Abstract

The National Aeronautical and Space Administration (NASA) supported summer engineering "Bridge" program is designed for students who have applied and have been accepted to join the University of Maryland Eastern Shore (UMES) as freshman in the fall semester. Furthermore, it is directed primarily towards students who have expressed an interest in pursuing engineering degree but have relatively low GPA and SAT scores. The program endeavors to "bridge" the gap between high school preparation and expected standards of engineering freshmen for these marginally accepted engineering majors. The program is also sensitive to the disproportionate number of minorities and women who pursue engineering. The program includes provision for financial incentives by way of tuition scholarships to be provided to promising students. The program includes academic as well as life-skills, social, and motivational components that would help the targeted students to deal with rigors of engineering education. The academic component of the program emphasizes the following: mathematics concepts and skills to solve practical problems; comprehension of physical principles; engineering problem solving and teamwork and development of communication skills.

UMES mathematics, science and engineering faculty members are directly involved in curriculum development and providing the enrichment activities. Engineering undergraduate students who are in good academic standing act as project advisors for design activities and software efforts integrated with the program. SEBP students also look up at them role models and can approach them for advise and counseling. A graduate student in mathematics and computer sciences provides additional tutoring support and is also responsible for enhancement of the project website.

I. Introduction

UMES is a historically black university and the 1890 Land Grant Institution for the State of Maryland offering bachelors, masters, and doctoral degrees. With support from NASA Goddard Space Flight Center’s Wallops Flight Facility and in collaboration with the College of Engineering at the University of Maryland College Park (UMCP), the UMES began offering the first two years of the engineering curriculum in the fall of
1982. All students transferred to either UMCP or other engineering schools after successfully completing the first two years of their engineering degree. Beginning in the fall of 1998, a 4-year degree program was initiated under a 3-way collaborative agreement among UMES, Salisbury State University (SSU), and UMCP. Under this agreement, the students at UMES and SSU campuses in the eastern shore of the state of Maryland obtain a professional Electrical Engineering (EE) degree from the ABET accredited Clark’s School of Engineering at College Park without having to relocate from the Eastern Shore of Maryland. The students are required to successfully complete the first two-year sequence of engineering courses at UMES or SSU. Then they take junior and senior level EE courses taught by the engineering faculty at UMCP and delivered live to UMES through Interactive Video Network (IVN). All laboratories and some of the upper division electives are taught on site.

Minority University Research and Education Division (MURED) of NASA has awarded a three year (2000-2002) grant titled “Pre-College Activities For Enhancing Minority Participation in Engineering”, to help reinforce UMES mission to improve the representation of minorities and women in mathematics, sciences, technology and in particular, in the field of engineering. The funding not only complements the UMES mission to actively recruit and retain minority, women, and economically disadvantaged students but is also intended to help the growth of the UMES engineering program.

This paper describes the “Summer Engineering Bridge Program (SEBP)” at UMES, outreach activities, accomplishments and outcomes related to the first year activities of the funding cycle.

The SEBP is a five weeks long enrichment activity designed to bridge the gap between high school preparation and expected standards for first year engineering students. The program integrates life-skills, motivational, recreational, parental involvement, and academic components so as to enable the participants to successfully cope with the rigors of mathematics, science, engineering and technology (MSET) fields. Significant attention has been paid to preparing the students to the changing demands of the engineering workforce in the new millennium for developing curricula for the SEBP. The guidelines outlined by the Accreditation Board of Engineering and Technology (ABET) for the engineering curricula for the new millennium has provided inspiration and framework for the SEBP. Similar efforts are also underway at other universities in the United States, however, unlike at UMES most of these programs last only for two weeks and hence have limited scope and influence on the participants. In all of these efforts the stated objectives are quite similar.

Besides enrichment activities a significant component of the program is also devoted towards recruitment and retention of the participants as well as assessment of desired outcomes. Recruitment efforts include spreading awareness about the field of engineering among high school students using fliers, postings on the world-wide-web, electronic mail as well as recruitment visits. There is a growing awareness among educators and policymakers in the United States that the number of high school students in general and
women and minorities in particular pursuing engineering careers are falling short of the projected need by the industry to meet the national economic growth ⁴.

Lot of universities have started devoting attention to spreading awareness of the engineering profession and engineering careers among high school students and high school teachers ⁵,⁶. At UMES "Service-Learning" project has been integrated with some of the engineering classes including "Introduction to Engineering Design (ENES 100)" that is helping to spread awareness of engineering profession among the local high schools and the community ⁷.

