2006-1900: SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS TALENT EXPANSION PROGRAM: AN ANALYSIS OF A PILOT PROGRAM

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Science, Technology, Engineering, and Mathematics Talent Expansion Program: An Analysis of a Pilot Program

Abstract

The University of Maryland Baltimore County (UMBC) in partnership with the Community College of Baltimore County (CCBC) is completing a pilot program on a series of initiatives that identified their effectiveness in increasing the number of undergraduate students, particularly those from underrepresented groups, pursuing and receiving associate or baccalaureate degrees in established or emerging fields within science, technology, engineering, and mathematics (STEM). These initiatives were funded by the National Science Foundation through their STEP (STEM Talent Expansion Program) (STEP-DUE-0230148) program. This was achieved through the following objectives:

- Developed a high school awareness activity that brought teams of UMBC engineering students to area high schools to introduce the high school students to STEM concepts using hands on engineering activities and demonstrations. During the presentation, the high school students were made aware of the various paths that UMBC students have taken in order to study engineering and what they plan to do upon graduation.
- Evaluated 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.
- Strengthened and expanded the current informal consortium arrangement between UMBC and CCBC to increase STEM program articulation and student transfer. A formalized internship program at CCBC is still being developed with science and technology-related companies.

An important part of the program is the full involvement of the Center for Women and Information Technology (CWIT), a UMBC organization whose mission is to increase the involvement of females in IT and technology-related fields, such as engineering. The Center was instrumental in developing a mentoring program for faculty and students and monitoring faculty and student participation.

This paper and presentation will include data collected for the pilot program which will include the outreach program to local high schools, as well as the impact of the summer bridge, scholarship, internship and mentoring programs on retention in STEM majors for the students receiving the full or partial intervention as compared to a control group.

Background

The exponential growth in spending for national security has left educational institutions with the enormous challenge of developing a workforce with sophisticated technological skills, and in particular, increasing the number of individuals graduating with degrees in 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 interests of the current undergraduate student body. 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 establishing innovative ways to teach engineering to address these changes may be needed, it may also be the most difficult to implement as faculty resistance to change remains a factor.[10]

This paper suggests a fourth, perhaps more pragmatic approach to increasing the enrollment and of undergraduate students, and particularly the retention of women and minorities in STEM programs. The program, funded by the National Science Foundation, pilots two initiatives that were open to all students but that also targeted 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 (CC) Essex, Dundalk, and Catonsville campuses. Further, this program identified the degree to which program elements contributed to recruitment, enrollment, and retention. Given the limited resources that universities, and particularly community colleges, often have, the project looked at the following:

1. An innovative yet inexpensive recruitment strategy that introduced high school students to STEM careers, but also aided in the retention of the UMBC undergraduate students who participated.
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 CCBC and UMBC students seeks to answer this question.

Project Goal and Objectives for Pilot Efforts

The goal of this pilot project was to identify which interventions, given limited time and resources, would 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 was 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 UMBC engineering students in teams of three to five visit high schools and teach high school students physics, chemistry, biology, mathematics, or technology concepts using engineering applications.

Students from a core Chemical & Biochemical Engineering class (Transport Phenomena II: Heat and Mass Transfer) were assigned an Engineering Education Outreach Project as part of their final grade. (In the first year of the outreach program sophomore level mechanical engineering students also performed this outreach program.) This project required 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.[11] Teams of 3-5 UMBC students delivered a presentation, had hands-on activities for the high school students to perform, and provided an evaluation to be completed by the class and the teacher. This project provided UMBC students with an opportunity to be creative, to share their experiences with high school students, and to introduce the high school students to technical areas and careers that they might not have considered. During the presentation, the high school students were 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 also discussed 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 tie concepts that the high school students have learned to what the UMBC students are learning in their advanced university courses. The UMBC students are then required to explain how the activities relate to practical industrial applications. For example, UMBC students have done the following:

- Begin the session by asking the high school students to discuss how they can tell when air pressure changes. *[Possible answers include diving down deep into a swimming pool or traveling into the mountains and their ears pop, etc.]*
- The students were divided into pairs, and given a straw, two pieces of string, and two balloons. The students blew up the two balloons to equal sizes, and tied each to a piece of string. The other ends of the string are tied onto the straw, so that the balloons are near the straw, but not touching. One student in the pair holds the straw and the other student blows so that his/her breathe goes directly between the balloons. The students are asked 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 therefore lower than the pressure of the air surrounding them, so they come together.]*
- The students were given a ping-pong ball, two small paper cups (2-3 inches tall), and some masking tape. They were asked to tape the cups onto the table-top, one behind the other, four inches apart. The ping-pong ball is placed in the first cup and the students are challenged to get the ball out of the first cup and into the second cup – neither the cups nor the ball can be touched. The students were reminded to think about what they learned in the previous activity. *[Blowing across the top of the cup will produce lift and cause the ball to pop out of the cup when the air speed is high enough. Controlling the ball's motion to get it to land in the second cup is not easy…. But great fun when accomplished!]*

These are just an example of hands-on activities that have been used to demonstrate Bernoulli's principle, (which the heat and mass transfer student have studied the previous semester in fluid mechanics). Then the UMBC students explained what they have studied in their engineering courses about the Bernoulli's principle and the use of science and math skills that they developed in high school to understand Bernoulli's principle, and how it relates to industrial applications (design of pumps, airplanes, etc.).

Assessment and Evaluation

To evaluate Objective 1 (increase high school student interest in STEM) the evaluation team (The Center for Social and Community Research [CSCR] at Loyola College) in collaboration with the PI have prepared questionnaires that the UMBC student teachers and the high school students and their teacher have used to evaluate the presentation and activities. This assessment has helped 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 was disseminated immediately to other UMBC students who had yet to perform their outreach project; it was also disseminated from one year to the next to the UMBC students in the Transport Phenomena II classes. This assessment helped 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.

Program Results -- Outreach Program

The Outreach Program was implemented in the spring of 2003. Forty-three UMBC students visited 10 high schools and educated over 300 middle and high school students to better

understand the applications that STEM subjects have to engineering and related occupations. In the second year, 24 UMBC students visited six high schools and educated 190 high school students, and in the third year 25 UMBC students visited seven high schools and educated 187 high school students.

T-tests were used to separately analyze statistical significance of means for each section of the student teacher questionnaire and the high school student questionnaire. Results of the t-tests identified which activities/subjects under each section were reported as being most beneficial to the students, and which aspects of the teaching program were rated as most effective by the student presenters. Statistical significance indicates that differences in responses are likely due to real differences and are not merely due to chance.

Percentages were calculated for each section of the student teacher and high school student questionnaires (see Appendix 1: Tables 1-3 and 4-5 for means as well). Qualitative responses for the feelings of student teachers and the high school students' feelings on the presentations were also collected, but not reported here. An analysis of variance of the means assessed differences between schools on each high school student questionnaire item, to determine if there was significant variation between schools that was not merely due to chance.

Based on individual means for each question on the high school student questionnaire, several significant differences were observed within question groupings, indicating a stronger effect for certain parts of the teaching program than others. While specific reasons why significant variation was observed between schools on responses to certain high school student questions cannot be determined from this analysis, the results do indicate this variation.

Outreach Program -- Student Teachers

The majority of student presenters rated the Outreach Program as "Effective" or "Very Effective" in increasing students' awareness in different areas (see Appendix 1 - Table 1). Percentages for rating the program as "Effective" or "Very Effective" ranged from 72% to 96% for the different areas.

Ninety-six percent of student teachers indicated that the teaching program was most effective in increasing the students' awareness of the connection between math / science to engineering. The program was also positively rated for increasing students' awareness in the importance of skills learned in high school aid in college which received "Effective" or "Very Effective" ratings by 88% of student teachers.

Awareness of the connection between math / science to engineering (Mean = 3.50) differed significantly from ratings given to careers not previously considered (Mean = 3.03), application of high school subjects to the real world (Mean = 3.05), and various paths available in STEM (Mean = 2.93), which were relatively lower rated aspects the teaching program (see - Table 1).

