Science, Technology, Engineering, and Mathematics Talent Expansion Program: A Focus on Diversity

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Background

The exponential growth in military spending in Maryland has left educational institutions with the enormous challenge of meeting workforce needs, particularly the need for individuals with degrees in computer science, technology, engineering, and mathematics (STEM). Given the need, universities and colleges must meet the growing challenge to identify and enroll students in these areas.[1] The September 2000 Report of the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development (CAWMSET), entitled *Land of Plenty; Diversity as America's Competitive Edge in Science, Engineering and Technology*, states that "Unless the SET (science, engineering, and technology) workforce becomes more representative of the general U.S. workforce, the nation may likely face severe shortages in SET workers, such as those already seen in many computer-related occupations." "Yet, if women, underrepresented minorities and persons with disabilities were represented in the SET workforce in parity with their percentages in the total workforce population, this shortage could largely be ameliorated."[2] A recent study by the American Association for the Advancement of Science in partnership with the National Science Foundation (NSF) confirmed this finding. "In our efforts to sustain U.S. productivity and economic strength, underrepresented minorities provide an untapped reservoir of talent that could be used to fill technical jobs."[3]

To date, most efforts to recruit and retain female and minority STEM students have been undertaken within departments or programs with a focus on classroom and departmental culture, climate, or activities. Adding women faculty, providing mentoring, and helping women to feel more included in the learning process would likely increase the participation of women in engineering technology and related programs.[4, 5, 6] But adding women and minority faculty remains a challenge for a number of reasons which makes providing role models and mentors difficult.[7]

A second focus for recruiting and retaining students has been on the students themselves and the unique attitudes of women and minorities that can affect their experiences in the program and, consequently, their retention. More specifically, understanding differences in attitudes between minority and majority students may allow departments to make informed programmatic decisions that can impact all attitudes in a positive manner.[8]

A third focus has been on the need to reform and revitalize the educational programs to be more in line with both the needs of employers and the current undergraduate student body.

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Engineering is no exception.[9] Recognizing that technology is rapidly changing is perhaps not as important as realizing that technology shapes each generation. Today's students come to university from a wide variety of backgrounds and a diversity of cultures and educational experiences that are different from students who entered even as little as ten years ago. But while a new paradigm to address these changes may be needed, it may also be the most difficult to implement as faculty resistance remains a factor.[10]

This paper suggests a fourth, perhaps more pragmatic approach to increasing the enrollment and retention of women and minorities in STEM programs. The program, funded by the National Science Foundation to begin in March 2003, will pilot two initiatives that target women and underrepresented minorities for recruitment, enrollment, and retention in STEM programs at the University of Maryland, Baltimore County (UMBC) and the Community College of Baltimore County (CCBC), Essex, Dundalk, and Catonsville campuses. Further, this program will identify to what degree program elements contribute to recruitment, enrollment, and retention. Given the limited resources that universities, and particularly community colleges, often have, the project will look at the following:

1. An innovative yet inexpensive recruitment strategy that introduces 1620 high school students to STEM careers, but also aids in the retention of the 270 UMBC undergraduate students who participate.
2. The relative effectiveness of a summer bridge program, a scholarship program, and an internship program on student retention in STEM compared to partial or no intervention. Both academic and economic supports have been shown to be effective in recruitment, enrollment, and retention at universities and colleges. But how much time and resources are needed to provide a strong positive outcome? A pilot project involving 30 CCBC and 30 UMBC students seeks to answer this question.

Project Goal and Objectives for Pilot Efforts

The goal of this pilot project is to identify which interventions, given limited time and resources, will best increase the number of students from underrepresented groups pursuing and receiving associate or baccalaureate degrees in established or emerging fields within science, technology, engineering, and mathematics (STEM). This will be achieved through the following objectives:

Objective 1: Outreach Program

Create an interest among high school students in STEM fields through a pilot program in which 90 upper level UMBC mechanical and chemical engineering students in teams of three to five visit ten high schools (representing approximately 540 students) and teach students physics, chemistry, biology, mathematics, or technology concepts using engineering applications.

