Attracting and Retaining Females in Engineering Technology through Curriculum Reform, Innovative Recruitment Strategies, and Industry-driven Initiatives

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Abstract—The need to attract and retain females in technology-based programs can form the basis of productive partnerships between academia and industry. The South Carolina Advanced Technological Education Center of Excellence (SCATE), with funding from the National Science Foundation, has developed a new, researched based approach that has produced results for engineering technology programs. Concurrently, IBM has stimulated the involvement of girls and women through its Multicultural People in Technology initiatives. Together, SCATE and IBM are applying research-based solutions to meet the challenge and to support one another's efforts. Industry and academic efforts, and the supporting research, will be shared.

A new SCATE-developed curriculum increases student success in first-year gatekeeper courses such as physics and mathematics. This curriculum for entering students, the Engineering Technology Core (ET Core), has proven to meet the needs of diverse learners and retain female students better than traditional approaches. The ET Core, which is available nationally, has been highly rated for its ability to prepare students for the technological workplace.

IBM offers workshops, technology demonstrations, technology camps, and other diversity and school-to-workplace initiatives. IBM employees regularly devote time to supporting these programs, creating a model for other employers to follow. An on-going exchange of ideas and resources between SCATE and IBM is resulting from a shared common vision for supporting equity in the engineering and technology workforce—creating synergy and helping build a bridge to the future for more women in engineering.

SCATE and IBM representatives will share strategies and best practices for creating environments that invite, welcome, encourage, and celebrate females in technology fields. Results from the most effective efforts will be shared. Ways for effective collaboration between academia and industry to address gender equity in engineering and technology will also be addressed.

Introduction

Fruitful partnerships begin in many ways, emerging when people or organizations discover that they share a common mission and values and find ways to work together to the benefit of both. The South Carolina Advanced Technological Education (SCATE) Center of Excellence (with its not-for-profit affiliate, SCATE, Inc.) and IBM's office of Multicultural People in Technology share goals related to increasing access and participation of women in advanced technology professions. SCATE has focused primarily on post-secondary education with an emphasis on increasing the quantity, quality and diversity of graduates from associate degree engineering technology programs in the nation's two-year technical and community colleges. Simultaneously, IBM's office of Multicultural People in Technology has focused on developing initiatives and programs to attract, develop, and retain diverse technical talent.

Improvements in teaching practices, classroom environments, curriculum by SCATE and focused outreach by the two organizations have resulted in positive results and produced replicable models that can be adapted or adopted by other employers and educators. The SCATE-IBM partnership is viewed by both organizations as a way to promote synergy and increase gender equity in technology.

The partnership began when Elaine Craft from SCATE and Donald McCoy from IBM were asked to work together to evaluate a project funded by the National Science Foundation. As gender and diversity issues related to the project were discussed, the common values and goals of SCATE and IBM became apparent. This joint assignment lead to future meetings and on-going collaboration.

IBM Programs: History

From its inception more than a century ago, IBM has considered workforce diversity fundamental to business success. The heritage and commitment to workforce diversity can be traced back to 1899, when the business hired the first women and Black employees. Part of that heritage includes the fact that eight IBM Chairmen have acknowledged the importance of workforce diversity to the business and culture as a cornerstone of values.

In 1935, twenty-eight years before the Equal Pay Act, IBM recruited its first professional women, and founder, Thomas J. Watson, Sr., said, "Men and women will do the same kind of work for equal pay. They will have the same treatment, the same responsibilities and the same opportunity for advancement."

In 1953, IBM CEO Thomas J. Watson, Jr. published to the business the first Equal Opportunity Policy *"It is the policy of this organization to hire people who have the personality, talent and background necessary to fill a given job, regardless of race, color or creed."* The policy was written one year before the U.S. Supreme Court Brown decision ending "separate but equal" in public education, and 11 years before the 1964 Civil Rights Act became law.

In 1995, IBM orchestrated one of the most dramatic changes to workforce diversity when eight diversity executive management task force teams were established and the subject became a marketplace issue about talent and getting the best people for the job.

Launched in 1998, the IBM Women in Technology (WIT) Project Office and the Multicultural People in Technology (MPIT) Project Office that was established the following year were charged by the corporation's executive management to develop initiatives and programs to attract, develop, and retain diverse technical talent. Today, the teams are tightly aligned to maximize outreach efforts and to reach their perspective constituencies and provide specific nurturing and requirements. The teams stands behind a diversity banner of "None of us is as strong as all of us" to help deliver and drive the business forward.

