If We Build It, Will They Come?
Attracting, and Retaining, Under-Represented Groups in Engineering

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Abstract

As the demand for engineers and other technically trained professionals grows in our increasingly technological society, the problem of attracting and retaining members of under-represented groups to these fields is becoming increasingly more critical. To address this issue, many universities, schools, and organizations have put in place programs to encourage under-represented groups to pursue technical careers. This paper will present a sampling of the many different programs and approaches being directed toward this goal, concentrating on those currently being funded through the National Science Foundation's education-related programs, including such programs as "Gender Equity" and "Bridges to Engineering Education." While these programs address many areas of Science, Technology, Engineering, and Mathematics (STEM) education, this paper will concentrate on exemplars of programs which are successfully addressing under-representation of such groups as women, the economically disadvantaged, Native Americans, African Americans, and Hispanics, in these fields. Programs which will be examined include school-based programs at all age levels from elementary school through graduate study; teacher education programs; informal education programs, including summer programs, after-school programs, and museum-based programs; software and website development; and conference and publication related activities. A special discussion will be given to three of the University of Tennessee at Chattanooga's relevant programs:

- Adventures in Computers, Engineering, and Space (ACES), to encourage middle school girls to consider careers in these fields, and to continue their education in science and mathematics;

- Upward Bound Promoting Resolve In Science and Math (PRISM), a program funded by the U.S. Department of Education to help students from low income families develop both interest and potential in these fields; and

- Bridges to Engineering Science: Teaching Teachers (BESTT), a new grant to develop a program to widen the pipeline to engineering by inserting appropriate engineering science-related content into K-12.

Each of the programs discussed can serve as a model for other communities concerned with under-representation of women, ethnic groups, and socioeconomic sectors in technical careers.

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The Problem of Under-Representation

"Under-representation" is defined in the literature as a group having a percentage representation in a given field significantly inconsistent with its percentage occurrence in the population. That women and minorities such as Hispanics, Blacks, and Native Americans continue to be under-represented in the fields of engineering and computer science can be clearly seen by an examination of the population demographics and degree breakdowns by race and gender in *Women, Minorities, and Persons with Disabilities in Science and Engineering*.[1] Women in 1997 comprised 51% of the general population of citizens and permanent residents in the United States, and, as illustrated in Figure 1, 49.3% of the population in the age range 20-29. Statistics show the percentage of bachelor's degrees awarded to women of those awarded in 1996 to citizens and permanent residents was 55.2%, and degrees in "Sciences and Engineering" at 47.1%. However, the government's definition of "Sciences" includes such areas as Sociology,