Table 1. Significance levels for the following question (Student Teacher response), **"Was this teaching program effective in increasing students' awareness in" (N = 92)**

Awareness Area Mean (*SD*)	Application HS subjects to the real world 3.05 (*0.7)*	Connection math / science to ENG. 3.50 (*0.59*)	Technical areas not previously known 3.06 (*0.75*)	Careers not previously considered 3.03 (*0.79*)	Various paths available in STEM 2.89 (*0.75*)	Diverse course work involved 3.10 (*0.71*)	Skills learned in HS that aid in college 3.29 (*0.67*)	What a career in ENG. Means 3.07 (*0.70*)
Application HS subjects to the real world 3.05 (*0.7)*	--	.001*	.507	.493	.299	.473	.156	.325
Connection math/science to ENG. 3.50 (*0.59*)	--	--	.060	.013*	.001*	.063	.113	.075
Technical areas not previously known 3.06 (*0.75*)	--	--	--	.693	.327	.817	.316	.784
Careers not previously considered 3.03 (*0.79*)	--	--	--	--	.573	.658	.319	.667
Various paths available in STEM 2.89 (*0.75*)	--	--	--	--	--	.319	.104	.371
Diverse coursework involved 3.10 (*0.71*)	--	--	--	--	--	--	.155	.908
Skills learned in HS that aid in college 3.29 (*0.67*)	--	--	--	--	--	--	--	.167
What a career in ENG. Means 3.07 (*0.70*)	**--**	**--**	**--**	**--**	**--**	**--**	**--**	--

* Indicates that differences between means are significant.
.05 or below indicates that differences between means are not likely due to chance.

In terms of activities, hands-on activities were rated most positively with ninety-one percent of the student presenters rating them as "Effective" or "Very Effective" in increasing students' interests in STEM fields (see Appendix One - Table 2). This activity was also rated as the most effective in each year of the Outreach results. However, none of the activities differed significantly from one another (see Table 2).

Table 2. Significance levels for the following question (Student Teacher response), **"Were the following activities effective in increasing students' interests in STEM fields?" (N = 92)**

	The hands-on activities	Sharing your experiences	Your presentation
The hands-on activities	--	.182	.122
Sharing your experience	--	--	.758
Your presentation	--	--	--

* Indicates that differences between means are significant.
.05 or below indicates that differences between means are not likely due to chance.

In describing students' learning experience (see Appendix One - Table 3), student teachers "Agreed" or "Strongly Agreed" eighty-eight percent that "the students were able to comprehend the concepts presented", the effectiveness of which was the highest agreed upon item among learning experiences. High school students having a better understanding of engineering was also rated highly, with ninety percent of student teachers having "Agreed" or "Strongly Agreed" to this statement. In addition, this perceived improvement understanding of engineering (Mean = 4.23) was rated significantly higher than the perception of students appreciating math and science better (Mean = 3.87). See Table 3.

With regards to one of the primary objectives of the project, 44% of the student presenters "Agreed" or "Strongly Agreed" that "the students are more encouraged to pursue a career in STEM fields" (see Table 3). Only a small percentage (3%) disagreed, but many of the student presenters (43%) chose "Neutral" in response to this statement. The students' ability to comprehend the concepts presented (Mean = 4.24) was also rated significantly higher than the students being more encouraged to pursue a career in STEM fields (Mean = 3.62), and significantly higher than students having a better appreciation of math / science (Mean = 3.87). See Appendix 3, Table 3. This observation is again consistent with each year's Outreach results, where "the students are more encouraged to pursue a career in STEM fields" was given the largest amount of neutral ratings.

Table 3. Significance levels for the following question (Student Teacher response), **"How well do the following describe the students' learning experiences?" (N = 92)**

Learning Experiences Mean	The students have a better appreciation of math/science 3.87	The students were able to comprehend the concepts presented 4.24	The students have a better understanding of how the subjects related to everyday living 4.04	The students were enthusiastic about the subjects 4.05	The students are more encouraged to pursue a career in STEM fields 3.62	Students have a better understanding of engineering 4.23
The students have a better appreciation of math/science 3.87	--	.012*	.214	.310	.255	.038*
The students were able to comprehend the concepts presented 4.24	--	--	.126	.201	.001*	.175
The students have a better understanding of how the subjects related to everyday living 4.04	--	--	--	.653	.040*	.251
The students were enthusiastic about the subjects 4.05	--	--	--	--	.012*	.603
The students are more encouraged to pursue a career in STEM fields 3.62	--	--	--	--	--	.007*

* Indicates that differences between means are significant.
.05 or below indicates that differences between means are not likely due to chance

Outreach Program -- High School Students

Students rated how beneficial several activities were for them. Consistent with the student teachers' perceptions, hands-on activities were rated as being the most beneficial by approximately eighty-two percent of the high school students indicating "A Lot" or "A Great Deal" (see Appendix One - Table 4). The student teachers sharing their real life experiences was also rated highly, with about seventy-seven percent rating the benefit from it as being "A Lot" or "A Great Deal."

In addition, hands-on activities (Mean = 4.05) were rated as being significantly more beneficial than exposure to STEM related professions (Mean = 3.15). The presenters sharing their real life experiences (Mean = 3.99) was also rated as being significantly more beneficial than exposure to STEM related professions, as was the real world application of the courses (Mean = 3.28). See Table 4.

Table 4. Significance levels for the following question (High School Student response), **"How beneficial were the following for you?"**

Activities Mean	**Exposure** to STEM related professions 3.15	Real world **Application** of the courses 3.28	The presenters sharing their real life experiences 3.99
Hands-on activities 4.05	.000*	.030*	.209
Exposure to STEM related professions 3.15	--	.020*	.024*
Real world **application** of the courses 3.28	--	--	.003*

* Indicates that differences between means are significant.
.05 or below indicates that differences between means are not likely due to chance.

Then, students were questioned about the degree to which their participation in the program had introduced them to technical areas and careers they might not have previously considered. Both technical areas (Mean = 3.39) and careers (Mean = 3.33) received moderate percentages around 46 percent for "A Lot" or "A Great Deal" (see Appendix One - Table 5). There was no significant difference between the two.

Objective 2: Interventions

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

Forty-eight students were selected to participate in this pilot project, twenty-four from UMBC and twenty-four from CCBC. Women and under-represented minorities were strongly recruited.

Twenty-four students were randomly assigned to the bridge, scholarship, mentoring, internship program; the other 24 were given the scholarship, mentoring and internship program only. Applications beyond the 48 were maintained as a control group. Students were 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 were selected from current high school seniors, recent high school graduates and transfer students from community colleges and four-year institutions. Once the eligible applications were determined, the students were ***randomly*** assigned into the intervention and control groups.

Academic Bridge Program

The bridge program provided a two-week, non-residential, on-campus summer experience for twenty-four of the STEM students. In addition, a faculty mentor within the student's area of interest provided monthly contacts for mentoring and advising throughout the academic year. Together, these program elements served as an academic boost to the "average" student. These students also received a scholarship and an internship as mentioned below. The following were 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 – for internship and service learning opportunities, etc.);
- Provide exposure for two-year and four-year students to the various professional societies (AIChE – American Institute of Chemical Engineers, ASME – American Society of Mechanical Engineers, SWE – Society of Women Engineers, Triangle Fraternity, etc.), recent graduates from CCBC and UMBC, and professionals from STEM-related professions, who were invited to come and discuss their job experiences.
- STEM research professors at UMBC were introduced and their undergraduate research students provided presentations so that the bridge students were exposed to exciting new areas, as well as met 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 three UMBC upper-class STEM students to serve as tutors, mentors, and guides on campus during the two weeks and provided an electronic mentoring component throughout the year.
- Provide academic review and enrichment to insure college preparedness in STEM areas, such as mathematics, physics, chemistry, engineering, computer skills, etc.
- Create an awareness of the issues of women and minorities in STEM areas of study.
- Provide team building activities to strengthen their leadership skills and teach them how to work as a team.