Ninety students from three Chemical & Biochemical and Mechanical Engineering classes will be assigned an Engineering Education Outreach Project as part of their final grade. This project requires undergraduate UMBC engineering students to go to a local high school and make a presentation to increase the high school students' awareness of the importance of mathematics, physics, chemistry, and biology to the field of engineering. Teams of 3-5 UMBC students will

make a presentation, have hands-on activities for the high school students to perform, and provide an evaluation to be completed by the class and the teacher. This project is a chance for UMBC students to be creative, to share their experiences with high school students, and to introduce these students to technical areas and careers that they might not have considered. During the presentation, the high school students will be made aware of the various paths and diverse coursework that UMBC students have taken in order to study engineering and what they plan to do upon graduation. UMBC students will also discuss what skills they learned in high school that have been helpful in their college education and during their summer research experiences and internships.

Hands-on activities will tie concepts that the high school students have learned to what the UMBC students are learning in their advanced university courses, and how they relate to practical industrial applications. For example, UMBC students could do the following:

- Begin the session by asking the high school students to discuss how they can tell when air pressure changes. *[Possible answers may include flying in an airplane, diving down deep into a swimming pool, traveling into the mountains and your ears pop, etc.]*
- Divide the students into pairs, and give each pair a straw, two pieces of string, and two balloons. Have the students blow up the two balloons to equal sizes, and tie each to a piece of string. The other ends of the string should be tied onto the straw, so that the balloons are near the straw, but not touching. One student in the pair will hold the straw and the other student will blow so that his/her breathe goes directly between the balloons. Ask the students to predict what will happen. *[The students usually expect the balloons to separate further but the opposite is the result; the balloons move together. Blowing between the balloons creates a stream of air that is moving faster than the surrounding air. The pressure between the balloons is lower than the pressure of the air surrounding them, so they come together. This is Bernoulli's Principle.]*

These are just a couple of examples of hands-on experiments that can be used to demonstrate Bernoulli's principle, an algebraic expression. Then the UMBC students will explain what they have studied in their engineering courses about Bernoulli's principle and the use of science and math skills that they developed in high school to understand Bernoulli's principle, which is used in the design of pumps and airplanes.

Objective 2: Interventions

Identify the relative effectiveness of a two-week summer bridge program, a scholarship program, and an internship program on student enrollment and retention in STEM programs compared to partial or no intervention.

Sixty students will be selected to participate in this pilot project, thirty from UMBC and thirty from CCBC. Women and under-represented minorities will be strongly recruited. Thirty students will be randomly assigned to the bridge, scholarship, internship programming; the other 30 will be given the scholarship and internship program only. Applications beyond the 60 will be maintained as a control group. Students will be selected to participate based on the recommendation of one teacher, 2.5 GPA and a student letter of interest in a STEM career. The

students will be selected from current high school seniors, recent high school graduates and transfer students from community colleges and four year institutions.

Academic Bridge Program

The bridge program will provide a two-week, non-residential, on-campus summer experience for thirty of the STEM students. Traditionally underrepresented groups will be targeted to provide additional preparation and enrichment for students interested in majoring in STEM to ensure they are fully prepared to succeed in their chosen discipline. In addition, a faculty sponsor within the student's area of interest will provide monthly contacts for mentoring and advising throughout the academic year. Together, these program elements will serve as an academic boost to the "average" student. These students will also receive a scholarship and an internship as mentioned below. Students selected for the bridge program will be identified as Treatment Group I. The following are the elements of the bridge program:

- Orient UMBC students to the university and acquaint students enrolled at a two-year college with the four-year college environment (Student Life, the library, Women's Center, Learning Resource Center, advisement center, counseling center, Shriver Center, etc.);

- Provide exposure for two-year and four-year students to the various professional societies (AIChE, ASME, IEEE, SWE, ACS, Triangle Fraternity, etc.), recent graduates from CCBC and UMBC, and professionals from STEM-related professions, who will be invited to come and discuss their job experiences.

