Women of Color in IT: Degree Trends and Policy Implications

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During the last century, the economic base of the United States has undergone two major shifts. The first was from agriculture to manufacturing of durable goods. The second was from the manufacturing of durable goods to the creation, organization, analysis, and dissemination of information. Naisbitt [18] calls this new era the information age because information technology drives the economy worldwide. Therefore, in order for a nation to have a competitive advantage in the world economy, it must develop the strongest and deepest talent pool from which to select workers in the information technology workforce.

Historically, the indigenous talent pool from which the U.S. recruited its science and engineering (S&E) workforce consisted largely of European American males. However, during the 1980s and 1990s, the promise of lucrative careers in law and business, attracted many of these males to these fields and away from S&E fields. The U.S. met its needs for additional S&E talent and workers by importing them from abroad. For a while, this did not appear to be problematic to some insofar as the best and brightest talent came to graduate schools in the U.S. for advanced training in science and engineering. Moreover, after graduation, many chose to stay in the U.S. It was, however, problematic to others who espoused the need to identify and develop indigenous talent for the S&E workforce. It is no longer as common for those educated in the U.S. to stay. This is due to several factors, such as increased opportunity in a foreign student's homeland, or competition for his or her talent from other enti-

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ties such as the European Union. Another issue is, as part of the aftermath of September 11, 2001, more people became concerned about security issues concerning S&E workers.

Establishing A Common Universe Of Discourse

Defining Terms

For the purposes of this article, the term African American will be used to refer to people of African ancestry born and raised in the United States. The term Hispanic will be used to denote Mexican Americans and Puerto Ricans. The U.S. Census Bureau uses the term "Hispanic" to refer to people who identify their origin on the census form as Mexican, Puerto Rican, Cuban, Central or South American, or some other Hispanic origin.

There is no consensus on a definition of information technology or information technology workers. This paper adopts Freeman and Aspray's [9] definition, which includes computer hardware and software, peripheral devices, and:

"the full gamut of technological considerations ranging from the design and production of chips…through the design and creation of complex, computer-based systems for a particular application….through the end use of such systems…" [9, p. 25].

Just as there is no consensus on the definition of information technology, there is no consensus on the definition of information technology workers. The broad definition of information technology means that there may be as many as 20 academic specialties that study some aspect of information technology and its use [9, p. 28]. The operational definition of information technology workers used in this article uses three of the nine disciplines identified by a National Research Council study panel [22]: computer science, computer engineering, and information systems. These fields are used as a "proxy" for information technology because the largest numbers of IT workers are trained in these fields.

Data Notes

Data on the science and engineering workforce must be disaggregated to reveal significant differences between and among groups within a category. Within the context of examining who does science and engineering, it is crucially important to make certain that the term "black" includes only indigenous blacks and excludes those people of African ancestry born and raised outside the United States, so that the numbers are not inflated.[1] Also, it is important to disaggregate data on Hispanics by origin because Mexican Americans are different from Puerto Ricans, who are different from Cubans. These differences include: historical background, geographic distribution, and family and work patterns. Moreover, experiences — especially those concerning education and the workforce — are different for Puerto Ricans born and raised on the island of Puerto Rico than for those raised primarily on the U.S. mainland.[2] Experiences vary — depending on the wave of migration — for Cuban Americans. In sum, Hispanics consist of diverse groups across which many generalizations cannot be applied. Recently the National Science Foundation (NSF) started to disaggregate some of its data on Hispanics into the categories Mexican American and Puerto Rican.

Most important, for the purposes of this article, it is important to disaggregate data by both race/ethnicity and gender. All too often, data are disaggregated by race/ethnicity OR gender — seldom by both. As the subsequent discussion will show, there are significant gender differences within race/ethnic groups that must be considered in order to make policy that effectively addresses those differences.

Demographic Overview

Between 2002 and 2050 Hispanics will represent the largest share of U.S. population growth, and the African American population will almost double. Indeed by 2003, Hispanic Americans comprised a slightly larger proportion of the U.S. population than did African Americans. To reveal significant differences, the Hispanic population should be disaggregated into its constituent groups. Hispanics of Mexican origin constitute 66 percent of the Hispanic population. Hispanics of Central and South American origin are a distant second, comprising 14.5 percent of the total Hispanic population. Puerto Ricans are the third largest subgroup constituting 9 percent; other Hispanics follow with 6.4 percent, followed by Hispanics of Cuban origin with 4 percent [30].