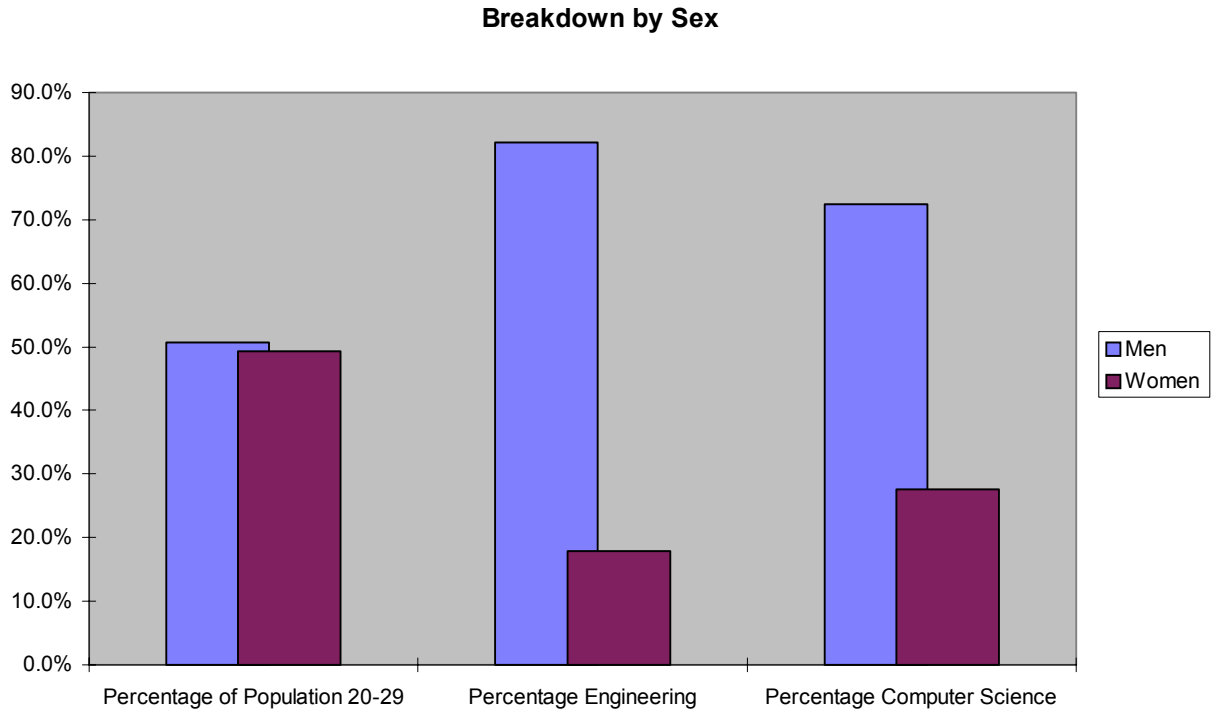

Figure 1. Breakdown of demographics and bachelor's degrees awarded by sex[1]

Anthropology, Linguistics, Ethnic Studies, and Psychology, in which women receive the majority of degrees granted. A closer examination shows that in the same year, women received only 17.9% of the bachelor's degrees granted in engineering fields and 27.6% of those in computer science. (1997 population information and 1996 degree information was used, as this was the most recent, and most time consistent, information available).

An examination of the population and degree statistics for Blacks, Hispanics, and Native Americans from the same source (illustrated in Figure 2) shows even more striking under-