The MPIT and WIT teams are part of a business imperative in the new millennium that is becoming an even more important topic for operations and for the more than three hundred thousand IBM employees worldwide. The issues surrounding diversity mandate that attracting, developing and retaining diverse technical talent must now be addressed on a global scale — from the workplace to the marketplace. IBM has set forth a global strategic framework requirement to help address emerging issues taking shape in the 160 countries in which IBM conducts business.

IBM Activities

The MPIT and WIT focused initiatives start with IBM Executive leadership. Business commitments, processes and measurements help deploy and drive activities. The team scope of work includes K-to-College national outreach programs and events, collegiate technical organizations, technology camps for middle school students, education-industry-diversity advocate partnerships, and IBM internal employee development and retention initiatives to address unique challenges facing technical multicultural people and women. Activities include:

K-to-12 National outreach programs and events (some activities)
- Engineers Week
- Introduce a Girl to Engineers Day
- Sally Ride Festivals
- Take Our Children to Work Day (IBM Locations)
- Technology Student Association Competitions
- Classroom Visits, Career and Science Fairs

College National outreach programs and events
- National conferences (e.g. AISES, NSBE, SHPE, SWE)
- University Campus Career and Job Fairs
- Internships and Co-op assignments (NACME, INROADS)
- Technology Workshops

Collegiate technical organizations (some activities)
- American Indian Science & Engineering Society (AISES)
- National Society of Black Engineer (NSBE)
- Society of Hispanic Professional Engineers (SHPE)
- Society of Women Engineers (SWE)

Technology camps for middle school students (major programs)
- "EXITE" (**EX**ploring **I**nterests in **T**echnology and **E**ngineering) Camps

- One-week day camp for middle school girls to:
  - Enhance their interest in math and science
  - Introduce girls to exciting technical careers
  - Provide girls with female role models
  - offer an environment that nurtures interest in engineering, technology, and computer science
  - Match young women with e-mentors
  - "EXITE" (**EX**ploring **I**nterests in **T**echnology and **E**ngineering) Camps

- "IGNITE" (**IGN**iting **I**nterests in **T**echnology and **E**ngineering) Camps
  - Same as above, but for multicultural middle school boys and girls

Education-Industry-Diversity Advocate Partnerships (some)
- K-College Institutions
- National Black Family Technology Awareness Week (February)
- LaFamilia Technology Week (October)
- Native American Technology Family Journey (November)

IBM Internal employee Development and Retentions initiatives
- Professional development and technical conferences
- Technical Forums, Recognition Progams
- Employee Diversity Network Groups, Diversity Councils
- Mentoring Programs (one-on-one, small and large group sizes)

IBM Impact/Results/Data

The teaming of the MPIT, WIT, IBM Corporate Community Relations, IBM Technical Resources Program Managers IBM Talent Managers, University Relations, Partnerships; and, perhaps most important, thousands of volunteers help drive positive growth and continuous improvement in IBM's K-College outreach activities. While specific internal workforce demographics are not available for sharing, the impact of the corporation's activities to create and sustain a diverse workforce is clearly positive. The magnitude of the IBM outreach effort to develop a diverse technical workforce, however, is reflected in the information below:

2005 K-College Outreach (key events only)
- # Events = 91
- # Reached = 79,000+ (visual minorities and gender)

2005 Engineers Week Results (Feb)
- # IBM Volunteers = 3,800 (1,650 Women; 850 under represented minorities)
- # Students Reached = 186,500 (92,200 Girls; 64,400 represented minorities)

2005 Technology Camps (middle school boys and girls)
- # Camps = 55+
- # Students = 1,750 (worldwide)
- Favorite Camp Activity
  - Forensics

- Lego Robotics
- Team Building
- Building a website
- Cool chemistry/Liquid Nitrogen Ice Cream
- Field trips to museums, manufacturing facilities and labs

SCATE Program: History

Since its inception in 1994, the South Carolina Advanced Technological Education (SCATE) Center of Excellence, a division of Florence-Darlington Technical College, Florence, South Carolina, has been dedicated to developing and disseminating solutions to the nagging problem of too few highly skilled engineering technicians to keep the United States competitive. The persistent demand by industry for many more highly skilled technicians than were available lead to a search for answers. The student demographic data at the on-set of the SCATE initiative were startling: no more than 12% of students enrolling in associate degree engineering technology programs in the state of South Carolina ever graduated, and the ones who graduated were 85% white male. The challenge was evident and the mission clear: increase the quantity, quality, and diversity of engineering technology graduates to support economic development.