Curriculum for the program was created by teams of selected faculty and staff from the two institutions. The teaming allowed the faculty not only to work collaboratively on this project but also to build relationships for other opportunities for collaboration to benefit students. During the curriculum-planning phase, the faculty determined when it was appropriate to combine the two-year and four-year students for learning and when it was best to provide separate classes. Faculty found ways to break out of the traditional lecture mode and found innovative, applications-based learning opportunities for students using hands-on activities and emerging

technologies. This allowed 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 met once per month with their faculty mentor on their respective campuses in their area of interest, as identified during the summer bridge program. The summer bridge students met with their mentors on the last day of the program and participated in mentor/mentee training conducted by CWIT. The goal of the mentor/mentee meetings is to evaluate progress, identify additional resources needed to support student success, and develop a mentoring relationship with the students.

STEP Scholarship

All forty-eight students were given an annual $1000 scholarship, renewable for a second year if the student met the 2.5 GPA criteria, remains in a STEM career path and participates in the mentoring program. 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; and
- A scholarship is renewable for a second year because it is hoped that after the second year most students would have participated in an internship in their area of interest.

After the first year, some of the scholarship students were no longer eligible for the STEM program since they no longer were able to meet the eligibility criteria; applications from additional students to participate in the program were accepted and from which new students were accepted to participate in the program based on the same criteria used for the original selection of participants.

Internship Opportunity

This program provides a paid internship experience for 48 students following the completion of thirty credit hours in a STEM related field. Internships were provided in companies not currently hiring interns from UMBC to increase internship support and encourage the involvement of more businesses with UMBC and CCBC. UMBC's Shriver Center provided leadership for this portion of the project.

Assessment and Evaluation

The outcomes for Objective 2 are reflected in student retention in STEM majors, grades, and commitment to careers in STEM. Attitudes toward STEM were assessed by a questionnaire developed especially for this project by the evaluator and PI. Program participants meeting eligibility criteria were randomly assigned to one of three groups: (1) the full program (summer bridge program, scholarship, mentoring and internship), (2) a partial program (scholarship, mentoring and internship), and (3) no program (control group). Analysis of program outcomes compared 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?

STEP Program Results

Interventions - Summer Bridge

After completing the two-week STEP Summer Bridge program, students were asked to complete an evaluation form and the results of the survey are presented below (see also Appendix 2).

Effects of Summer Bridge Participation

Acquaintance with the Campus
Students felt participation in the program helped them to become better acquainted with UMBC's campus. In particular, students felt that participation in the program helped them "a lot" or "a great deal" to feel comfortable walking around the campus (72.7%) and feel more prepared than other incoming freshman (77.3%). Answering if participation helped students feel comfortable in the college transition, 59.1% answered "a lot" or "a great deal".

STEM Development
Students felt that participation in the program increased their understanding of STEM fields, and future careers. Participation in the program helped students increase confidence in their majors "a lot" or "a great deal" (71.4%). Also, 59.1% of students felt that the program helped them "a lot" or "a great deal" to increase knowledge of the internship program in their major.

Mentoring
Students felt comfortable speaking to their mentors. In addition, 72.7% of students felt that the program helped them "a lot" or "a great deal" to meet interesting people and find new connections.

Effectiveness of Summer Bridge Elements

The most beneficial aspect of the bridge program was UMBC student panel discussions, with 72.7% of students feeling they were beneficial "a lot " or "a great deal". The least beneficial aspect was the tour of businesses (31.8%). Discussions with recent graduates (68.2%), exposure to STEM related professions (68.2%), and instruction in study skills (66.6%) were also highly beneficial. The remaining elements of the summer bridge had an average of 50% for being beneficial "a lot" or "a great deal".

Overall Impression of STEP Summer Bridge Program

85.8% of the students felt that the STEP program was very good or excellent.

Effectiveness of the STEP [Scholarship, Internship and Mentoring] Program

As part of determining the ongoing effectiveness of the STEP Program, an Attitude Assessment questionnaire was developed to measure student attitudes towards STEM content, perceptions of helpful faculty relationships within the program, and career oriented outlook. This questionnaire was first given in the form of the Baseline Attitude Assessment conducted in the summer of 2003 with program awardees and wait-list control group students from UMBC. At the end of the Spring 2004 semester the assessment was administered again as the Year One Attitude

Assessment (with additions), with the intention of providing an objective measure of the effectiveness of the STEP Program in increase student's positions towards STEM material.

As a result of the inability to link some initial Baseline Attitude Assessments to individual participants, and the relatively low number of Year One Attitude Assessments received from CCBC, the ability to analyze the program's effectiveness was less than optimal. Common reasons for not returning Year One Attitude Assessments can be found in Table 5.

Table 5: Reasons for Non-response (Number of students per school in the five most common categories of students who did not return the Year One Evaluation.)

	UMBC	CCBC
Status	N	N
Did not receive Spring 2004 award	4	6
Did not receive Fall 2004 award	5	0
Eligible, but did not return Year One	1	9
Transfer to UMBC for Fall 2004	--	3
New Fall 2004 awardees (received only the Baseline)	--	12

We were, however, able to identify twelve individuals from the Baseline Attitude Assessments by matching them with demographic information and their Year One Attitude Assessment. In addition, four students from UMBC's control group had been awarded STEP Program admission in the past year. As a result of these students not having experienced a full year of the STEP Program, they have been considered as control group participants for the Year One Attitude Assessment. Including these students, the current control group for this year's evaluation consists of sixteen UMBC students.

One hundred twenty one students from UMBC and CCBC completed the Baseline Attitude Assessment, and fifty students from UMBC and CCBC completed the Year One Attitude Assessment. Of this sample, six STEP Program students who attended Summer Bridge were matched as having returned both a Baseline and a Year One evaluation. Eleven STEP Program students who did not attend Summer Bridge were matched as having returned both evaluations. Therefore, all statistical analyses included only these six students with Summer Bridge, eleven without Summer Bridge, and sixteen control group students. The participant demographics for these students can be found in Table 6.

The retention of the UMBC STEP students in STEM has been 72 % (to date). The retention of STEM students receiving the full program and the partial program are essentially the same (73 and 72 % respectively). The retention of students in STEM areas for the control group is 52 %. When comparing the original bridge and non-bridge students, ***none*** of the UMBC summer bridge students have left the university due to academic probation/suspension. [However, some of the STEP students that participated in the summer bridge have changed their majors to a non-STEM major.] Whereas 20 % of the non-bridge STEP students and 21 % of the control group have left

the university due to academic probation and/or suspension. The average GPA of the STEP students is 3.32 and the average GPA of the control group is 3.07.

Table 6: PARTICIPANT DEMOGRAPHICS (Number of Attitude Assessments returned, with percentages.)

		Baseline	Year One
UMBC STEP with Summer Bridge	Race %	20 % African American 80 % Caucasian	40 % African American 60 % Caucasian
	Gender %	50 % Male 50 % Female	40 % Male 60 % Female
	N	10	5
UMBC STEP without Summer Bridge	Race %	25 % African American 8.3 % Asian 58.3 % Caucasian 8.3 % Hispanic	87.5 % Caucasian 12.5 % Other
	Gender %	75 % Male 25 % Female	50 % Male 50 % Female
	N	12	8
UMBC Control	Race %	4.7 % African American 18.8 % Asian 76.3 % Caucasian	3.4 % African American 17.2 % Asian 75.9 % Caucasian 3.4 % Other
	Gender %	78.1 % Male 21.9 % Female	82.8 % Male 17.2 % Female
	N	64	29
CCBC STEP with Summer Bridge	Race %	50 % African American 10 % Asian 30 % Caucasian 10 % Other	50 % African American 50 % Caucasian
	Gender %	60 % Male 40 % Female	50 % Male 50 % Female
	N	10	2
CCBC STEP without Summer Bridge	Race %	28 % African American 12 % Asian 44 % Caucasian 8 % Hispanic 8 % Other	33.3 % African American 16.7 % Asian 50 % Caucasian
	Gender %	52 % Male 48 % Female	33.3 % Male 66.7 % Female
	N	25	6

The retention of the CCBC STEP students in STEM has been 42 %; at this time. Because of the low number of students identifying their degree area early on and applying to participate, CCBC is still working to identify their control group for comparison. One third of the CCBC STEP students have transferred to four-year academic institutions. Over 70 % of the STEP students at both UMBC and CCBC have completed their internship.