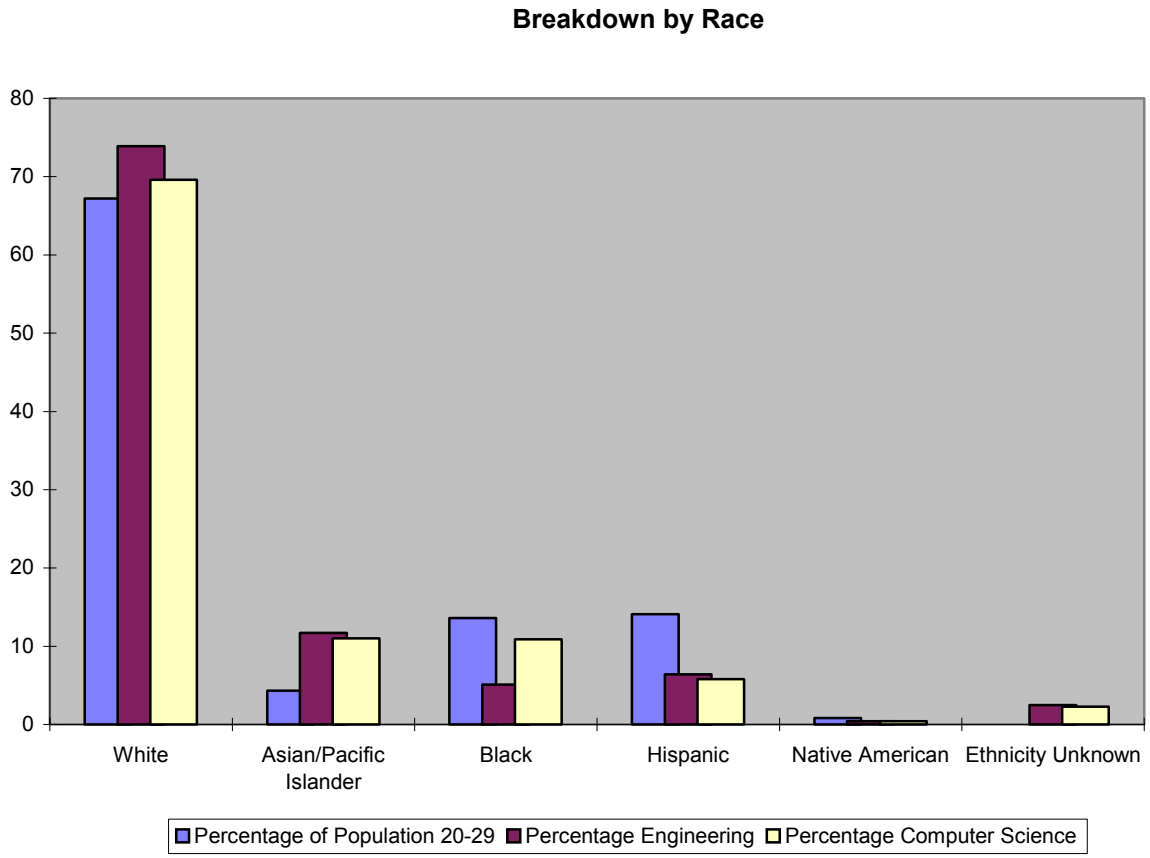

Figure 2. Breakdown of demographics and bachelor's degrees awarded by race[1]

representation in all fields. Blacks, who represented 13.6% of the population in the age range 20-29, received 5.1% of the bachelor's degrees in engineering and 10.9% in computer science; Hispanics, at 14.1% of the population, formed 6.4% of engineering, and 5.8% of computer science, degrees; Native Americans, .8% of the population, received .4% of both engineering and computer science bachelor's degrees. The only group which had a significantly higher representation in technical fields than their percentage of the population was Asian/Pacific Islanders, who at 4.3% of the population of citizens and permanent residents in the age range, received 11.7% of the undergraduate engineering degrees and 11% in computer science.

When all sources agree that this nation will become increasingly more dependent on technology in the current century, we must find a way to include these under-represented groups in engineering and computer science careers to meet the future personnel demands in these fields. In "Underrepresented Minority Achievement and Course Taking—the Kindergarten-Graduate Continuum," Richard Tapia and Cynthia Lanius of the Center for Excellence and Equity in Education at Rice University, [2] quote a 1999 Computer Technology Industry Association (CompTIA) study estimating a shortage of IT professionals in the U.S. of approximately one million workers by 2001, and then note that under-representation

... has never been a threat to science or mathematics, because when we need more scientists or mathematicians, we import them, and science and mathematics lives on. That's the way we, as a nation, have dealt for decades with SMET shortages…[The United States] imported scientists during World War II; math faculty in the 60's from England (and questionably left England in a bad situation); graduate students since the 70's; and faculty today. Yet now our quick-fix importation strategy fails us. We can't possibly import fast enough to solve our IT shortages. Experts say that if the U.S. imported all the IT workers it needed, this would leave Europe in dire straits. And frankly, what would contribute more to the general economic health of the nation, import more, or prepare domestic workers to fill these jobs?

Programs to Address Under-Representation

The problem of under-representation can have a variety of causes, including problems of access and problems of attitude: personal, familial, and societal. Which factor, or which combination of factors, would prevent an individual from an under-represented group from seeking a career in engineering or computer science depends on the personality and the circumstances of that individual. Thus no one approach, however excellent, can hope to be effective in having significant impact on a problem of this magnitude. In addition, the question of at what point, or points, intervention is most effective does not have a single answer. Programs exist which employ formal education at elementary school, middle school, high school, undergraduate, and graduate institutions. Informal education programs make use of such collaborators as museums, Girl and Boy Scouts, and industry to impact both attitudes and access. Mentoring programs, both in person and virtual, have been used at all levels, from K-12 up through professional practice in technical fields. A recent study has indicated that the programs which provide a variety of methods of intervention, for example one-on-one mentoring, combined with college awareness and financial counseling, are more effective than programs which employ a single strategy.[3]

Many programs and approaches are being applied in this country and worldwide. While the number of programs makes it impossible to discuss all in this paper, the programs highlighted here illustrate the spectrum of approaches which are currently being tried, and the emphasis which government, industry, and educational establishments place on solving this problem. Programs were chosen for discussion based on factors such as success, level of innovation, population addressed, and variety of approaches, to provide a spectrum of information on effective approaches for those interested in addressing the issue of STEM under-representation of any race, gender, or economic group. Programs include both those that address engineering directly, and those that address other relevant areas such as mathematics and physics. Programs from around the country are discussed in detail in section a., followed by relevant programs at the University of Tennessee at Chattanooga in section b., and a brief mention of additional programs of note in section c.