Research from the South Carolina Technical College System and elsewhere also showed that the highest attrition rate for students from engineering technology programs occurs in the first year of study. Those who struggle in the second year of study are likely to have avoided or done poorly in key prerequisite courses as freshmen. Addressing the first year of study and preparation of students for success in the first year of study became the focus of SCATE work.

SCATE has been guided by educational research and focused on improving the success of pre-college and first-year college students in the educational pipeline leading to associate degrees in engineering technology and/or college transfer. The research-based SCATE curriculum model successfully integrates the study of physics, English/communications, mathematics and technology for pre-engineering and engineering technology students. With content integration across disciplines and classrooms that model the workplace, learning becomes relevant for students. SCATE has demonstrated successful strategies for increasing the quantity, quality, and diversity of associate degree engineering technology (ET) graduates. SCATE innovations have been integrated into high school and college programs at multiple locations and sustained for more than seven years. Time-to-graduation for ET students has been reduced (Zakhour, 2005), and graduation rates, diversity, and employer satisfaction with graduates have all improved (Bucci & Braza, 2001) as a result of SCATE-stimulated reform.

Florence-Darlington Technical College (FDTC) in Florence-South Carolina has achieved results that are representative of those at other implementation sites. From 1998 baseline data, graduation rates at FDTC have increased from 12% to more than 40%, and African American success rates have increased from 15% to 39%. Females in the program are graduating at a higher rate than males, and the time-to-graduation for an associate degree has been reduced from an average of 3.8 years to 2.2 years. The Engineering Technology (ET) Core curriculum was designed by SCATE to improve the success of first year and diverse learners, and it is achieving the desired goal. In addition, an independent study conducted by Western Michigan University in 2003 ranked the SC ATE ET Core curriculum 4.0 on a 0-4 scale for "its effectiveness in

helping students learn the knowledge and skills and/or practices needed to be successful in the technical workplace."(Appleton & Lawrenz, 2005)

Since September 2002, SCATE has served as an ATE National Resource Center for Engineering Technology Education, broadly sharing expertise, best practices, and successful SCATE models in areas of student recruitment and retention, curriculum, faculty development, industry partnerships, and project improvement and evaluation. As a National Resource Center, SCATE has assisted more than 81 organizations in 26 states. Multi-day, more extensive help has been provided to 50 of the 81 organizations. More than 5,000 engineering technology students in South Carolina high school and technical college locations have benefited from SCATE initiated reforms. The SCATE curriculum or adaptations thereof are in use at Benedict College, Columbia, SC, and in community/technical colleges in Texas, Kentucky, Louisiana, Illinois, California, Missouri, Virginia, and South Carolina. ATE has established a national reputation as a valuable resource for improving technician education.

Most recently, SCATE, Inc. has been formed to broaden SCATE Center services to educators. SCATE, Inc. is a not-for-profit affiliate of the SCATE Center and the Southeastern Institute of Manufacturing and Technology located in Florence, South Carolina. SCATE, Inc. provides educational and professional services, promotes best practices, supports educators, collaborates with private and public entities, and conducts research to affect Systemic Change in Advanced Technological Education (SCATE).

SCATE Gender Equity Activities

SCATE recruitment strategies (SC ATE Center of Excellence, 2000) and innovations in the teaching/learning environment have been designed to encourage more females to choose engineering technology careers. Recruitment strategies that have shown promise of increasing female participation include the following:

- gender-specific advertising,
- events that promote camaraderie among females enrolled in engineering technology,
- outreach initiatives that feature female engineering technology students,
- ET Career Ambassador role models,
- special brochures and bookmarks to appeal to female audiences; and,
- advertisements and articles in gender-specific publications like SHE magazine published in Florence, South Carolina.

One special event that has generated national recognition is the annual ET Ladies Tea Party. The Tea Party activity was started as a way to celebrate National Engineering Week. The event has been publicized in two national publications, *Community College Week* (Finken, 2004), and *National Dropout Prevention Center/Network Newsletter* (Reimer, 2005; Craft, 2005). In addition to promoting camaraderie among women enrolled in engineering technology, the Tea Party activity emphasizes that it is not essential to mimic male behavior in order to be an engineering technician.

