AC 2007-1734: IMPROVING RETENTION: ENGAGING PRE-ENGINEERING STUDENTS VIA INTEGRATED ENRICHMENT ACTIVITIES

Mahmoud Ardebili, Borough of Manhattan Community College/CUNY

Mahmoud Ardebili, Ph.D., PE. is Associate Professor and Coordinator of Engineering Science Program at Borough of Manhattan Community College/City University of New York. He teaches Engineering Graphics, Thermodynamics, and Freshman Design classes. His research interests include computational fluid dynamics, alternatively fueled vehicles and engineering education.
Improving Retention: Engaging Pre-engineering Students via Integrated Enrichment Activities

The Engineering Science program at Borough of Manhattan Community College is undertaking an NSF funded program to improve its retention and graduation rates. The program targets cohort of pre-engineering students, self-declared engineering majors but academically unprepared for university level calculus and physics courses traditionally taken at freshman year. The program consists of three components: enrichment workshops, design competition and peer mentoring.

The enrichment workshops are designed to improve visualization, chemistry and physics fundamentals, skills traditionally acquired in high schools. Competition component groups the cohorts in small teams who use robotics kits to design and built modules in order to meet specified requirements. The competition activities are planned to promote collaborative group learning skills. The mentoring component further sustains this effort by bringing sophomores / juniors as peer group leaders in weekly sessions focusing on learning in fundamental classes.

Majority of cohort do not meet placement requirements, start at remedial mathematics level. The long series of remediation needed to enroll in freshman level classes contributes greatly to large attrition rate. The integrated enrichment activates engages this group; provides counseling, stipend and a nurturing up-to-date environment. This program is part of a larger project to increase baccalaureate level graduation rate at collaborating sister institution.

Introduction

The engineering science program at Borough of Manhattan Community College in partnership with school of engineering at the City College of New York and the pre-engineering program at Hostos Community College are undertaking 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 engineering. These initiatives are funded by the National Science Foundation through their STEP (STEM Talent Expansion Program). The project addresses five objectives to improve graduation rate; (1) curricular coordination, especially for first- and second-year courses; (2) use of new media resources to support the teaching/learning process; (3) incorporation of a peer mentoring model into instruction at introductory levels; (4) development of high interest, hands-on research experiences for freshmen and sophomores; and (5) careful attention to preparing students well for the transfer experience and for success in Engineering.
Retention is an issue among university academic programs nationwide; however, in a field already plagued with declining enrollment, retaining engineering students is of particular importance. The pool of students graduating high school with sufficient skills for likely success in engineering is limited, thus making improvement of graduation rate a major focus for engineering education community. Many studies have investigated pre-college factors that predict retention, including standardized test scores, academic performance in high school, gender, ethnicity, students age, parents education and economic status.\textsuperscript{1,2,3,4}

An additional factor contributing to low graduation rate in (campus identity) engineering science program is proficiency in mathematics. Many students (up to 70 percent) entering the college intending to major in engineering do not meet the mathematics placement requirement to enter freshman engineering curricula. These students begin remedial courses that they consider irrelevant to their chosen major become discouraged and drop out or change majors. Those students who do place in the entry-level courses, the retention rate in the freshman year courses taught in the traditional-lecture is low. Many of these students are not able to complete the freshman courses in mathematics, physics, which results in the students' not being able to undertake their major courses. All of these have resulted in very low graduation rate, less than 10%.

In addressing the above issues the following initiatives have been undertaken:

- Curricular articulation among partner institutions, focusing on gateway courses, to implement two models of small group collaborative learning in targeted classes
- Summer bridge workshops to enrich academic preparation of entering freshman and existing students,
- Design competitions,
- Research opportunity for freshman and sophomore level students.

This paper describes the efforts that have gone into creating an environment to improve under prepared freshman retention. These activities have an integrated approach that foster academic preparedness in subjects needed to succeed in the program.

