654.

Moore, J. L. (2006). A qualitative investigation of African American males' career trajectory in engineering: Implications for teachers, school counselors, and parents. *Teachers College Record, 108*(2), 246–266.

National Science Foundation. (2009). Division of science resource statistics (SRS). In: *Science and engineering doctorate awards: 2006*. NSF 09-311. Arlington, VA: National Science Foundation.

National Science Foundation Broadening Participation in Computing (BPC). (2009). *Broadening participation in computing (BPC): 2009 (Solicitation No. NSF 09534)*. Arlington, VA: Author.

U.S. Census Bureau. (2008a). Annual estimates of the resident population by sex, race, and Hispanic origin for the United States: April 1, 2000 to July 1, 2008. Available at http://www.census.gov/popest/national/asrh/NC-EST2008-srh.html. Retrieved on June 5, 2009.

U.S. Census Bureau. (2008b). Educational attainment of the population 18 years and over, by age, sex, race, and Hispanic origin: 2008. Available at http://www.census.gov/population/www/socdemo/education/cps2008.html. Retrieved on June 10, 2009.

IN PURSUIT OF AFRICAN AMERICAN MALES AS SCHOLARS: PRESCRIPTIVE VIEWPOINTS

Roger L. Pulliam and Richard C. McGregory Jr.

INTRODUCTION

There are a sufficient number of African American males in higher education that could shape the foundation of scholarship which addresses African American society (Cook & Cordova, 2007). This foundation could be further strengthened through the reliance on African American faculty members. Whether they arrive as athletes, TRIO or multicultural program participants, or the sons and daughters of alumni, the key factor is forging a common understanding. The models and proposals that the authors are addressing have implications for broadening the pool of African American males to include those who are untapped and neglected through the educational process. This is consistent with the historical comments of educators, sociologists, and historians such as William Julius Wilson, who challenged the American educational system to become more inclusive and not reliant on the system to be perpetual, expecting the growth and productivity of African Americans to evolve solely from those who have prominent roles in society.

Beyond discussions, this chapter includes new insights into approaches that could accelerate the development and growth of African American

Black American Males in Higher Education: Research, Programs and Academe
Diversity in Higher Education, Volume 7, 331–355

ISSN: 1479-3644/doi:10.1108/S1479-3644(2009)0000007019