a. Programs from Around the United States

a.1 Exploring Physics in Cyberspace

One program which seeks to intervene with under-represented students in grades 5-12, by a variety of methods, is the Exploring Physics in Cyberspace program at the University of

Missouri-Columbia. This program has been supported by a grant from the National Science Foundation Gender Equity Program (NSF-HRD-96-19140), and is directed by Professor Meera Chandrasekhar of the Department of Physics and Astronomy. The program relies on cooperation among University of Missouri personnel, the Columbia public schools, industry, and parents of the participants to encourage interest and participation in the physical sciences, primarily by young women. The program includes activities designed to influence the students directly, activities aimed at increasing parental awareness and support for their daughters' interest in the physical sciences, and programs to increase both subject knowledge and gender equity awareness of middle school science teachers.

The first portion of the program for the students is Exploring Physics, an after school program for girls in grades 5-7. In this program, girls participate in eight 90 minute sessions, taught by science teachers, and comprised of hands-on activities in areas of physics such as mechanics, electricity and magnetism, optics, and sound. The program is currently available in several Missouri schools, and includes approximately 400 girls each year. Families Exploring Science and Technology (FEST) involves both boys and girls in the sixth and seventh grades, and their parents, once a week for four weeks. This program includes about 60 families per year, and is taught by science and industrial technology teachers, who guide the families in building a working drawbridge. As this portion of the program involves both parents and children, it can aid in altering parental attitudes as to "appropriateness" of careers in the technological fields for both boys and girls. The Saturday Scientist is a series of Saturday morning activities for both boys and girls in the eighth and ninth grades. These sessions focus on hands-on activities and career exploration, and involve strong collaboration with local industries such as the city of Columbia Water and Light Department, the Fire Department, the Columbia Area Career Center, 3M, and KOMU-TV. The Newton Academy is a ten day residential summer workshop for girls in grades 9-11, and integrates Physics, Chemistry, Math, and Engineering to aid the girls in constructing a working polymer ball factory. The 30 or more girls who participate in this program each year explore such practical issues as economics and patents, as well as the technical areas of polymers, spectrophotometry, system design, electrical systems, gearing, and graphical solution of the problem of generating the optimal mix.

To aid middle school science teachers in both technical knowledge and gender equity considerations, the program includes a course in gender equity, designed for practicing teachers, and a series of three-week summer physics institutes which cover

- Matter, Mechanics and Energy
- Electricity and Magnetism
- Optics and Sound.

As a means of spreading the concepts and influence of the program beyond the Columbia area, the project personnel have recently completed development of a CD-ROM called "Exploring Physics: Electricity and Magnetism," designed for use by in-service teachers, and which contains hands-on activities from the electricity and magnetism unit aimed at children in grades 5-9. The Electricity and Magnetism CD has been field-tested at an in-service training institute for teachers, has received favorable reviews from such prestigious groups as the National

Science Teacher's Association (NSTA), and is available at a nominal cost from the website www.exploringphysics.com.

According to Professor Chandrasekhar, the ingredients which have made this program a continuing success included clearly defined themes, hands-on activities, and "take home gadgets" to engage student interest, and involvement of both parents and teachers who deal with the students to influence attitudes and reinforce lessons learned by the children. More information about this program can be obtained from the project website http://www.missouri.edu/~wwwepic/ or from Professor Chandrasekhar at meerac@missouri.edu.[4]

a.2 SECME RISE

Unlike Exploring Physics in Cyberspace, which is based at a university, SECME RISE (Raising Interest in Science and Engineering) is a collaboration between the Miami Museum of Science, the Miami-Dade County Public Schools, and SECME, Inc., a non-profit consortium of school systems, universities, and both corporate and government investors, formed with a goal of increasing the number of under-represented, under-served, and differently-abled students pursuing careers in science, mathematics, engineering, and technology. This project was funded by the National Science Foundation Gender Equity Program (NSF-HRD-98-13891). It built on an earlier project at the Miami Museum of Science, Girls RISE, also funded by the NSF, and on the SECME Clubs, at elementary, middle, and high school levels, which provide students with informal opportunities for hands-on engineering and science activities outside normal school hours.