**Collaborative Learning**

Curricular revisions include incorporation of two models of collaborative small-group learning in freshman and sophomore level courses, both involving peer support. The models are:

---

**Peer Instruction** The first is suggested by the work of Mazur\textsuperscript{5,6} and involves the use of very short problem-solving interludes in lecture courses, in which students work with those seated around them to decide on the correct answer to the question. The model provides for active roles for students in lecture courses and, in addition, gives feedback to the instructor regarding the level of student understanding of the reading and lecture material.

---
Peer-Led Team-Learning Specially-trained undergraduates are used as discussion/problem-solving session leaders for students in first-level science courses\(^6\). This model is implemented as an addition to the classes. Students participation was voluntarily, although, they were encouraged to attend the sessions. Assessment is underway to ascertain optimum strategy in incorporating peer-mentoring.

**Student Support**

Enrichment/Research workshop for pre-engineering students is offered every summer. It is designed to reach out to engineering majors who are academically not prepared to enroll in the science and mathematics courses of engineering curriculum. The motivation is to strengthen students’ academic skills and therefore increasing the likelihood of their retention in engineering.

The five-week long workshop focused on improving students’ Physics, Chemistry and Visualization skills in an inquiry-based/active-learning environment. Upon completion of each module in the workshop, students were required to write reports about their subject matter. It also provided opportunities to conduct internet research on topic relating to the themes of the workshop. Students participating in the workshop received a small stipend as incentive to devote time to workshop and be rewarded for their effort. The workshop conductors also serve as consolers for students. They help students in academic issues that are known to be contributing factor to attrition in engineering. The workshop introduce students to college life and offer them network opportunities. (Attachment 1)

The first workshop was offered in summer of 2006. Of the 15 cohorts who undertook the workshop, 14 are still retained in the program. Workshop participant are tracked throughout the academic year. We will determine the success of this effort based on these findings and will make improvement/adjustment for future workshops. Among new topics being considered for the workshop is Virtual Reality application with the aim to increase participants’ spatial visualization skills and generate enthusiasm for engineering.

Two different student-centered activities are implemented during the academic year. One is robotic competition planned for pre-engineering (per-calculus level) (attachment 2), and the other is regional design competition for post-calculus and physics level students (attachment 3). To attract and maintain students’ interest, small stipend and awards are allocated to the participants.

The first activity is dedicated to the Lego Mindstorms robots segment. The modules/labs were classified as Introduction to Lego Mindstorms robots, Programming, and Advanced Programming. The objective for the introduction module was pedagogical uses of robots. The building of the robots provided kinesthetic learning, pattern matching, foreground/background discrimination, and sequential ordering. The participants learn the purpose of an operating system and how to load firmware. They also learn programming by using small blocks in the graphical programming language provided
with the Lego Mindstorms kits. Finally, algorithms, testing, and the process of adding refinements are introduced. The participants work in group of two to create a “robot car” and demonstrate its functionality. The Programming module/lab added programming concepts to the robot activity. The students have to demonstrate the use of programming techniques for repeating elements and add variables to the program. Also, they have to use timers, pseudo code, and “if statements” for decision making.

The second activity is intended for post calculus students. It addresses content learning and motivational needs of students who have passed remediation but are not yet exposed to challenges of engineering. Contests, and in particular design contests, are powerful motivating tools. They satisfy the need to invent, design, build, test and win. Many engineering disciplines departments have arrived at the same conclusion and provide regional and national contests. It has been discovered that those who do best in design are not necessarily the best academic achievers and that winning in design contests does not necessarily correlate with high grades. Students’ discovery that they have talent that is recognized and rewarded enhances their morale, spirit and determination. We are convinced that there are students who will discover their innate strengths and talents during this experience.

As this activity is evolving, we plan to incorporate collaborative group team work consisting of freshman and seniors. The objective is a desire to increase the retention rate of the freshmen by involving them with the seniors in what appears to be interesting design work. We feel that, the seniors also benefit by developing the ability to communicate their ideas to a non-technical, educated audience as their design work progresses.

The number of students participating in these activities is 16. Majority of these students are pre-calculus level and are participating in the robotic design, which are our prime targeted cohorts. We will monitor their academic performance and retention as this project progress. Longitudinal data concerning their retention enables us to adjust these activities to gain optimal retention.