Both African Americans and Hispanics are more than twice as likely as non-Hispanic whites to live in a central city within a metropolitan area (55 percent and 46.4 percent *vs.* 21 percent). This is significant in terms of access to information technology. These concentrations could suggest the need for regionally-based programs to effectively target different racial and ethnic groups. Both the black and Hispanic populations are younger than the non-Hispanic white population. In 2000, 35.7 percent of the Hispanic population and 33 percent of the black population were under age 18, compared with 24 percent of the non-Hispanic white population [29], [30].

[1] In the context of the S&E workforce, it is especially important to distinguish between native-born and non-native-born citizens.

[2] In the discussion below about undergraduate education, disaggregating the data reveals the significant role that the Hispanic-Serving Institutions (HSIs) play in educating Puerto Ricans.

Trends in Degree Production

Undergraduate Education

The fact that both the African American and Hispanic populations are younger than the non-Hispanic White population has important implications. According to some predictions, the traditional college-age population (18-22 years of age) will grow by 16 percent between 2000 and 2015, of which 80 percent will be non-white and almost half will be Hispanic [3]. Despite this, the Educational Testing Services (ETS) projects that "Among minority groups, only Asian youth will be attending college in numbers roughly proportionate to their share of the U.S. college-age populations. African American and Hispanic students will continue to lag behind." [8]. During the last 25 years, at every key measurement point along the educational pipeline leading to a bachelor's degree, females have surpassed males [8], [17].

Recent research indicates that only 20 percent of freshman would have to switch their choice of major to achieve minority/non-minority parity in five fields of study — engineering, education, health care, communications, and business [24]. Seymour [26] contends that women tend to switch degree fields if they are not rewarded by praise from teachers. Women may interpret a lack of encouragement as discouragement, according to studies by Seymour and Hewitt [27] and Leggon [13]. However, the Seymour study [26] identified African American women as an important exception to the tendency toward discouragement. Seymour describes the African American women in her study as "distinctively inner-directed and determined, compared both with most other women and with most Black men" [26, p. 122]. This is consistent with recent findings that African American females have more positive attitudes toward science careers than do African American males and white females [11]. Moreover, Hanson [11] found that African American girls' motivation to pursue a science career is the desire to "give back to their community." This is consistent with research that indicates that college women are more likely to enter fields that they perceive as being "people-oriented." One factor that impedes switching fields is laboratory experience. Among women of color, Clewell and Ginorio [6] found that 87 percent who had participated in single-sex labs planned to continue science studies, while only 57 percent of women in co-ed labs planned to do so. Researchers posit that single-sex labs — like all-women's colleges — provide a supportive and encouraging environment in which women feel more comfortable pursuing science and engineering.

Science and Engineering Bachelor's Degrees

Race/Ethnicity and Gender

In 1998, African American and Hispanic women accounted for 12 percent of the U.S. population, 9 percent of total bachelor's degree recipients, and 9 percent of science and engineering bachelor's degree recipients. By contrast, white women accounted for 37 percent of the U.S. population, 41 percent of total bachelor's degree recipients, and 33 percent of science and engineering bachelor's degree recipients. Like white women, women of color earned relatively higher percentages of the bachelor's degrees in psychology and the social sciences than bachelor's degrees in other fields and a lower percentage of the bachelor's degrees in engineering. Women of color earned 13 percent of the bachelor's degrees in psychology and 11 percent of the bachelor's degrees in the social sciences, but only 3 percent of the bachelor's degrees in engineering in 1998. Although the numbers of S&E bachelor's degrees earned by women of color are far smaller than the numbers of S&E bachelor's degrees earned by white women, the trends over time in total S&E degrees have been roughly the same; i.e., showing steady increases throughout the 1980s and 1990s. Within specific S&E fields, the trends for women of color diverge somewhat from those of White women. In computer science, the number of bachelor's degrees earned by women of color dropped sharply in the 1980s but increased erratically in the 1990s.