The goal of SECME RISE was to target 52 middle schools serving 80,000 students to enhance access of girls, especially girls of color, to improved education in science, mathematics, engineering, and technology, and to careers related to engineering. Like the program discussed earlier, SECME RISE employs a multi-pronged approach to influence both the students themselves, and attitudes and knowledge of their teachers and families. A Summer Leadership Academy each year included "a combination of team-based engineering design challenges, technology training, field trips, and opportunities to interact with women engineers." The engineering design projects included such items as basswood bridge building, an "egg drop" activity, and an introduction to robotics using the Lego *Robolab* materials (a special, educationally oriented, version of the popular Lego *Mindstorms* products). The sixth and seventh grade girls for the academy were selected by teachers at participating middle schools. The teachers who performed the selection were primarily those who were themselves participating in the series of in-service workshops offered by SECME RISE staff in the areas of hands-on engineering projects, strategies for gender equity, and integration of technology in the curriculum. In order to reinforce the lessons learned in the summer program, in March the girls were invited back to the Museum for an overnight reunion (the RISE 'N' Shine! Camp-In), including hands-on science activities such as a science-based scavenger hunt in the Museum's "Sharks! Fact and Fantasy" exhibit.

Two methods were used to encourage parental participation and awareness of the SECME RISE activities. One was inviting the parents to the closing day events for the Summer Leadership Academy, including presentation of award certificates, exhibition of the web pages which the teams designed describing their summer activities, a "brain-bowl" quiz, and a competition testing the bridges which the girls had built. Also included was a luncheon, and presentation of each girl with a $300 stipend for participation. The second method used to raise parental awareness was the hosting of two family "E-Days" at the Museum. The girls, their parents, and the SECME RISE teachers were all invited to half-day sessions, including hands-on designs, female engineers as guest speakers, career planning information, and discussions of how to best encourage the girls' interest in science, mathematics, and technology.

In addition to the activities to influence girls, their teachers, and their parents, it is a goal of SECME RISE "to contribute to the research base on how socioeconomic status and ethnicity interact with gender to influence mathematics and science learning."[5] This will aid other researchers in constructing programs to change both attitudes and access for girls and all persons in under-represented groups to careers in engineering and technology.

In 2001, the SECME RISE personnel began a new NSF award building on SECME RISE. Information about all of the RISE programs can be obtained from the program website http://www.miamisci.org/rise/index.html, or from Jennifer Santer, Co-Project Director, Miami Museum of Science, at jsanter@miamisci.org.[6]

a.3 Girls in the SYSTEM

Girls in the SYSTEM (Sustaining Youth in Science, Technology, Engineering, and Mathematics) is a program aimed at girls in grades 3-8 in southern Arizona, placing special emphasis on Mexican American, Native American, and economically underprivileged groups. The program is funded by the National Science Foundation, and is a collaboration between the Ecology and Evolutionary Biology Department, the Materials Science and Engineering Department, the Mathematics Department, the Mining and Geological Engineering Department, and the Women's Studies Department of the University of Arizona, with the Sahuaro Girl Scout Council. The foundation of the program is the STEM (Science, Technology, Engineering, and Mathematics) Academies for teachers, both in- and pre-service, and Girl Scout leaders, geared toward providing them with knowledge of both gender equity issues, and interesting and innovative approaches to science, technology, engineering, and mathematics. The adults trained in the STEM Academies aid in conducting five one-week summer day camps for boys and girls in the Tucson vicinity. This both aids the children who participate in forming positive attitudes toward STEM subjects, and gives the educators an opportunity to "try out" the materials and strategies learned in the STEM Academies. Some of the adults so trained also facilitate six-week sessions incorporating STEM activities into Girl Scout troop meetings. This emphasis on training teachers and other relevant adults, and then aiding *them* in working with children in STEM makes this program unique among those discussed. Workshops are also available for families of the children who participate the in the program activities, to inform them about science and technology, and to emphasize to them the great significance of the role of parents in preparing their children to succeed academically. Another aspect of this program which is unique to the