The Engineering Technology (ET) Career Ambassador program was initiated in 2003 as a peer recruiting activity. In selecting current engineering technology students as Career Ambassadors, diversity has been emphasized to provide important role models. Each year, one or more

females in the program serve as ET Career Ambassadors. ET Career Ambassadors visit high schools and talk with students and engage in other activities than enable them to talk with peers about their career choice. As role models, Career Ambassadors frequently take samples of their work to show perspective students. Female students in high school are usually amazed at the creativity and design found in engineering technology. For example, one engineering technology student was working in an internship where she designed ornamental wrought iron gates for fine homes and buildings. She shared her CAD drawings while making a presentation to high school mathematics classes. This student always wanted to be an artist, but she did not think she could earn a living that way. Her message was "If you think you want to be an artist, perhaps engineering technology is for you."

The teaching/learning environment has also been changed to increase appeal to female students. The curriculum model that integrates content across disciplines appeals to global learners. The curriculum design makes it easier for instructors to address multiple intelligences and a broad spectrum of learning styles. The problem-based approach is hands-on, and the use of teams in the classroom beginning with the first semester creates learning communities and support structures that have been shown to work well with female learners. Because instructors from the four key disciplines of mathematics, physics, engineering technology, and communications also work together as a teaching team to coordinate learning for students in the curriculum, female engineering technology students have more female instructional support throughout the study of engineering technology that has been traditionally available.

Even the arrangement and décor of classrooms has received attention. Using results from a project in California entitled "Connections Across Cultures: Inviting Multiple Perspectives into Classrooms of Science, Technology, Math, and Engineering," (Pac-Tec, 1996) SCATE classrooms have been rearranged and decorated to model the workplace and increase comfort levels for diverse students. Green plants are placed in all classrooms, artwork on the walls is attractively framed and focuses on themes from the workplace (e.g., teamwork), portraits of females and people of color who have excelled in the fields of science and engineering appear in every classroom. Studio designs with workgroup clusters and tables to encourage and facilitate student team meetings are now standard. The result is a professional look and function that has broad appeal regardless of gender, race, or ethnicity.

IBM and SCATE Collaboration
IBM Multicultural People in Technology Program Manager, Donald L. McCoy, will be serving as a member of the National Visiting Committee for a new four-year SCATE project funded by the National Science Foundation entitled, "SCATE National Resource Center for Expanding Excellence in Technician Education." This project's national outreach will leverage IBM work across the nation. In addition, IBM will be providing the keynote speaker for a SCATE-sponsored national faculty development event. SCATE has partnered with IBM to prepare a presentation for the 2006 WEPAN annual conference. In addition, SCATE is developing several diversity activities that can be jointly sponsored, and the networks of each organization are being expanded by association with the other.

Conclusions and Recommendations

SCATE and IBM agree that "none of us is as strong as all of us." To achieve our ambitious goals, each partner must play a vital role in supporting the work of the other and in expanding the national effort. The challenge of attracting females and others who are underrepresented in the fields of engineering and engineering technology persists:

"Today the United States is the world leader in the global science, technology, engineering, and mathematics (STEM) enterprise, but other countries stand ready to challenge this economic strength. One of the main reasons is a shortage of US workers to fill STEM jobs."(George, Neale, Van Hone, & Malcom, 2001)

"…we've got trouble in manufacturing —trouble filling jobs."(Eisen, 2004)

"America is about to experience the greatest labor shortage in its history. American employers are facing a crisis in finding skilled workers. According to an Associated Press story, Siemens recently received 1,000 applications for 500 new manufacturing jobs, but only 35 had the skills necessary to perform the job."(Zeiss, 2004)

Likewise, much more change is needed throughout academia to effectively support learners and ensure that academic institutions and their faculty work effectively to promote student retention and success:

"The American higher education establishment largely ignores the science that already exists about how people learn best. We continue to substitute the traditional model of education for an informed, professionally based educational process. As a result, millions of people of all incomes and races fail to thrive in our schools, not because they lack the capacity to learn, but because our schools and colleges lack the capacity to educate." (Smith, 2004)

One key solution to the challenge lies in close collaboration between employers, academia, and others who develop research-based solutions that work. Partnerships, however, can not be forced but rather must arise from shared values and goals. Individuals should be pro-active in seeking out opportunities to connect with initiatives and projects that are likely to make a difference, and all organizations should follow IBM's lead in making diversity a core value.
Using successful models developed by others is also recommended. Look for strategies that have data to support claims of success, and engage those who have experience with successful models to provide assist.

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