In contrast to both white and Asian women, black, Hispanic, and American Indian women earned more than half of the bachelor's degrees in science and engineering awarded to their respective racial/ethnic group in 1998. The gains over time that women of color have made in attaining S&E bachelor's degrees have been more pronounced than the gains among men of color. The numbers of bachelor's degrees earned by black and Hispanic men (as well as American Indian men) in science and engineering increased during the 1990s, but at a lesser rate of increase than was the case for women of color. In contrast, the number of bachelor's degrees awarded to white men dropped in the 1990s. Within S&E fields, the direction of trends in S&E bachelor's degree attainment is similar for women and men of color, although the magnitude of the changes may differ. The gender gaps in earning a bachelor's degree in computer science among whites and Hispanics are large and increasing. However, this gender gap is much smaller among African Americans.

Race/Ethnicity and Institution

Minority-serving institutions (MSIs) consist of: historically black colleges and universities (HBCUs), hispanic-serving institutions (HSIs), and tribal colleges and universities That a significantly greater portion

of African Americans earn their bachelor's degrees in science and engineering in general and computer science in particular from HBCUs is noteworthy in two ways. First, it indicates that HBCUs could work with majority institutions to improve the latter's production of African Americans earning S&E degrees. Second, HBCUs should be rewarded by public and private funders for their continuing achievements in developing S&E talent among African Americans. From 1990 to 1996 approximately 30 percent of all bachelor's degrees in all S&E fields awarded to African Americans were from HBCUs. During this same time period, HBCUs consistently awarded more than 37 percent of bachelor's degrees in computer science awarded to African Americans. For both bachelor's degrees in all S&E fields in general and math/computer science degrees in particular, HSIs award a smaller proportion to Hispanics, than HBCUs award to African Americans. MSIs constitute a larger source of computer science degrees for blacks than for Hispanics.

Top Academic Institutions Awarding Bachelor's Degrees to Women of Color: 1994-1998

It is most noteworthy (for the same reasons mentioned above) that many of the top academic institutions awarding bachelor's degrees to women of color are minority-serving institutions.

Black women. The top five schools producing black female S&E recipients are: Spelman, Howard, Xavier, Florida A&M, and Southern University. Moreover, of these 20 institutions, 13 are in the South. This is consistent with research on the baccalaureate origins of African American women [13]. Of the seven non-HBCUs, three are in the City University of New York (CUNY) system; John Jay College of Criminal Justice, Hunter College, and Hebert H. Lehman College.

Hispanic women. The top 20 academic institutions awarding bachelor's degrees to Hispanic women are mainly in Puerto Rico, Texas, and California. Sixty percent (12) of these 20 institutions are Hispanic-serving institutions (HSIs). These 20 institutions account for 31 percent of the total S&E degrees earned by Hispanic women. Six of the top 20 are in Puerto Rico, and four are in Texas — all part of the University of Texas system (San Antonio, El Paso, Pan American, and Austin). Among the non-HSIs, six are in the University of California (UC) system: UC-Los Angeles, UC-Berkeley, UC-Santa Barbara, UC-Davis, UC-San Diego, and UC-Irvine. Four campuses in the University of Texas are also high producers: Austin, San Antonio, Pan American, and El Paso. Two colleges in the CUNY system are high producers for both Hispanic and African American women: Hunter College and Herbert H. Lehman College.

The University of California at Los Angeles is the only institution in common among the 20 schools for black and Hispanic (as well as native American) S&E bachelor's recipients. Two campuses of the City University of New York (CUNY) system were among the top 20 schools for both Hispanic and black women: Hunter College and Herbert Lehman College.

Examining the types of institutions from which the computer science bachelor's degrees are earned, suggests that whether an African American female attends an HBCU or a non-HBCU is important. Specifically and consistently, at HBCUs more African American females are awarded bachelor's degrees in computer science than is the case for their male counterparts [14]. It is noteworthy that although HBCUs comprise less than 10 percent of colleges and universities in the United States, between 1989 and 1997 they have consistently awarded from 39 percent to 47 percent of the bachelor's degrees in computer science earned by African American females.

What Works—and What Does Not Work—to Recruit and Retain Underrepresented African American and Hispanic Females at the Undergraduate Level

Studies indicate that when female students start studying science and technology at the college level, their career goals are not as well defined as those of their male counterparts. Moreover, research reveals that the first undergraduate year is a significant time when women disproportionately abandon plans to major in science [5], [26, p. 120], [21], and that there is a positive correlation between an increase in women's retention rates and their comfort with and confidence in their technical skills. Research indicates that this is also the case for women undergraduate students in computer science. The more comfortable and confident they are about their technical skills, the more likely they are to continue to major in computer science [15].