programs described here is the availability of mini-grants to parents of the students who participate and to STEM Academy participants for such activities as presentations to community groups, formation of STEM study groups, and hosting of mother-daughter STEM events. Information on this program was obtained from the project website at http://gistem.math.arizona.edu/ .[7]

a.4 Techbridge

Techbridge is a technology program designed for girls in middle and high school, primarily in the Oakland, California area, and is funded by National Science Foundation under Grant No. HRD-00-80386. The name "Techbridge" comes from a recognition that this age range represents a

> *critical time in girls' development. Girls have many important decisions to make in middle school and high school, but don't always have the support they need. Techbridge supports girls by teaching them technology skills and helping them plan for the next steps to college and careers.*

The activities take place as after-school clubs, lunch clubs, and early morning class meetings. Activities include Lego Mindstorms robots, launching hot air balloons, building radios from kits, movie and web page design, and interaction with female professionals in science and engineering. This program also offers teacher and parent programs similar to those discussed in other programs; more information can be obtained at the Techbridge website at http://www.chabotspace.org/visit/programs/techbridge.asp. However, what makes this program unique is participation of students from the California School for the Blind, in Fremont, California.[8] Very little reliable data exists on college degrees granted to students with disabilities due to privacy concerns by universities, and the lack of a consistently applied definition of the term "disability." However, it is recognized that persons with traditionally defined disabilities, such as blindness, deafness, or significant lack of personal mobility, form a significant portion of the population.[1] The few programs such as Techbridge, which encourage persons from such groups to pursue new options in technical fields, serve a valuable, and definitely under-represented, portion of the available pool of technical talent for the future.

a.5 Learning Mathematics Through Transactional Writing

A very different program, which increases the available pipeline of under-represented students into engineering and computer science by increasing the number of students adept at mathematics, is the Learning Mathematics Through Transactional Writing program funded by NSF Grant 95-94188, and conducted by Miami-Dade Community College. Studies indicate that males tend to perform better than females in mathematics, especially at higher levels, but not in writing. Yet engineering employers agree that both technical skills, such as a good understanding of mathematics, and communication skills such as effective writing are necessary for success in today's technical career fields. The Transactional Writing program uses the traditional strengths of female students to both enhance their skills in math, and to reshape attitudes toward it. Students use "transactional writing," defined as expository or informing

descriptions meant for an audience such as a teacher, to express their understanding of significant mathematical concepts. This enables the teachers both to measure and correct students' understanding of important concepts, and to also provide feedback and opportunity for development in writing capabilities. The program was conducted at three middle schools, with male and female students in sixth through eighth grades, and in college level courses taught at the university. Similar sections of each course used provided a control group with which to compare results. Data collected included both measurement of attitudes and measurement of math skills by appropriate instruments, e.g., for the middle school students, the math portion of the Stanford Achievement Test. Results indicate that the students at all levels in the sections using transactional writing improved both in math skills and in attitudes toward math. While among males the link between writing and attitude is less striking, a clear and convincing link between both attitude improvement and skill level among females in the writing sections was indicated at both middle school and college levels. Additional information on this program can be obtained from Suzanne Austin at saustin@mdcc.edu.[9]

b. Programs at the University of Tennessee at Chattanooga

b.1 Adventures in Computers, Engineering, and Space (ACES)