**Research Activities**

Undergraduate students who participate in research apprenticeships are more likely to complete their studies in a STEM area and to pursue graduate degrees. Research experience provides students with a connection to the real world and brings him/her into contact with cutting edge technology. Students gain a greater appreciation of the math, science and engineering science courses they take during their studies and better understand their connection to engineering practice.

Opportunities have been provided for students who are excelling academically to participate in research. In the course of the project four students were engaged in research project focusing on testing strength of plastic welds, experimental study of solar powered fuel cell, and characterization of composite material electrical resistivity.
Concluding Remarks

Our goal is to make the activities of this project an integral part of the recruiting and training efforts and expand them to reach a larger geographical area and a higher number of underrepresented students. As we are undertaking 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). We are planning to pursue:

- Develop a high school awareness activity that bring teams of consortium 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 will be made aware of the various paths the engineering students have taken in order to study engineering and what they plan to do upon graduation.

- Evaluate the relative effectiveness of the summer bridge program, the research scholarship and design competition programs on student enrollment and retention.

- Strengthen and expand consortium arrangement to increase STEM program articulation and student transfer.
References


4. Smith, T., 2000-01 SMET retention report: the retention and graduation rates of 1993-99 entering science, mathematics, engineering, and technology majors in 175 colleges and universities, Norman, OK: Center for Institutional Data Exchange and Analysis, the University of Oklahoma, 2001.


Attachment 1

SUMMER ENGINEERING WORKSHOP

• Want to learn new skills
• Want to further your academic studies
• Want to experience a change of environment
• Want to learn how to do research
• Want to earn $600 for doing it.

BMCC Engineering Science Program is proudly offering a free five-week long summer academic enrichment workshop for ESC majors. The workshop aims to strengthen students’ Physics, Chemistry and Graphics skills. Qualified students will receive a stipend of $600 upon completion of the workshop.

The workshop will run Monday through Thursday, 9:00 AM-12:30 PM. It will commence on June 5, and will end on July 6, 2006.

Qualifications for participating in the workshop are:

• BMCC Student
• Engineering Science Major
• US Residency
• Students at remedial mathematics level who have not taken Calculus I.

To attend, complete application form and submit to:
Working in teams of two or three, students will create their own robot. They get the opportunity to work with programmable radio controls, pneumatics, motors, electrical circuits, mechanics, computer animation, computer assisted design, and other technologies – just like professional engineers do.

Eligibility:
Freshmen Engineering Science Major who have not enrolled in Calculus classes
US citizens or permanent residents are eligible to receive stipends

When:
Competition will take place in spring 2007
First Meeting: Wednesday November 29, 2006
Weekly meeting on Wednesdays 2:00 to 4:00 PM – N635

Prizes:
1st Place team: Laptop computer for each member
2nd Place: $500 for each member
3rd Place: $300 each member
All participants who complete the competition receives a $300 stipend

For additional information and registration please contact:
“Water, water, everywhere
And not a drop to drink”
-Coleridge, “The Rhyme of the Ancient Mariner”

Interested in changing the world?
Would you like to take part in developing machines that improve the quality of the world we live in? Everyone thinks about creating an invention that will change the world, but who will it appeal to? High technology may be the way for the more developed nations; but the less developed parts of the world would never see such gains.

Consider this:
• The world is mostly water, but only a tiny part is considered close to drinkable
• As the demand for freshwater increases every year, the amount available in the world decreases.
• In the more developed nations, technologies such as reverse-osmosis desalination have been around for decades, but for the lesser developed nations, what is their solution?

Think you can solve this problem?
One possible solution is to develop a human-powered still. Though this can provide only limited amounts of freshwater, it should be enough in an emergency situation.

Working in teams of two or three, students will develop a human-powered machine capable to distilling drinking water. In doing so, they get the opportunity to develop their engineering skills while working in a team environment - just like professional engineers do.

Prizes:
http://www.asme.org/Events/Contests/DesignContest/Prizes.cfm
Eligible students who complete a prototype and attend competition will receive a stipend of $1,000.

When:
During academic year Wednesdays 2:00 to 4:00 PM, more as needed
During winter intersession all day on Wednesdays
(Closed on December 27)

Where:
N635