Evaluation of the Baseline Attitude Survey and Year One Attitude Assessment

As part of determining the effectiveness of the STEP Program, a STEM Attitude Assessment Questionnaire was developed to measure students' perceptions of STEM content, and eventually be used as an objective measure of the effectiveness of the STEP Program in increasing students' positions toward STEM material. Therefore, the Attitude Assessment Survey was conducted during the summer of 2003 and was conducted in the spring of 2004. The final Attitude Assessment Survey will be conducted during spring 2006 to insure that the students are given sufficient time to complete the internship portion of the program. Incentives are being provided to both the STEP students and control group students to encourage the students to complete the surveys.

The STEM Program Baseline Attitude Assessment and Year One Attitude Assessment for STEP students and control group students from UMBC was developed by CSCR at Loyola College, with the collaboration of the project's PI. One-hundred and twenty students from UMBC and CCBC completed the assessment, comprised of twenty STEP awardees who attended Summer Bridge, twenty-two STEP awardees who did not attend Summer Bridge, and sixty-four control group students from UMBC. Responses to all questions are based on a five-point scale, ordered as 1 = "Strongly Disagree", 2 = "Disagree", 3 = "Neutral", 4 = "Agree", and 5 = "Strongly Agree".

The assessment was divided into the following sections:

- How beneficial the following were: success in their STEM subject related to mentoring, the presence of positive STEM role models, and teacher and faculty helpfulness.
- How valuable and exciting studies in STEM subjects are perceived.
- How grades affect attitudes about studying STEM subjects.
- How students perceive the prospect of STEM careers.

Three scales composed of conceptually similar question groups were formed to help focus on response trends within overarching STEP Program goals. Each scale's inter-item reliability was tested prior to performing statistical tests, and were found to be reliable (Alpha = 0.66 - 0.81). The three scales are composed of the following questions from the Attitude Assessments:

STEM Major Scale

- "I feel enthusiastic about my STEM major."
- "I am likely to continue in my STEM major."
- "My major is too difficult." (R)
- "I think about switching my major." (R)

STEM Subjects Scale

- "I value STEM subjects."
- "STEM subjects are boring for me." (R)
- "I enjoy learning STEM subjects."
- "STEM subjects are difficult for me." (R)
- "STEM subjects are exciting for me."

STEM Helpful Relationships Scale

- "Having a mentor is vital to my success."
- "I have not had positive STEM role models." (R)
- "STEM role models have had a positive effect on me."

- "I think faculty involvement is important."
- "Good teachers are helpful to my success."
- "Teachers have helped me to understand difficult STEM concepts."
- "Good teachers in STEM subjects have helped me."

Note: Responses to questions marked with (R) were reverse scored [Items that are negatively worded in a scale are rescored in a positive] before statistical analysis to allow higher scores to indicate a greater amount of progress towards STEP Program goals for all questions.

The first section contains the same questions asked on the Baseline Attitude Assessment, with the same 5-point scale. The second section asks questions regarding the helpfulness of relationships formed within the STEM program, namely the mentoring relationship, and also uses a 5-point scale that is ordered as 1 = "Not at All", 2 = "A little", 3 = "Somewhat,", 4 = "A Lot," and 5 ="A Great Deal."

The second section of the assessment was divided into the following sections:

- How available, personable, and encouraging the mentor was.
- How well the mentor supplied information regarding research and career opportunities
- The presence of other supportive relationships related to school work and similarity of interests.

Open-ended written responses were provided for the following questions:

- Whether or not a summer internship in the student's field had been obtained, and if not what the student plans on doing.
- Current career goals and plans.
- The amount to which the stipend has been an incentive to stay in a STEM major and maintain grades and mentoring.
- If the summer bridge program was beneficial in preparation for academic success, for those students who participated.

The STEM Program Year One Attitude Assessment for wait-list control group participants attending UMBC contains all of the questions from the Year One Attitude Assessment for program participants, except it does not contain the second section of questions regarding STEM program relationships, and open-ended written responses assess:

- Whether or not a summer internship in the student's field had been obtained, and if not what the student plans on doing.
- Current career goals and plans.

An analysis of variance of the means assessed differences between STEP Program groups and controls on each evaluation question, and on each combined question scale. Sign tests were then used to access consistent patterns of responding in the hypothesized direction, i.e., that STEP Program groups would respond with consistently higher attitudes than the control group.

While few direct statistically significant contrasts between STEP with Summer Bridge, STEP without Summer Bridge, and control group students can be made based on their individual means, consistent differences between STEP Program students and controls were observed. Specifically, on several questions there appeared to be a consistent difference between STEP Program students and controls on the Year One evaluation, such that Program students tended to

show increased positive attitudes over controls. See Tables 7 through 11 for a question-by-question breakdown.

Table 7. STEM Major Scale Questions

	STEP Program with Summer Bridge (N = 6)		STEP Program without Summer Bridge (N = 11)		Control Group (N = 16)	
Questions	Baseline Mean(*SD*)	Year One Mean(*SD*)	Baseline Mean(*SD*)	Year One Mean(*SD*)	Baseline Mean(*SD*)	Year One Mean(*SD*)
I feel enthusiastic about my STEM major *	4.17 (*0.41*)	4.17 (*1.17*)	4.73 (*0.47*)	4.64 (*0.67*)	4.75 (*0.45*)	4.56 (*0.51*)
I am likely to continue in my STEM major *	4.33 (*0.82*)	4.33 (*0.82*)	4.63 (*0.50*)	4.72 (*0.47*)	4.62 (*0.50*)	4.44 (*0.63*)
My major is difficult (R)	3.17 (*0.98*)	3.17 (*0.75*)	3.82 (*0.75*)	3.64 (*0.67*)	3.56 (*0.63*)	3.57 (*0.96*)
I think about switching my major (R) *	3.00 (*0.89*)	4.00 (*0.63*)	4.00 (*1.09*)	4.36 (*0.67*)	3.88 (*0.80*)	3.37 (*1.06*)

Table 8. STEM Subjects Scale Questions

	STEP Program with Summer Bridge (N = 6)		STEP Program w/o Summer Bridge (N = 11)		Control Group (N = 16)	
Questions	Baseline Mean (*SD*)	Year One Mean (*SD*)	Baseline Mean (*SD*)	Year One Mean (*SD*)	Baseline Mean (*SD*)	Year One Mean (*SD*)
I value STEM subjects *	4.00 (*0.00*)	4.00 (*0.63*)	4.18 (*0.60*)	4.55 **1** (*0.52*)	4.50 (*0.52*)	4.25 **2** (*0.68*)
I enjoy learning STEM subjects *	3.67 (*1.50*)	4.33 **1** (*0.52*)	4.18 (*0.60*)	4.27 **1** (*0.78*)	4.56 (*0.63*)	4.13 **2** (*0.96*)
STEM subjects are exciting to me	4.50 (*0.55*)	4.00 (*0.63*)	.18 (*0.60*)	4.18 (*0.75*)	4.44 (*0.51*)	4.20 (*0.68*)
I'm smart in STEM subjects *	3.83 (*0.41*)	3.67 (*0.52*)	4.18 (*0.60*)	4.00 (*0.89*)	4.31 (*0.70*)	3.93 (*0.57*)
STEM subjects are boring me (R)	4.50 (*0.55*)	4.33 (*0.52*)	4.37 (*0.50*)	4.00 (*0.77*)	4.56 (*0.51*)	4.50 (*0.52*)
STEM subjects are difficult for me (R) *	3.33 (*0.82*)	3.17 (*0.98*)	3.82 (*0.87*)	3.64 (*0.81*)	4.06 (*0.57*)	3.56 (*0.81*)

Note: Scale ranges from 1 to 5 (low to high).