The University of Tennessee at Chattanooga, in partnership with Girls Incorporated of Chattanooga and the UTC Challenger Learning Center, is conducting a small experimental program entitled Adventures in Computers, Engineering, and Space (ACES) to encourage girls to consider careers in these fields, and to continue their educations in science and mathematics. ACES specifically targets girls entering the seventh or eighth grades (ages 12 – 14), with half of the participants being drawn from economically disadvantaged households and half from the general school population of Hamilton County, Tennessee. These groups are being tracked separately so that the success of ACES in influencing attitudes in each can be assessed. ACES includes a one-week residential summer workshop for twenty-four girls each year. It was considered critical by personnel familiar with the economically disadvantaged segment of the population that ACES attempts to reach that the girls stay on the UTC campus, as many of them might never have been to a college campus or personally known someone who had attended college. The workshop provides space-related activities at the UTC Challenger Center including a "Mission to Mars," in which girls are divided into "mission control" and "away team" groups which must work cooperatively to complete the mission safely, design and launch of CO2 powered rockets, and design and construction of a "space station" designed by the girls, and built in the UTC pool using buoyant materials to simulate the problems of construction in weightless conditions. Engineering activities during the workshop include circuit construction, design and construction of programmable cars using Lego Mindstorms robotic materials, manufacturing process design, and construction of towers designed to hold a load for a specified time limit. Computer activities included simple programming tasks, generation of a disk with a computer version of the "hangman" game, web page design, and Computer Aided Drawing. The girls have made field trips to locations such as the Tennessee Valley Authority's Raccoon Mountain pumped storage facility, where they were taken on a tour including the power generation floor not usually open to visitors; and the Mayfield Dairy in Athens, TN, where they were able to watch milk cartons being made and filled, and to see ice cream being packaged. In addition to

technical activities, ACES attempts to address the "whole person" by including sessions related to nutrition, exercise, crafts, and exposure to positive female role models from the engineering and computer industries.

Figure 3. ACES participants perform a mission at the UTC Challenger Center

During the school year, follow-up activities occur approximately monthly to maintain the interest and knowledge created during the summer program. Follow-up activities include small design projects that encourage originality in solving problems with constraints, such as the "egg drop" competition, in which students were given design constraints by an industry "customer," made detailed design drawings and revisions, and tested their designs against criteria involving "egg safety," size, weight, and time required to release the egg after landing. Other follow-up activities for the girls have included web page enhancement, product dissection, and a field trip on an amphibious vehicle.

To widen the influence of the project, an ACES Fair, featuring hands-on engineering, computer, and space activities, has been conducted at selected elementary and middle schools, and other

"targets of opportunity." The fair is designed to allow boys and girls of all ages to explore engineering and computer concepts through hands on exhibits. The most comprehensive fair was held at Hamilton Christian School in February 2002 for approximately 100 sixth-eighth graders. The exhibits and activities included an electronic quiz on engineering, an electronic quiz on electricity, a forces/pulleys activity, a tower-building competition, a sound-wave exhibit, a Lego Mindstorms robot, a reliability activity, a motor-model display, a poster display about computer science, and an electro-magnet. The fair was staffed by UTC faculty and students, and engineers from local industry. While this activity was very successful, it was also very labor intensive. Later fairs have been smaller in scope, have included a subset of the original exhibits, and have been aimed toward a single classroom; this allows a single professor to conduct the activities, making the events much easier to schedule.

Figure 4 . ACES Fair at Hamilton Christian School

While this program has not been in existence for a long enough period to judge long term effects, the combination of in-depth engineering, computer, and space activities, regular follow-up activities, and the ACES Fair provides a unique and considerable variety of approaches for such a new and small program, and one which could be replicated elsewhere on a relatively small budget. This project is being funded under the National Science Foundation Gender Equity Program grant number 00-03185. Additional information on ACES can be obtained from the author at Claire-McCullough@utc.edu or from the project website at http://www.utc.edu/aces.

b.2 Upward Bound Promoting Resolve In Science and Math (PRISM)

Upward Bound PRISM is a program funded by the U.S. department of Education to help both prepare and encourage high school students to seek college degrees and progress to careers in math and science fields. The participants are selected from economically disadvantaged families where neither parent has a four-year college degree. The inner city Chattanooga area which the

program serves has an average per capita income of only $11,634, and over 91% of adults have less than a high school education. These statistics, combined with a per student expenditure among the lowest in the nation, make programs like PRISM vital to breaking the cycle of poverty in this area. The program includes an academic year component of weekly classes, including areas such as SAT/ACT preparation and career exploration, in addition to academic topics like computer science and English Composition; cultural enrichment to broaden the horizons of the students; a mentoring component; and mandatory tutoring for participants who make grades of C or below in their academic subjects. A six-week summer component provides enrichment and intensive research in math and science. This program serves fifty students per year, and requires both a recommendation from a math or science teacher and parental involvement for an applicant to be accepted into the program. While the program has only been conducted since 1999, the available results are extremely promising. Since the inception of the program, 94% of the students beginning PRISM have been retained in the program; 25% of the participants demonstrated a grade level improvement in science; 57% achieved a grade level improvement in math; 92% continued to postsecondary education; and none of the PRISM students were forced to interrupt their high school educations due to crime, substance abuse, or pregnancy. [10] Additional information about the program can be obtained from the project director, Twyler Boykin, at Twyler-Boykin@utc.edu.