- Highlight outstanding professors at UMBC and CCBC and have their undergraduate students provide presentations so that the bridge students are exposed to exciting new areas, as well as meet undergraduates who have had the opportunity to perform research.

- Provide instruction in academic survival skills (study skills, time management, preparing for tests and test-taking strategies, etc.).

- Provide two UMBC upper-class students to serve as tutors, mentors, and guides on campus during the two weeks and provide an electronic mentoring component throughout the year.

- Provide academic review and enrichment to insure college preparedness in STEM areas, such as trigonometry, algebra, physics, chemistry, computer skills, etc.

- Create awareness of current research on the issues of women and minorities in STEM areas of study

- Provide social activities to build a cohort of students by putting students in teams and playing various team-building games to strengthen their leadership skills and teach them how to work as a team.

Curriculum for the program will be created in the first year by teams of selected faculty and staff from the two institutions. The teaming will allow the faculty not only to work collaboratively on

this project but also to build relationships for other opportunities for collaboration to benefit students. The faculty will determine during the curriculum planning phase when it is appropriate to combine two-year and four-year students for learning and when it is best to provide separate classes. Faculty will be encouraged to break out of the traditional lecture mode and find innovative, applications-based learning opportunities for students using high-tech labs and emerging technologies. This will allow for an enrichment experience for the entire faculty and an appreciation of the abilities and interests of two-year and four-year students, as well.

Upon completion of the summer bridge program, students will meet once per month with a faculty member on their respective campuses in their area of interest, as identified during the summer. The meetings will be to evaluate progress, identify additional resources needed to support student success, and develop a mentoring relationship with the students. They will also establish electronic contact with one of two upper-class UMBC students.

Step Scholarship

All sixty students will be given an annual $1000 scholarship, renewable for a second year if the student meets the 2.5 GPA criteria and remains in a STEM career path. The non-bridge students will be identified as Treatment Group II.

The STEP proposal development team identified scholarships as an important component to evaluate for the following reasons:

- The scholarship may serve as an incentive to participate in the two-week bridge program
- The scholarship would encourage students to try a STEM degree or program where they might otherwise lack confidence
- A scholarship is renewable for a second year because it is hoped that after the second year most students would have internships in their area of interest.

If some of the scholarship students do not enroll in a STEM program in the following semester or fail to meet other criteria, applications from additional students may be accepted based on the criteria above.

Internship Opportunity

This program will provide a paid internship experience for 60 students following the completion of thirty credit hours in a mathematics, science, or technology-related field. Internships will be provided in companies not currently hiring interns from UMBC to increase internship support and encourage the involvement of more businesses with UMBC and CCBD. UMBC's Shriver Center will provide leadership for this portion of the project. The Shriver Center, places over 1000 students annually in co-ops and internships at over 300 businesses and organizations throughout the Baltimore/Washington area, allowing students to connect theory with practice. This level of involvement reflects the importance of gaining work-based, experiential learning for students interested in careers in STEM areas

The Shriver Center will also assist CCBC in the development of a strong and effective internship infrastructure for the placement of their students. CCBC students will complete the requirements as they become established with the creation of a centralized internship infrastructure at CCBC. Since 30 credit hours are required and students are not always able to complete thirty hours in one year, the internships will be available over two years. Finally, internships will be for students who have participated in prior STEP program elements.
The Shriver Center will be responsible for the following activities:

1. Develop new internship opportunities for UMBC students in STEM areas. Students will be encouraged to link their internships with academic credit through their major departments.

2. Develop internships with companies not currently providing internship opportunities by paying for the internship through the funded proposal. This is particularly important to insure all students receive internships and that CCBC's program is launched successfully.

3. Place 30 UMBC undergraduates in internships at companies new to UMBC to expand current internship opportunities at the university. Program staff at CCBC will coordinate the placement of the 30 CCBC students in opportunities developed under the new internship infrastructure.