* Combined STEP Program students had significantly more positive change in attitudes over time than control group students.

1, **2** indicate that the change between Baseline and Year One is significantly different between groups with different numbered superscripts.

(R) Responses were reverse coded so that higher scores indicate higher degrees of agreement, consistent with STEP project goals.

Table 9. STEM Helpful Relationships Scale Questions

Questions	STEP Program with Summer Bridge (N = 6)		STEP Program w/o Summer Bridge (N = 11)		Control Group (N = 16)	
	Baseline Mean (*SD*)	Year One Mean (*SD*)	Baseline Mean (*SD*)	Year One Mean (*SD*)	Baseline Mean (*SD*)	Year One Mean (*SD*)
Having a mentor is vital to my success *	3.16 (*1.60*)	4.33 (*0.52*)	3.63 (*0.67*)	4.36 (*0.92*)	3.13 (*0.81*)	3.50 (*0.97*)
STEM role models have had a positive effect on me *	4.00 (*0.00*)	4.17 (*0.41*)	4.09 (*0.70*)	4.27 (*0.78*)	4.38 (*0.80*)	3.87 (*0.82*)
I think faculty involvement is important *	4.50 (*0.55*)	4.50 (*0.55*)	4.36 (*0.50*)	4.36 (*0.50*)	4.25 (*0.45*)	4.06 (*0.68*)
Good teachers are helpful to my success *	4.83 (*0.41*)	4.67 (*0.52*)	4.72 (*0.47*)	4.64 (*0.50*)	4.81 (*0.40*)	4.44 (*0.73*)
Teachers have helped me to understand difficult STEM concepts *	3.67 (*0.82*)	3.67 (*0.82*)	4.27 (*0.78*)	4.36 (*0.67*)	4.25 (*0.57*)	4.25 (*0.68*)
Good teachers in STEM subjects have helped me *	3.83 (*0.41*)	4.33 (*0.52*)	4.27 (*0.65*)	4.27 (*0.65*)	4.44 (*0.63*)	4.56 (*0.51*)
An advisor has helped me with my career planning	2.67 (*1.21*)	3.17 (*1.17*)	3.00 (*1.09*)	3.72 (*0.90*)	2.69 (*1.19*)	3.38 (*0.96*)
I have not had positive STEM role models (R) *	3.50 (*1.05*)	4.67 **1** (*0.52*)	3.82 (*0.98*)	4.18 **1** (*0.87*)	4.25 (*0.77*)	3.69 **2** (*1.14*)

Note: Scale ranges from 1 to 5 (low to high).

* Combined STEP Program students had significantly more positive change in attitudes over time than control group students.

1, **2** indicate that the change between Baseline and Year One is significantly different between groups with different numbered superscripts.

(R) Responses were reverse coded so that higher scores indicate higher degrees of agreement, consistent with STEP project goals.

Table 10. STEM Careers Questions

Questions	STEP Program with Summer Bridge (N = 6)		STEP Program w/o Summer Bridge (N = 11)		Control Group (N = 16)	
	Baseline Mean (*SD*)	Year One Mean (*SD*)	Baseline Mean (*SD*)	Year One Mean (*SD*)	Baseline Mean (*SD*)	Year One Mean (*SD*)
Many career opportunities are available in STEM careers	4.33 (*0.52*)	4.17 (*0.75*)	4.72 (*0.47*)	4.63 (*0.67*)	4.56 (*0.63*)	4.50 (*0.63*)
An advisor has helped me with my career planning	2.67 (*1.21*)	3.17 (*1.17*)	3.00 (*1.09*)	3.72 (*0.90*)	2.69 (*1.19*)	3.38 (*0.96*)
I am familiar with STEM professional societies *	2.67 (*1.36*)	3.67 (*1.03*)	3.09 (*1.36*)	3.36 (*1.29*)	2.88 (*1.20*)	3.19 (*0.83*)
I intend to pursue a career in STEM *	4.17 (*0.41*)	4.50 (*0.55*)	4.63 (*0.50*)	4.64 (*0.50*)	4.56 (*0.51*)	4.56 (*0.51*)

Note: Scale ranges from 1 to 5 (low to high).
* Combined STEP Program students had significantly more positive change in attitudes over time than control group students.

Table 11. Grades in STEM Subjects Questions

Questions	STEP Program with Summer Bridge (N = 6)		STEP Program without Summer Bridge (N = 11)		Control Group (N = 16)	
	Baseline Mean (*SD*)	Year One Mean (*SD*)	Baseline Mean (*SD*)	Year One Mean (*SD*)	Baseline Mean (*SD*)	Year One Mean (*SD*)
Good grades encourage me *	4.33 (*0.52*)	4.83 [1] (*0.41*)	4.36 (*0.67*)	4.64 [1] (*0.50*)	4.62 (*0.50*)	4.31 [2] (*0.48*)
I'm easily discouraged by low grades (R) *	3.67 (*1.03*)	3.50 (*1.05*)	3.64 (*0.81*)	3.18 (*1.17*)	3.57 (*1.03*)	3.25 (*0.86*)

Note: Scale ranges from 1 to 5 (low to high).
* Combined STEP Program students had significantly more positive change in attitudes over time than control group students.
(R) Responses were reverse coded so that higher scores indicate higher degrees of agreement, consistent with STEP project goals.
1, **2** indicate that the difference between Baseline and Year One is statistically significant between groups with different numbered superscripts.

Analysis of Variance of the Means

In order to further investigate consistently observed differences between STEP Program students and controls, an analysis of variance of the means revealed that four questions had statistically significant differences between the Baseline and Year One evaluations for STEP students and control group students. These questions asked about the value of STEM subjects, the enjoyment of learning STEM subjects, not having had positive STEM role models, and how encouraging good grades are.

Sign Tests between Summer Bridge, Non-Bridge, and Control Group Students

We investigated whether the differences between STEP Program students and controls were consistently in the hypothesized direction (i.e., the STEP Program groups consistently scored higher than the control group). First, we calculated the differences between the Baseline and the Year One evaluations for each group. Then we compared how many times one of the STEP groups experienced a larger change in the positive direction than the control group. We used the sign test to determine whether the number of comparisons consistent with the hypothesis differed from chance (i.e., was greater than 50%).

A sign test indicated a statistically significant pattern for the STEP students with Summer Bridge, who changed more in a positive direction than control group students on 17 of the 24 questions. Another sign test indicated a statistically significant pattern for the STEP students without Summer Bridge, who changed more in a positive direction than control group students on 17 of the 24 questions. However the 17 questions which differed significantly were not the same as STEP students with Summer Bridge.

We performed another sign test to determine whether there was a consistent pattern in comparing STEP with Summer Bridge and without Summer Bridge; there was no significant difference, indicating that STEP students are equivalent. A sign test then compared all STEP students combined with control group students, and revealed a statistically significant pattern; on 18 of 24 questions, STEP students changed more in a positive direction than control group students.

Program Differences Analyzed Using Combined Question Scales

An analysis of variance of the means comparing STEP with Summer Bridge, STEP without Summer Bridge, and the control group on each of the three question scales revealed no statistically significant differences in the change over time. In order to combine STEP Program groups, and thus increase statistical power, an analysis of variance of the means was performed comparing STEP with and without Summer Bridge on each scale; these revealed no statistically significant differences, and thus STEP groups are equivalent. An analysis of variance of the means comparing the combined STEP Program group with the control group revealed a statistically significant difference for the STEM Subjects scale, such that STEP students held more positive attitudes towards STEM subjects than control group students (see Table 12). Again, we used the sign test to determine whether there was a consistent pattern in the hypothesized direction, i.e., the STEP Program groups consistently scored higher than the control group. Both STEP groups showed a more positive than the control group students on each scale (6 of 6 comparisons in the predicted direction); this result is statistically significant.