II. Academic and Enrichment Activities for SEBP

The Summer Engineering Bridge Program offered at University of Maryland Eastern Shore includes academic as well as life-skills, social, and motivational components that would help the targeted students to deal with rigors of engineering education as well as other degree programs in Mathematics, Sciences and Engineering Technology fields.

The academic component of the program that was designed and delivered to the SEBP participants in the summer of 2000 emphasized the following:

- Mathematics concepts and skills to solve practical problems;
- Comprehension of physical principles;
- Engineering problem solving and teamwork;
- Development of communication skills.

In the mathematics area intensive effort was devoted to reinforce basic algebra, trigonometry, interpretation of graphical information, basic statistics and data analysis. Some exposure to the concepts in Calculus-I was also provided. A full time faculty in the Department of Mathematics and Computer Science provided the instruction. The intent was to prepare the students for the Calculus-I course and other preparatory pre-calculus courses that are offered in the campus.

The following topics were emphasized:

- Solving equations and inequalities in one variable - Complex numbers, quadratic equations, nonlinear and inequalities
- Polynomial Functions - Synthetic division, long division-polynomials, real zeros
- Trigonometry: A review of Triangles, Law of Sines, Law of Cosines; Reference angles, identities, applications of solving right triangles; Unit Circle
- Graphing - Linear, quadratic and polynomial equations (degree 3 and higher); Sine, cosine, tangent, cotangent, cosecant and secant functions; Rational equations, circles, logarithmic and exponential functions; Systems of equations in two variables; Transformations and graphing; Inverse functions
Pre-program and post-program evaluations were conducted in mathematics. These evaluations not only allowed the mathematics instructor to gauge the level of the students and their needs but also provided indications as to which mathematics course the students should enroll in during the regular semester in fall.

The freshman year requirement in the 'engineering sequence' includes a course in calculus based Physics. It has been observed that significant number of freshmen have trouble coping with the rigor of the course due to inadequate preparation in high school physics. Many have misconceptions about the physical principles. Microcomputer Based Laboratory (MBL) activities are found to be very effective and provide an environment in which the student can experience the physical principles in action under different experimental conditions. Experiments were designed for SEBP participants using MBL tools. The participants also received instruction on report writing using MS WORD and data visualization using MS EXCEL. The co-author of this proposal who also teaches Physics 161 (the first Calculus based Physics course for engineering majors) offered these enrichment activities so as to prepare the participants for the course during the regular semester.

SEBP students completed several Microcomputer Based Laboratory (MBL) exercises designed to develop a clear understanding of some of the physical principles. They were given pre-lab and post-lab questions to gauge the degree of improvement in their understanding of the principles involved. An average of 50% in the pre-lab evaluations rose to 95% after completing the exercises in the post lab evaluations. This immediate demonstration of improved performance is expected. However, it is hoped that the understanding achieved by direct hands-on experiences will stay with them much longer than it would otherwise.

An example of one of many laboratory exercises performed by the students include an experiment designed to address the question "Do heavy objects fall faster than lighter ones?". In this activity, a picket fence (a clear 2" wide plastic strip with uniformly spaced opaque bands) was dropped through a photo-gate. The photo-gate was connected to a PC through an interface box. As the edge of the opaque band intercepted the light beam in the photo-gate, the computer made note of the time. The software then sorted out the time of travel from one leading opaque edge to the next. The total time of fall, velocity and acceleration from band to band were easily computed. The picket fence was then loaded with a heavy weight (~ 500 grams) and dropped from the same height. The data were analyzed for the loaded and unloaded fence. Comparison of the results proved that both fall at the same rate and that they take the same time to fall through the same distance, thereby demonstrating the fundamental concept of acceleration due to gravity.

The common belief is that a heavy object exerts a greater force on a lighter one, during a collision. Experiments were designed to demonstrate that the two forces are equal at every instant of the time. In this exercise, two carts of unequal masses were equipped with force sensors that recorded the forces at every thousandth of a second. The students plotted the data to discover the two collision impulses were identical.
Experiments were also designed to study Archimedes’ principle to demonstrate why things float or sink.

The principal author of this paper provided orientation to the field of engineering to the SEBP participants. He offers Introduction to Engineering Design (ENES 100) - a freshman year requirement for engineering majors during the regular semester. In this course the students work in teams to design and develop an engineering product and receive instruction on different fields of engineering, project management, history of engineering, engineering graphics, engineering ethics, technical writing and teamwork. SEBP provided an opportunity to involve the students with hands on activities and teamwork. Both soft and technical skill developments were emphasized. The students were exposed to various disciplines within engineering. The World Wide Web was used extensively for this purpose. The students worked as a team and learned cooperatively while they worked on simple engineering projects.