OBJECTIVE 3: Program Building

Enhance the current informal consortium arrangement between UMBC and CCBC to increase STEM program articulation and student transfer and foster the development of a formalized internship program at CCBC with science and technology-related companies.

Internships

UMBC's Shriver Center will also provide leadership for this portion of the project. The Center will work with CCBC faculty and administrators to develop a formal, centralized internship program infrastructure, provide guidance in purchasing and training on software to manage student resumes and business interests and train a part-time CCBC business developer on how to develop internship opportunities for students. This pilot project will also strengthen faculty ties between the two institutions and open a dialogue between the two organizations that will benefit all students.

Assessment and Evaluation

To evaluate Objective 1 (increase high school student interest in STEM) the evaluation team will prepare a questionnaire that the class and high school teacher will use to evaluate the presentation and activities. This assessment will help determine what was done well, what could have been done better, and how improvements can be made to the presentation and activities for future high school visits. The information gathered from the evaluation will be disseminated immediately to other participating UMBC classes. This assessment also will help to identify any

learning by the high school students and determine if these students developed a greater appreciation for and interest in a STEM area.

The outcomes for Objective 2 will be retention in STEM majors, grades, and commitment to a career in STEM. Attitudes toward STEM will be assessed by a questionnaire, either developed especially for this project or validated for this purpose. Program participants meeting eligibility criteria will be randomly assigned to one of three groups: (1) the full program (summer program, scholarship, internship), (2) a partial program (scholarship, internship), (3) no program (control group). Analysis of program outcomes will compare these three groups against each other to answer the following research questions: (1) Does either program produce better outcomes than no program, (2) Does one program produce better outcomes than another program? A cost effectiveness analysis will be performed to determine which program generates greater benefits per dollar invested.

The outcomes for Objective 3 are development and implementation of a formalized internship program. In addition the evaluation will track the number of internship placements sites developed and the number of STEM students who participate in the internship program.

Summary and Conclusions

This paper describes a plan to identify over three years which elements are most effective in supporting the recruitment, enrollment, and retention of students in STEM. For obvious reasons, most universities focus their resources on the most academically talented, providing honors programs and special freshman seminar courses to students who have already demonstrated academic success in their high schools. Retention among these students should be relatively easy as they are already well prepared for the rigors of college. But the bulk of entering freshmen have not yet demonstrated their academic gifts. Students, and particularly women and minorities, haven't been given or taken the opportunity to explore more rigorous science, technology, and engineering career areas.[11, 12] Students too often come from high schools that fail to provide the academic preparation needed and give up too quickly on the opportunities available.[13] Given additional attention and support, will they demonstrate increased academic success? Is it possible to create change in enrollment and retention rates without changing whole departments but solely with the collaboration of the innovators of the departments? Hopefully, as this project unfolds, it will give us a glimpse of an answer to these questions and begin a new focus on how we can best use our scarce resources to address the needs of all of our STEM students.

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Biographical Information

TARYN BAYLES, Chemical and Biochemical Engineering faculty member and Undergraduate Coordinator, has spent half of her career working in industry and the other half teaching Chemical Engineering. She emphasizes practical applications from her industrial experience when teaching engineering courses. She has been recognized by her students and peers with various teaching awards.

ANNE SPENCE, Mechanical Engineering faculty member, has been an engineering educator for seven years. During that time, she has developed curricula and programs to increase the participation of women in engineering, and foster an interest in engineering among middle and high school students. While at UM College Park and at UMBC, she is recognized as an outstanding engineering instructor through several awards.

CLAUDIA MORRELL, Director of Planning and Grants for the Center for Women and Information Technology at UMBC, joined the University in August of 2001. In both this and her previous position at CCBC, she became familiar with and has worked to address the issues related to the lack of participation of girls and women in STEM programs. Her skill as a collaborator have been instrumental in building bridges between the two institutions.