Research has identified several strategies that enhance the recruitment and retention of women in undergraduate science courses: opportunity for undergraduates to perform hands-on research [25], mentoring by professors and upper-class students [7], [10], [25], and curricula designed to emphasize the problem-solving applications of science and technology [7]. Faculty can become sensitive to the classroom climate and strive to actively encourage females to pursue courses and careers in information technology.

Hands-on experience. Ideally, students should have laboratory experience during the academic year. However, for those students from undergraduate institutions lacking adequate infrastructure and equipment, summer experiences at other institutions can help to "fill

the void." While one summer experience is better than none, ideally students should have a series of such experiences — at different institutions. This not only provides opportunities to learn techniques on a variety of equipment, it also provides opportunities to experience how science is done in different laboratories and institutional settings. A critical component to getting students to participate in these summer programs is financial. Many students of color may not be able to afford spending their summers attending programs instead of working. Therefore, programs need to pay students a stipend as well as cover living experiences.

Mentoring. Mentoring is critically important for all women, because research indicates that not encouraging women has the same effect as actively discouraging them. Undergraduate students can be mentored by more than one faculty member as well as by graduate students. For summer programs, graduate students mentor undergraduate students in both academic and non-academic areas. Mentoring should be an ongoing aspect of a student's career — from grade school to graduate school and beyond. There are a variety of ways to mentor. Within the past 20 years, a body of literature has developed around mentoring. Whether on a formal or informal basis, mentoring matters — it makes a significant difference in a student's experiences.

Curricula. Another thing that works at the undergraduate level and beyond is having inter-, cross-, or multi-disciplinary courses that "demonstrate the connection of the sciences to other areas of study like the arts and to social, political and health issues" [21, p. 13]. This is certainly the case for computer science. According to a report from the National Council for Research on Women, "young women are drawn into computer technology when it is presented not as a set-aside activity but integrated into a subject area that interests them, whether it is history or language, ecology or economics" [21, p. 15]. A study from the American Association of University Women found that women tend to develop an interest in computer science technology over time. Therefore, first-year courses that serve to weed out students may discourage women from pursuing a career in computer science [1, p. 44].

One thing that works well to recruit African American and Hispanic women (as well as all students) to major in computer science is for institutions to offer introductory courses that give the student an idea of what it is like working in the information technology fields on a daily basis. These courses would also relate computer technology to other fields and illustrate practical applications. This also means courses that begin to socialize students into these fields; such courses include information on how to select and apply to graduate school. One thing that does not work is for institutions to offer courses during the first year that function as gatekeepers insofar as they weed students out.

Some research suggests that it is important for the best professors to teach the introductory courses. Since they are the most experienced, they can play a crucial role in catalyzing and sustaining students' interest in science in general, and a specific field in particular. Indeed, teachers play a vital role in creating and maintaining interest in computer science. Although all students are hurt by problems with teaching and curriculum, such problems hurt women and minorities even more [15, p. 82].

Successfully recruiting women to technological courses is facilitated by both cross-disciplinary "applications and opportunities" [21, p. 13]. One aspect of the curriculum shown to be significant in increasing females' interest in and enthusiasm for computer science classes is female-only computer labs. In this context, women's studies programs and departments, and research and policy centers can play a crucial role in two ways. First, they can create and maintain "safe spaces" for a critical mass of scholars interested in both women's issues and science and technology. Second, they can become the environment that stimulates critical questions—about the "social construction" of scientific and technical knowledge in general, and the foci of various scientific and technological initiatives, in particular.

Non-academic aspects. Increasing the participation of African American and Hispanic women in information technology requires considering the non-academic aspects of their lives. For example, are they at least partially responsible for taking care of children (their own and/or their siblings) and/or elderly relatives. This means that if these women attend enrichment programs where they live, they should be paid transportation costs. Ideally, the program should make or help to make arrangements for child care. Care must be taken so that no program is stigmatized by targeting certain groups. Such stigmas can prevent participation on the part of the groups for whom the program was designed, because they fear the perception that such participation supports the notions that they are "not qualified" and need "special help."

Table I summarizes research findings on what works and what does not work in recruiting and retaining women in undergraduate computer and information sciences.