b.3 Bridges to Engineering Science: Teaching Teachers (BESTT)

In September 2002, the University of Tennessee at Chattanooga received a planning grant from the new Bridges to Engineering Education program at the National Science Foundation to design a coordinated, comprehensive program to increase the number of students entering engineering fields in the targeted Tennessee/Georgia area. By including and impacting both pre-service and in-service teachers at grades K-12, BESTT, if fully implemented, has the potential to affect the over 115,000 students in grades K-12 in thirteen school systems in Tennessee and Georgia identified as potential partners. The program will include partnership between the Colleges of Engineering and Education; interaction among faculty and students of the colleges and the thirteen targeted school systems; development of high quality, self contained, kit-based engineering science experiments and curriculum units which meet the education system goals and educational standards; development and dissemination of teaching materials on hands-on, age appropriate, engaging engineering science units for grades K-12; special targeted inclusion of groups currently under-represented in engineering; and formative and summative assessment at all stages of the project. During the planning grant period, the Engineering and Education principal investigators are working to facilitate development of the Engineering/Education partnership; establish contact with the targeted school systems, and obtain both commitment and a science curriculum point of contact for each; perform an initial study and assessment of engineering science topics appropriate to different age groups and how they fit with school system goals and educational standards; conduct a workshop including all school system representatives and the Engineering and Education Principal Investigators of the proposed project to provide insight on the detailed project proposal; develop a detailed assessment plan for the program; and obtain commitment for publication/dissemination of resulting kits and modules. Although this project is in the initial stages, we believe it has the potential to significantly broaden the pipeline to engineering education in the target area, as well as to create

self-contained units and workshops which will make the program replicable elsewhere. Also, although the ACES and PRISM programs appear to be successful, they reach relatively few students. By putting the engineering science content into the classrooms of all science students in the partner school districts, many more students can be positively affected by this approach than by the previous programs. Additional information on BESTT can be obtained from the author at Claire-McCullough@utc.edu.

c. Additional Programs

While only a few programs could be described in a paper such as this, some other programs of note include

- Georgia Tech's Center for Education Integrating Science, Mathematics, and Computing programs, including workshops for students and teachers, a National Science Foundation sponsored program to increase "the proportion of women choosing to pursue technological fields by inspiring significant changes in science, mathematics, and engineering education across Georgia," and mentoring of K-12 students by Georgia Tech students with strong STEM backgrounds; (http://www.ceismc.gatech.edu/ceismc/programs/homepg.htm)
- The interCONNECTIONS™ series of books, being developed under an NSF grant to help girls "connect" to abstract concepts such as magnetic fields and atomic structure through use of metaphor and imagery (http://www.off-the-pageworks.com/);
- The UM-GIRL (Using Math: Girls Investigate Real Life) program, at the University of Michigan, aimed at minority and/or low-income girls who are under-performing in math (http://www.umich.edu/~umgirls/); and
- The Girls Tech program, a collaboration between Douglass College and the Girls Scouts of America, to developed a framework and criteria to "evaluate web sites, CD-ROMS, games, and other electronic information resources to judge their likely appeal to girls and young women and stimulate their interest in science and technology" (http://girlstech.douglass.rutgers.edu/).

Conclusions

While many excellent programs exist, the problem of under-representation of women, minorities, and those with disabilities in the fields of engineering and computer science remains a serious one, and will grow more serious as society's dependence on technology grows. The magnitude of the problem necessitates a concerted effort by school systems, universities, government, communities, and industry. Programs such as the ones detailed here, and the many others which are being conducted both here and in other countries, can serve as models for all interested in developing programs to attract and retain under-represented groups to careers in technology.

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