Hands on activities were provided to expose students to launching rockets and building gliders. Basic aerodynamic principles and its relation to design of gliders and rockets were discussed. Geometry, stability, controls and performance concepts were introduced. Photograph 1 and 2 show the SEBP participants building and launching gliders and rockets.

Engineering projects also included development of kinematics mechanisms such as the four bar linkage that form the basis of a variety of machines. Students were introduced to Working Model, a microcomputer based simulation environment for virtual prototyping of their design before actually building them using thumb tacks and cardboard pieces. They worked in small teams to design and analyze the four bar linkages. The simulation environment not only allowed the students to experiment with various parameters but also allowed them to comprehend the principles of physics and mathematics associated with the design. Photograph 3 shows one of the student teams building a four bar linkage and Photograph 4 shows the student team observing a simulation of the four bar mechanism on the computer.

Working in small teams of three to four members the SEBP participants also built small electric motors using simple ingredients such as batteries, paperclips, toilet paper rolls and magnet wires following guidelines provided in the Beakman’s Electric Motor website.

The students were exposed to simple robotic applications using "Handy Board” developed at MIT and the LEGO Mindstorm Kit. Integration of mechanical design, instrumentation and computer programming were emphasized. Photographs 5, 6 and 7 show the students and the devices designed by them using LEGO Mindstorm Kit.

SEBP students also participated in the maiden launch of the instrumented blimp for the UMES-AIR project. The UMES-AIR (Undergraduate Multidisciplinary Earth Science Airborne Imaging Research) project, is partially funded by NASA GSFC and the University System of Maryland. It is an ongoing project involving teams of
undergraduate students from mathematics, science, engineering and technology (MSET) majors who are involved in flying an instrumented payload on a helium filled tethered blimp to learn about remote sensing and conduct exploratory research in the area. The maiden successful launch of the blimp with all instrumentation (on board as well as on ground) took place on July 19, 2000. The SEBP participants not only witnessed the launch but also enthusiastically assisted in some of the ground crew responsibilities. Photograph 8 shows some of the SEBP students observing the blimp launch. Several of the bridge students are now permanent members of the UMESAIR team. The UMES-AIR is a pilot project to provide data concerning vegetation growth, shoreline erosion, changing land use patterns, agricultural analysis and wildlife management.

*Communication skills* were developed in concert with engineering ethics education by involving the student teams to debate over real world engineering case studies that have ethical implications. Besides oral communication emphasis was provided on written communications as well as engineering graphics.

### III. Motivational Activities

Low motivation levels among women and underrepresented minorities contribute significantly to high attrition rate among these groups of student in MSET fields. The following activities were undertaken with a view to improve the motivation level among the SEBP participants:

- The students visited two local industries and NASA facilities at Wallops and Greenbelt. Invited speakers from NASA, industry and UMES administration gave motivational presentations and lectures to the students.
- Students also learned about the job market and the demand for engineering professionals.
- Students were introduced to various professional engineering societies including NSBE (National Society of Black Engineers), SWE (Society of Women Engineers), ASME (American Society of Mechanical Engineers) and IEEE (Institute of Electrical and Electronics Engineers).
- Students learned about scholarships and financial aid programs.

### IV. Life Skills

Life skills development component of the program were performed in concert with academic activities. The students participated in workshops and received advisement with regard to time management, stress management, study skills/habits, test taking skills, enhancement of self esteem, goal setting, maintaining positive relationships and other relevant topics. The team projects also provided valuable life-skills pertaining to conflict resolution and project management skills.
V. Role Models and Tutors

Two undergraduate engineering students who were in transition from sophomore to junior level as well as a graduate student in mathematics and computer sciences supported the SEBP. One of the undergraduate students stayed with the SEBP participants in the dorm throughout the five-week duration of the program. He not only acted as a role model but also provided valuable advise to the participants regarding campus life. He also accompanied the participants to all industrial visits and recreational day trips. The other undergraduate student provided tutoring in mathematics and supported project activities of the SEBP participants. The graduate student in mathematics and computer science also provided tutoring in mathematics and was also responsible for developing the program website.\textsuperscript{10}

VI. Parents Involvement

Parents and/or guardians of the SEBP participants were invited to take part in an overview of the program, on the first day. They were informed of the structure of the summer program and follow-up activities. The parents had an opportunity to meet with the UMES faculty and administrators involved with the program. The welcome session was concluded with dinner. Photographs 9 and 10 are snapshots from the inaugural dinner held on June 17, 2000.