Table 12: COMBINED QUESTION SCALES (Means and Standard Deviations for combined question scales.)

	STEP with Summer Bridge Mean (*SD*) (N = 6)		STEP without Summer Bridge Mean (*SD*) (N = 11)		Control Group Mean (*SD*) (N = 16)	
	Baseline	Year One	Baseline	Year One	Baseline	Year One
STEM Major Scale	3.66 (*0.65)*	3.92 (*0.49*)	4.29 (*0.55*)	4.34 (*0.46*)	4.20 (*0.33*)	4.08 (*0.64*)
STEM Subjects Scale *	4.00 (*0.42*)	3.96 (*0.46*)	4.15 (*0.54*)	4.13 (*0.61*)	4.43 (*0.40*)	4.14 (*0.46*)
STEM Helpful Relationships Scale	3.64 (*0.37*)	4.00 (*0.25*)	3.85 (*0.34*)	3.99 (*0.40*)	3.82 (*0.31*)	3.80 (*0.38*)

* Combined STEP Program students maintained statistically significant positive attitudes between evaluations compared with control group students, whose positive attitudes significantly decreased.

Due to the small sample size, differences which might be significant in a larger study did not reach significance here. Therefore, we examined the effect size so see how much of an effect the program had. An effect size estimate revealed a medium effect of the STEP Program on increasing positive attitudes towards helpful relationships within the STEM major. The effect of STEP on positive perceptions of STEM subjects was also medium, while the effect of STEP on positive perceptions of the STEM major itself was small.

These findings indicate an effect of the STEP Program, such that positively effecting mentor and role model relationships, as well as the value and interest in STEM subjects, would subsequently be expected to positively influence perceptions of the STEM major's difficulty and one's ability to continue with major.

Year One Attitude Assessment Follow-up Questions

The helpfulness of relationships within the STEP Program during the past year as assessed with eight additional questions on the Year One Attitude Assessment. Seven Year One evaluations from STEP students with Summer Bridge were returned, and fourteen from STEP students without Summer Bridge were returned.

The majority of responses indicated positive attitudes towards the Program, including the quality of mentoring relationships was rated overall as quite high by Summer Bridge Program STEP students and Non-Bridge STEP students, as well as their mentor's promotion of support networks (See Table 13).

However, mentors on average were rated moderately on having provided research and career opportunities, as was having a role model to look up to and help with maintaining focus, and the ability of students to find a friend with similar interests.

In terms of the open-ended responses provided by program students (Summer Bridge and Non-Bridge), a majority responded that they had not received an internship during the summer of 2004, and instead indicated that they took other jobs instead. The reasons for not obtaining an

internship varied in the qualitative responses, which are not included here. In addition, the stipends that students had received were noted as valuable by a majority of students.

Of the students who attended the Summer Bridge Program, all agreed that it was motivational. All responding students indicated that they would be full-time with a qualifying STEM major in Fall 2004 and that they would renew their STEM scholarship.

Table 13: Means and Standard Deviations for Year One Evaluations Follow-up Questions (Reponses to question "After participation in the program, did you…?")

	STEP Program with Summer Bridge (N = 7)	STEP Program without Summer Bridge (N = 14)
Questions	Mean (*SD*)	Mean (*SD*)
Find that your mentor was readily available	4.29 (0.49)	4.29 (0.73)
Find that your mentor listened to what you had to say	4.57 (0.53)	4.71 (0.47)
Build a relationship with someone who you can turn to when you need help with school	4.00 (0.58)	3.93 (1.27)
Receive encouragement from your mentor	4.29 (0.49)	4.43 (0.85)
Find a friend who shares similar interests	2.71 (1.11)	3.57 (1.50)
Have a role model who you could look up to and help maintain your focus	3.14 (1.07)	3.57 (1.45)
Receive research or career opportunities from your mentor	2.86 (1.21)	2.64 (1.22)
Find that your mentor promoted support networks	3.57 (0.79)	3.86 (1.17)

Summary

This paper describes a pilot program 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 and summer bridge programs 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. However it has been our experience on our campus that these enrichment programs have not been available to the "average" students. Students, and particularly women and minorities, haven't been given or taken the opportunity to explore more rigorous science, technology, and engineering career areas.[12, 13] Students too often come from high schools that fail to provide the academic preparation needed and give up too quickly on the opportunities available.[14] 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? This project gives us a glimpse of an answer to these questions and begins a new focus on how we can best use our scarce resources to address the needs of all of our STEM students.

Student Outreach Program

In examining the results of the STEM Program Outreach Questionnaire for High School Students, several important findings were noted.

- Both student teachers and high school students indicated that hands-on activities were the most positive activities.
- Student teachers rated awareness of the connection between math / science and engineering to be most effectively influenced.
- Ninety-six percent of student teachers perceived that the students were able to comprehend the concepts presented, and specifically that understanding engineering was perceived as significantly better than better appreciating math and science in general.
- Forty-four percent of UMBC student teachers "Agreed" or "Strongly Agreed" that high school students were encouraged to pursue STEM careers.
    - However, comprehension of the presentation was perceived by student teachers to be significantly higher than the effect of encouragement for high school students to pursue STEM careers.
    - High school students themselves rated the hands-on presentation activities significantly more beneficial than exposure to STEM related careers, and significantly more beneficial than real world applications of STEM courses.

The current results indicate that the Outreach program is largely meeting its goals for increasing awareness and appreciation of engineering and STEM subjects. With regards to one of the primary objectives of the project, almost half of the student presenters were in agreement that "the students are more encouraged to pursue a career in STEM fields".

Lastly, while UMBC student teachers were rated highly on communicating their histories related to studying engineering, an increased focus on communicating college post-graduation plans would be recommended, as it has remained significantly lower than history in ratings from year one to year two of the program.

STEM Retention

A review of the retention data for the students receiving the STEP program interventions appears to have a positive impact.

- UMBC STEP student retention in STEM is 72 %
- UMBC control group retention in STEM is 52 %
- None of the students who attended the STEP Summer Bridge program have left the university due to academic probation and/or suspension [versus 20 % for the non Summer Bridge STEP students and 21 % of the control group]. Although some of the Summer Bridge student have changed their major to a non STEM field, they have all been successful in their academic pursuits.
- Average STEP student GPA is 3.32 versus 3.07 for the control group

STEM Evaluation of Student Attitudes

In examining the results of the STEM Baseline Attitude Assessment and the STEM Year One Attitude Assessment, several findings were noted.

- First, overall the majority of Program and control group students rated various facets of their STEM experiences highly, particularly the STEM major, STEM subjects in general, the helpfulness of teachers, and the prospects of STEM careers.
- Second, STEP participants exhibited small improvements on most of the specific outcome questions, compared to the control group.
- When items were combined into composite scores, STEP participants exhibited statistically significant improvement compared to the control group.
- There were not enough participants in the STEM program who completed the follow-up assessment to be able to distinguish potential differences between those who did or did not participate in the Summer Bridge program.