Recruitment and retention strategies are more effective when they have strong support from the top leadership — not just pay lip service but link these goals to other college/university goals. For example, increasing the number of African American and Hispanic female students in undergraduate

computer science courses and majors can be made a specific criterion in the performance evaluations of teachers, department heads, and program chairs. Recruiting and retaining African American and Hispanic women (and other underrepresented groups) at the student and faculty levels should be an integral part of the university's goals.

Policy Implications

What works to recruit and retain women of color in information technology careers is an example of the "canary-in-the-mine" phenomenon. That is, what works for women of color also works for everyone. Things that improve the educational and work environment for women of color improve it for everyone — for example, mentoring. My discussion of what works at all levels has made this point.

There are two ways to approach issues of recruitment and retention. One is to focus on the individual, and develop and implement interventions to make the individual fit in with the existing system or structure. Another approach is to implement systemic change in the organization or institution. This is not to say that one or another approach must be taken. Quite the contrary! In order to be successful in both the short- and long-term, interventions should target both the individual and the institution. Indeed, increasing the participation of underrepresented groups in S&E fosters a climate conducive to institutional change. However, it is important to emphasize that numbers alone are not enough. More is needed than a so-called "critical mass." What is needed are purposive, deliberate, concerted efforts to bring about change in the institution (and institutional environment) that make it more conducive to the participation of groups that were previously underrepresented.

Whether on the individual or institutional level, in order to bring about change it is crucial to establish and implement mechanisms for accountability. Such mechanisms should clearly and unambiguously specify who is responsible for what, and provide a means for monitoring performance and activity. Accountability should be strictly enforced. As mentioned above, it is important to make recruitment, retention, and advancement of women of color (and other groups) a major part of the evaluation criteria for faculty, administrators and managers.

All too often, funding for a model program (whether it is on the undergraduate level, graduate level, or professional level) ends before its success or failure is fully measured or before strategies are developed for infusing a successful approach into the mainstream [21, p. 26]. At least two things are critically important in terms of extending demonstration or pilot programs. First, they must include a mechanism to become self-sustain-

Table I
What Works/What Does Not Work at the Undergraduate Level to Recruit and Retain Underrepresented Women in Science, Engineering, and Technology (SET) Fields

	What works	What does not work
Introductory courses	Inclusive Have best faculty teach introductory courses	Gatekeeper/weed out
Curriculum	Inter-, cross-, multi-disciplinary combining liberal arts and science majors. Courses giving female students opportunities for hands-on work	
Approach	Women's studies with SET courses; cross-disciplinary courses Better teaching styles for women — e.g., cooperative rather than competitive	Fiercely competitive environment
Pedagogy	Hands-on learning experiences in non-threatening environment Curricula emphasizing problem-solving applications of SET	Not doing science Curricula that excludes problem-solving applications
Faculty	Actively encouraging female students; mentoring; having faculty from underrepresented groups.	Discouraging and/or not encouraging female students

ing after the funding for the pilot program ends. Second, program evaluation must be built in from the beginning. Often, evaluations are thought of as the culmination of programs. This conceptualization refers to summative evaluation. Equally if not more important are formative evaluations. Formative evaluations are conducted throughout the program to ascertain from the various stakeholders (administrators, mentors, faculty, students, etc.) which elements of the program seem to be working and which do not. Formative evaluations provide information that enables program administrators and staff to make real-time corrections.

A substantial body of research has identified factors that facilitate recruitment, retention, and advancement. These factors include supportive mentors, role models, and networks [21]. It is noteworthy that "in all fields and in major technology corporations, women have formed national organizations and networks to support each other develop visible leadership for change and advance an agenda of equity" [21, p. 16]. Moreover, national women's networks have been formed within corporations and academic disciplines. However, NCRW and others have found that more research is required to assess what programmatic factors enhance and sustain females' long-range interest and success in S&E careers.

Research on the degree trends in information technology focuses either on gender OR racial gaps. Since degree trends are different for women of color than for white women, it may be the case that what works for one group will not work for the other. Therefore, policy designed to increase women of color in the information technology workforce should be based on research on women of color. In the absence of such research, policy is often based on research either on men of color or white women. Basing policy for women of color on research on men of color or research on white women results in practices and initiatives that are flawed at best, and ineffective at worst. Therefore, much research needs to be done on women of color — specifically, African Americans and Hispanics.

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