The parents were invited back at the end of the program for an awards ceremony so that they could share in the achievements of their sons or daughters. During the awards ceremony the faculty members presented an overview of the program and some tips for the forthcoming semester. The ceremony concluded with a luncheon. Photograph 11 shows some of the SEBP participants and their parents during the closing luncheon on July 21, 2000. Photograph 12 shows one of the SEBP participants after he had just received an award during the award ceremony at the closing luncheon.

VII. Conclusion

The SEBP 2000 has been a learning experience for student participants as well as faculty and staff participants. The student participants have benefited a great deal from the experience in terms of settling down in campus and dealing with their first semester courses. The faculty and staff have identified areas where the program can be improved and is directing attention to these areas so as to improve future "Bridge Programs". An assessment process has been implemented which is being integrated with the overall recruitment and retention programs on Campus so as to get proper feedback for the continuous improvement agenda. The assessment of program outcomes is being performed in accordance with the list provided in Appendix II.
VIII. Acknowledgment

The authors would like to thank Minority University Research and Education Division of National Aeronautics and Space Administration Program for their support. (NASA Grant - NAG5-9243) . The authors also wish to thank UMES administration and staff for their guidance and support during the execution of the program and Ms. Tina Dube of the Department of Mathematics and Computer Science for providing the mathematics instruction. Authors also acknowledge with thanks the supervision provided by Ms. Berit Bland for the rocket and glider design component of the program. The support and assistance from Ms. Manpreet Kaur (UMES Graduate Student), Mr. Jeremy Rodgers and Mr. Jason Tilghman (UMES undergraduates - Juniors) are also gratefully acknowledged.

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Gurbax Singh is a Professor of Physics and Acting Chair of Department of Engineering and Aviation Sciences at University of Maryland Eastern Shore. He earned a doctoral degree in the area of Quantum Electronics from the University of Maryland College Park in 1971. His current research deals with the trace detection of energetic materials using laser photo-fragmentation coupled with LIF or REMPI. His earlier work dealt with nuclear radiation effects on solid state devices, device physics, optical pumping of cesium with diode lasers to study light shifts and to make miniature atomic clocks, and nuclear instrumentation.
Appendix –I (Summer Engineering Bridge Program, Fall 2000)
## APPENDIX -II : Program Evaluation and Outcome Assessment

<table>
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<tr>
<th>Outcomes</th>
<th>Assessment</th>
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<tbody>
<tr>
<td>1. Improvement in retention</td>
<td>Number of SEBP participant successfully completing freshman year in engineering or other MSET areas.</td>
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<tr>
<td>2. Improvement in mathematical skills at the end of the SEBP program</td>
<td>(i) Difference of pre-program and post-program placement examination</td>
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<td></td>
<td>(ii) Success in the Calculus - I or the mathematics course SEBP participants were placed in at the end of the program in the fall semester.</td>
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<tr>
<td>3. Improvement in fundamentals of engineering and basic physics</td>
<td>(i) Performance evaluation by way of exams and quizzes during SEBP.</td>
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<td>(ii) Success/Performance of SEBP participants in Introduction to Engg. Design (ENES 100)</td>
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<td></td>
<td>(iii) Success/Performance of SEBP participants in Physics 161</td>
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<tr>
<td>4. Improvement in Motivation Level</td>
<td>(i) Number of SEBP participants volunteering to participate in ongoing experiential learning activities (UMESAIR Project) during regular semester.</td>
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<td></td>
<td>(ii) Number of SEBP participants joining professional engineering societies and volunteering to hold office</td>
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<tr>
<td>5. Other non-academic outcomes, realted to life-skills, financial information, ability to quickly settle down in regular semester etc.</td>
<td>SEBP student survey by way of questionnaire at the end of their first semester in UMES.</td>
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<tr>
<td>6. Grade Point Average</td>
<td>Tracking of SEBP student participants transcripts at the end of each semester</td>
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<tr>
<td>7. Increase in quality/quantity of freshman enrollment</td>
<td>Comparison of enrollment statistics in MSET areas from year to year</td>
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<tr>
<td>8. Increase in SEBP applicants</td>
<td>Data on SEBP applications from year to year</td>
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<tr>
<td>10. Stronger partnership among UMES/NASA</td>
<td>(i) No: of MSET proposals developed in response to NASA solicitations</td>
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<td></td>
<td>(ii) More interaction of UMES faculty and NASA personnel, steps towards realization of the proposed NASA - UMES Center.</td>
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