Bibliographic Information

1. Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century. 30 Apr. 2002 <http://www.ed.gov/americacounts/glenn/toolate-execsum.html>.
2. "Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology." Report of the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development. September 2000, pp. iii, 1.
3. In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research Priorities to Enhance Participation by Underrepresented Minorities. *American Association for the Advancement of Science and the National Science Foundation* (HRD 9817536, A002), Dec. 2001, p.2.
4. Gallaher, J. and F. Pearson, "Women's Perceptions of the Climate in Engineering Technology Programs," *Journal of Engineering Education*, vol. 89, no.3, July 2000, pp. 309-314.
5. Vesilind, P.A., "Mentoring Engineering Students: Turning Pebbles into Diamonds," *Journal of Engineering Education*, vol. 90, no. 3, July 2001, pp. 407-411.
6. Chesler, N.C. and M.A. Chesler, "Gender-Informed Mentoring Strategies for Women Engineering Scholars: On Establishing a Caring Community," *Journal of Engineering Education,* vol. 91, no.1, Jan. 2002, pp. 49-55.
7. Etzkowitz, H, C. Kemelgor, C., and B. Uzzi, *Athena Unbound: The Advancement of Women in Science and Technology,* Cambridge University Press, Cambridge, UK, 2000.
8. Besterfield-Sacre, M., M. Moreno, L.J. Shuman, and C.J. Atman, "Gender and Ethnicity Differences in Freshmen Engineering Student Attitudes: A Cross-Institutional Study," *Journal of Engineering Education*, vol. 90 no. 4, Oct. 2001, pp. 477-488.
9. Splitt, F.G. "Engineering Education Reform: A Trilogy," *International Engineering Consortium*, Chicago, IL. Oct. 2002.
10. Ibid, p.12.
11. Ross, J.M. and T.M. Bayles, "Incorporating High School Outreach into Chemical Engineering Courses", invited paper for publication in Chemical Engineering Education, Volume 37, Number 3, 2003, pp. 184-187.
12. Seymour, E. and N.M. Hewitt, *Talking About Leaving: Why Undergraduates Leave the Sciences,* Westview Press, Oxford, 1997.
13. Thom, M., *Balancing the Equation: Why are Women and Girls in Science, Engineering, and Technology?,* The National Council for Research on Women, New York, NY, 2001.
14. American Association of University Women Educational Foundation. Gender Gaps: Where Schools Still Fail Our Children. Washington, D.C.: American Association of University Women Educational Foundation, 1998.

Appendix ONE

Table Table 1. Student teacher responses to the question, **"Was this teaching program effective in increasing students' awareness in:" (N = 92)**

	Not at all effective %	Somewhat effective %	Effective %	Very effective %	Mean (out of 4)
Connection of math / science to engineering	0	4	41	55	3.50
The diverse coursework that is involved	1	18	49	32	3.10
What a career in engineering means	2	22	51	25	3.07
Technical areas that might not previously have been known	1	22	49	28	3.06
Skills learned in high school aid in college	0	12	51	37	3.29
Careers that might not have previously been considered	4	19	49	28	3.03
The application of high school subjects to the real world	1	18	59	22	3.05
The various paths that are available in STEM fields	1	27	50	22	2.93

Table 2. Student teacher responses to the question, **"Were the following activities effective in increasing the student's interests in STEM fields?" (N = 92)**

	Not at all effective %	Somewhat effective %	Effective %	Very effective %	Mean (out of 4)
The hands-on activities	0	9	38	53	3.45
Sharing your experience	1	14	39	46	3.29
Your presentation	0	13	49	41	3.25

Table 3. Student teacher responses to the question, **"How well do the following describe the students' learning experience:" (N = 92)**

	Strongly Disagree %	Disagree %	Neutral %	Agree %	Strongly Agree %	Mean (out of 5)
The students were able to comprehend the concepts presented	0	0	12	52	36	4.24
The students have a better understanding of engineering	0	5	4	55	36	4.23
Students were enthusiastic about the subjects	0	4	20	42	34	4.05

The students have a better understanding of how the subject relate to everyday living	0	3	14	59	24	4.04
The students have better appreciation of math/science	0	1	20	70	9	3.87
The students are more encouraged to pursue a career in STEM fields	0	3	43	32	12	3.62

Table 4. High School student responses to the question, **"How beneficial were the following for you?"**

	Not at all %	A little %	Somewhat %	A lot %	A great deal %	Mean (out of 5)
Hands-on activities * (N = 671)	0.8	4.3	19.2	40.5	35.2	4.05
The presenters sharing their real life experiences * (N = 668)	1.9	5.1	19.6	39.0	34.4	3.99
Real world application of the courses (N = 668)	2.2	7.9	27.1	36.3	26.5	3.28
Exposure to STEM related professions (N = 667)	3.8	10.1	26.4	37.4	22.3	3.15

Note. Asterisk (*) indicates a significant difference exists between high schools on responses to the question.

Table 5. High School student responses to the question, **"Did participation in the program introduce you to:"**

	Not at all %	A little %	Somewhat %	A lot %	A great deal %	Mean (out of 5)
Technical areas you might not have previously considered? (N = 672)	8.9	8.3	37.1	26.7	19.0	3.39
Careers you might not have considered? (N = 670)	9.7	12.2	31.9	27.9	18.3	3.33

APPENDIX TWO

SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) TALENT EXPANSION (STEP) PROGRAM – SUMMER BRIDGE QUESTIONNAIRE

This is a voluntary anonymous survey (do not write your name on the form). Please answer as honestly as possible.

DIRECTIONS:
The following statements are about the summer bridge program. Please read each statement carefully and rate what you think about it. Then circle the appropriate response.

Not=Not at all L=A Little S=Somewhat Lot=A Lot G=A Great Deal

DID YOUR PARTICIPATION IN THE PROGRAM HELP YOU TO?

	Not	L	S	Lot	G	*Mean*
Develop more of a interest in science courses	***4.5%***	***4.5%***	***18.2%***	***59.1%***	***13.6%***	*3.73*
Improve your academic career goals	***0.0%***	***4.5%***	***36.4%***	***36.4%***	***22.7%***	*3.77*
Learn more about your major	***0.0%***	***4.5%***	***27.3%***	***36.4%***	***31.8%***	*3.95*
Get a better understanding of your future career	***0.0%***	***13.6%***	***22.7%***	***45.5%***	***18.2%***	*3.68*
Learn about the different fields of STEM	***0.0%***	***0.0%***	***18.2%***	***36.4%***	***45.5%***	*4.27*
Establish a better understanding of STEM professions	***0.0%***	***4.5%***	***36.4%***	***27.3%***	***31.8%***	*3.86*
Build a relationship with someone who shares your ideas and passions	***4.5%***	***18.2%***	***13.6%***	***40.9%***	***22.7%***	*3.59*
Feel comfortable talking to your mentor	***0.0%***	***0.0%***	***27.3%***	***40.9%***	***31.8%***	*4.05*
Find a friend who can help when you need it	***9.1%***	***9.1%***	***18.2%***	***22.7%***	***40.9%***	*3.77*
Have a role model who you could look up to and help maintain your focus	***0.0%***	***9.1%***	***18.2%***	***54.5%***	***18.2%***	*3.82*
Get help with scheduling	***0.0%***	***4.5%***	***31.8%***	***13.6%***	***50.0%***	*4.09*
Gain better time management skills	***0.0%***	***4.5%***	***36.4%***	***22.7%***	***36.4%***	*3.91*
Feel comfortable walking around campus	***4.5%***	***4.5%***	***18.2%***	***40.9%***	***31.8%***	*3.91*
Feel more prepared than other incoming freshman	***4.5%***	***9.1%***	***9.1%***	***40.9%***	***36.4%***	*3.95*
Improve knowledge of campus resources	***0.0%***	***13.6%***	***9.1%***	***31.8%***	***45.5%***	*4.09*
Feel comfortable in the college transition	***0.0%***	***4.5%***	***36.4%***	***40.9%***	***18.2%***	*3.73*

	Not	L	S	Lot	G	*Mean*
Meet interesting people and find new connections	***0.0%***	***9.1%***	***18.2%***	***50.0%***	***22.7%***	*3.86*
Increase knowledge of the internship program in your major	***0.0%***	***18.2%***	***22.7%***	***40.9%***	***18.2%***	*3.59*

Note. Responses were based on a 5 point Likert-Scale (1 =*Not at All,* 2 =*A Little,* 3 =*Somewhat,* 4 =*A Lot,* 5 =*A Great Deal.)*

DIRECTIONS:

The following statements are about the summer bridge program. Please read each statement carefully and rate what you think about it. Then circle the appropriate response.

Not=Not at all L=A Little S=Somewhat Lot=A Lot G=A Great Deal

HOW BENEFICIAL WERE THE FOLLOWING FOR YOU?

	Not	L	S	Lot	G	*Mean*
Tour of campus	***4.5%***	***9.1%***	***45.5%***	***31.8%***	***9.1%***	*3.32*
Tour of businesses	***9.1%***	***22.7%***	***36.4%***	***18.2%***	***13.6%***	*3.05*
UMBC student panel discussions	***0.0%***	***9.1%***	***18.2%***	***50.0%***	***22.7%***	*3.86*
Hands on academic activities	***0.0%***	***4.5%***	***45.5%***	***40.9%***	***9.1%***	*3.55*
Academic review	***0.0%***	***0.0%***	***36.4%***	***50.0%***	***13.6%***	*3.77*
Exposure to STEM related professions	***0.0%***	***0.0%***	***31.8%***	***31.8%***	***36.4%***	*4.05*
Discussions with recent graduates	***0.0%***	***0.0%***	***31.8%***	***36.4%***	***31.8%***	*4.00*
Academic enrichment	***0.0%***	***9.5%***	***33.3%***	***33.3%***	***23.8%***	*3.71*
Lunch with graduates/professionals	***9.5%***	***0.0%***	***38.1%***	***23.8%***	***28.6%***	*3.62*
Presentations of undergraduate research	***4.8%***	***9.5%***	***38.1%***	***33.3%***	***14.3%***	*3.43*
UMBC upper-class guides	***0.0%***	***4.8%***	***42.9%***	***33.3%***	***19.0%***	*3.67*
Exposure to current STEM research issues	***4.8%***	***9.5%***	***42.9%***	***23.8%***	***19.0%***	*3.43*
Instruction in academic skills such as:						
Study skills	***0.0%***	***0.0%***	***33.3%***	***33.3%***	***33.3%***	*4.00*
Time management	***0.0%***	***0.0%***	***47.6%***	***14.3%***	***38.1%***	*3.90*
Test taking strategies	***0.0%***	***14.3%***	***38.1%***	***23.8%***	***23.8%***	*3.57*
Communication skill development	***0.0%***	***14.3%***	***38.1%***	***33.3%***	***14.3%***	*3.48*
Problem solving	***0.0%***	***4.8%***	***47.6%***	***28.6%***	***19.0%***	*3.62*

DID YOUR PARTICIPATION IN THE PROGRAM HELP YOU TO?

	Not	**L**	**S**	**Lot**	**G**	*Mean*
Increase my feelings of confidence	***0.0%***	***4.8%***	***42.9%***	***38.1%***	***14.3%***	*3.62*
Increase my interest in STEM careers	***0.0%***	***0.0%***	***42.9%***	***33.3%***	***23.8%***	*3.81*
Increase my confidence in my major	***0.0%***	***0.0%***	***28.6%***	***47.6%***	***23.8%***	*3.95*
Resolve to have a STEM career	***0.0%***	***4.8%***	***23.8%***	***42.9%***	***28.6%***	*3.95*

Note. Responses were based on a 5 point Likert-Scale (1 =*Not at All,* 2 =*A Little,* 3 =*Somewhat,* 4 =*A Lot,* 5 =*A Great Deal.)*

OVERALL HOW WOULD YOU RATE YOUR IMPRESSION OF THE STEP PROGRAM?

Excellent: ***42.9%*** Very Good: ***42.9%*** Good: ***14.3%*** Fair: ***0.0%*** Poor: ***0.0%*** *Mean=1.71*

Note. Responses were based on a 5 point Likert-Scale (1 =*Excellent,* 2 =*Very Good,* 3 =*Good,* 4 =*Fair,* 5 =*Poor.)*

APPENDIX THREE:

RESULTS OF BASELINE ATTITUDE SURVEYS FOR ORIGINAL PARTICIPANTS IN BRIDGE PROGRAM (Summer 2003)

Table 1. **Enthusiasm Towards STEM Subjects**. *Responses to the statement "check the box that best describes how you feel about the following:"*

Question	Bridge Program Mean (*SD*)*	Non-Bridge Program Mean (*SD*)*	Control Group for UMBC Mean (*SD*)**
1. I feel enthusiastic about my STEM major	1.65 *(.489)*	1.55 *(.605)*	1.70 *(.497)*
2. I am likely to continue in my STEM major	1.75 *(.550)*	1.50 *(.513)*	1.67 *(.510)*
3. I expect to do well in a STEM area	1.70 *(.470)*	1.65 *(.489)*	1.52 *(.536)*
4. My major is too difficult	-.550 *(.944)*	-.500 *(.761)*	-.400 *(1.21)*
5. I think about switching my major	-.950 *(1.05)*	-.950 *(.759)*	-.867 *(1.08)*
6. I value STEM subjects	1.50 (*.513)*	1.30 *(.657)*	1.55 *(.565)*
7. STEM subjects are boring to me	-1.60 *(.598)*	-1.55 *(.510)*	-1.47 *(.833)*
8. I enjoy learning STEM subjects	1.20 *(1.06)*	1.25 *(.716)*	1.57 *(.592)*
9. STEM subjects are difficult to me	-.700 *(.801)*	-.700 *(.864)*	-.500 *(1.17)*
10. STEM subjects are exciting to me	1.50 *(.607)*	1.00 *(1.00)`*	1.33 *(.629)*
11. Good Grades encourage me	1.75 *(.444)*	1.55 *(.686)*	1.57 *(.532)*
12. I am smart in STEM subjects	1.05*(.605)*	.950 *(.604)*	1.23 *(.673)*
13. I am easily discouraged by low grades	.000 *(1.30)*	-.450 *(.825)*	-.017 *(1.32)*

Table 2. **Feelings Towards Faculty Involvement**. *Responses to the statement "check the box that best describes how you feel about the following:"*

Question	Bridge Program Mean (*SD*)*	Non-Bridge Program Mean (*SD*)*	Control Group for UMBC Mean (*SD*)**
14. Having a mentor is vital to my success	.450 *(1.05)*	.600 *(1.05)*	.667 *(1.17)*
15. I have not had positive STEM role models	-.400 *(.995)*	-.900 *(.718)*	-.750 *(1.17)*
16. STEM role models have had a positive effect on me	.800 *(.615)*	.750 *(.786)*	1.21 *(.976)*
17. I think faculty involvement is important	1.40 *(.680)*	1.45 *(.510)*	1.40 (.558)
18. Good teachers are helpful to my success	1.85 (.366)	1.75 *(.444)*	1.72 (.454)
19. Teachers have helped me to understand difficult STEM concepts	1.10 *(.852)*	1.00 *(.725)*	1.30 *(.743)*
20. Good teachers in STEM subjects have helped me	1.30 *(.656)*	.900 *(.641)***	1.51 *(.676)****
21. Many career opportunities are available in STEM careers	1.40 *(.680)*	1.55 *(.510)*	1.65 *(.515)*
22. An advisor has helped me with career planning	-.050*(1.35)*	.200 *(1.11)*	.033 *(1.23)*
23. I am familiar with STEM professional societies	-.150 *(1.27)*	-.250 *(.786)*	.1167 *(1.21)*
24. I intend to pursue a career in STEM	1.65 *(.489)*	1.60 *(.598)*	1.61 *(.555)*

Note. For all tables, Responses were based on a 5 Point Likert Scale (2= *Strongly Agree,* 1= *Agree,* 0= *Neutral,* -1= *Disagree,* -2= *Strongly Disagree*).

* N=20 for Bridge Program; N=20 for Non-Bridge Program; These group sizes are a result of currently identifying STEP participants.

** N=60 for UMBC control group. CCBC is currently in the process of forming a control group for STEP.

*** Indicates a significant difference was found between conditions (In this case, most likely due to chance)