Impacting First Year Engineering Retention

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Abstract

A two week program was initiated summer 2012 at the University of South Alabama for high-achieving incoming engineering students. The program introduces students to two highly popular areas: robotics and composite materials. The participants are exposed to a graphical programming tool, LabVIEW™, which is widely used in engineering curricula, and use the tool to program LEGO MINDSTORM® robots. This combination provides immediate, visual, verification of project solutions. The students quickly gain skills and facility with both tools, creatively addressing the various assigned tasks. The program has been highly successful in capturing the interest of the participants and has led to increased retention of these students in engineering.

Introduction

Recruiting and retaining students in engineering programs is a national problem that has been addressed in many, varied ways.[1] Many universities offer bridge programs for incoming freshmen to increase their success in engineering programs.[2,3] These programs are often designed to improve skills in fundamental courses such as mathematics and English as well as academic strategies. In contrast, the University of South Alabama offers Exploring Engineering (E^2) to improve the retention of *high achieving* incoming freshmen. E^2 is designed to:

- Enhance critical thinking and problem solving skills
- Expose students to instrumentation and visual programming tools
- Apply STEM knowledge to open ended problems
- Build community
- Introduce students to campus life
- Increase retention in engineering

Results from the first two summer sessions are extremely encouraging and indicate that similar programs can have a significant impact on graduation rates for engineering students.

E^2 introduces students to two main engineering disciplines: electrical and computer engineering and mechanical and materials engineering. LabVIEW™ and the LEGO MINDSTORMS® platform were selected as the tools for the program. LabVIEW is an especially useful tool, which engineering students repeatedly encounter during their undergraduate careers. LEGO Mindstorms give students an intuitive approach to programming, with immediate, visual results.

As a result of strong teaming experiences in the workshops, the students work more effectively and collaboratively in their coursework. The students also interact one-on-one with undergraduate and graduate engineering students who exhibit enthusiasm for engineering. These relationships continue into the academic year, providing a support community for the new students.

Highly motivated, inquisitive incoming freshmen are identified for the program based on ACT scores, high school GPAs, and completed high school coursework (math, chemistry, and physics). Admission decisions are based on academic achievement and interest (demonstrated through an essay). In two years, the program has been offered to 130 students (upper 25% of the incoming freshman engineering class). Twenty-four of these students have chosen to participate in the program. Funding for program instruction and materials is provided through Alabama NSF EPSCoR, so there are no costs to participants who live in the area.

Summer Program

Students spend two weeks immersed in interdisciplinary engineering topics ranging from robotics to composite materials. A companion thread for the program is LabVIEW programming, which is integrated into each topic. Robotics and the associated programming are intriguing topics for the students and provide immediate motivation for studying engineering. The students explore instrumentation, sensors, and control using Lego Robots. They use LabVIEW to investigate material properties and behavior for metals, polymers, and composites. The LabVIEW and MINDSTORM combination provides immediate, visual, verification of project solutions. Each topic is introduced by a series of short lectures followed by hands-on interactive laboratory sessions. The students quickly gain skills and facility with both tools, using creative approaches to accomplish the various assigned tasks.

Recruitment

The program is advertised during summer orientation sessions for incoming students. Students with ACT scores of 28 or above are individually contacted and given details of the summer program. Additional underrepresented students with high math scores or high school coursework in calculus were recruited for the 2013 program.

Resources

The program is conducted by two engineering faculty, one in electrical engineering and the other in mechanical engineering. Each faculty member spends one week with the participants, presenting brief lectures and supervising laboratory activities. Undergraduate students, majoring in electrical or mechanical engineering, are hired to assist with laboratory sessions and provide role models for the incoming students. An important resource for the program is LabVIEW Lessons[2] which features activities designed to develop computational thinking and engineering design skills through the presentation of open-ended problems.

Schedule

Each day is divided into a morning and an afternoon session, each 3 hours long. A typical session begins with a brief lecture and is followed by hands-on activities. The two week schedule is given in Table 1. Details for each of the sessions and specifics of the individual lessons are available in the ASEE paper.[4] The lessons expose the students to increasingly more complex configurations and programming tools. They are deliberately left open-ended to give

students creative license. This format results in very different robot implementations and LabVIEW program strategies. It also encourages informal competitions between the groups. The second week introduces applications for the robots in materials testing. At the culmination of the program, the students are assigned an open ended design project encompassing activities from the two week program.

Table 1. E^2 Daily Schedule

Week 1 – Electrical and Computer Engineering		
Day 1	Lecture	Getting started, introductory activities
	Lab	Intro to LabVIEW, Lego Mindstorm NXT robots, building and programming a two-motor car
Day 2	Lecture	Sensors and lights, LabVIEW programming concepts
	Lab	Burglar alarm, clap-on lamp controller, light-controlled electric fan, electronic cockroach
Day 3	Lecture	Program loops and iterations
	Lab	Dice game using random number generation, three-speed fan, sound generation
Day 4	Lecture	Robotics and programming
	Lab	Cloverleaf, dancing robot, bug in a box
Day 5	Lecture	Sensor applications and concluding remarks
	Lab	Haunted house, musical instrument, grassfire algorithm, student design project
Week 2 – Materials and Mechanical Engineering		
Day 6	Lecture	Simple and Compound Machines
	Lab	Crane – mass challenge
Day 7	Lecture	Introduction to Mechanics of Materials
	Lab	Build & program robot to determine linear displacement and angular velocity of a rotating wheel
Day 8	Lecture	Instrumentation for Mechanics of Materials and Data Analysis
	Lab	Tension Test (LVDT), Torsion Test (Troptometer)
Day 9	Lecture	Communication, Concluding Remarks
	Lab	”Gauntlet” obstacle course, Generate Presentation
Day 10	Lecture	Critical Thinking retest,, Chemical Engineering Lab Tour
	Lab	Closing Ceremony/Presentations

Program Observations

The personalities of the participants have varied widely. Some are very outgoing, while others are initially very apprehensive and reserved. After the first day, all students are engaged and interested in learning about the robots. The less outgoing students find the environment to be non-threatening and become more collaborative as the workshop proceeds.

The students are organized into groups of three. The group dynamics are interesting – some students pick up the programming very quickly and are eager to try new ideas on their own. Other students "play it safe" using programming algorithms from the text with little modification. In the first year, one group settled into a format with one member doing all of the programming and the other two members managing the hardware construction.

Some students design robots that are functional, but use a minimum number of components. Other students add an aesthetic component by decorating their robots. Again, in the first year, two groups collaborated to teach their robots to "sing" a duet in two-part harmony, which was not a design requirement, but the group members found the exercise to be an interesting challenge. These groups consisted of two pairs of twins, which were separated into different groups.

Group strategies for meeting design specifications have been strikingly different. Some groups prefer to just start putting parts together and writing code, refining as they go, and other groups do significant planning before beginning to build any hardware. The interesting thing is that both approaches are generally successful.

After the first day, it is difficult to get the students to leave at the end of the day. It is obvious that they find working with the Mindstorms to be interesting and challenging. It is surprising how quickly all the students learn LabVIEW and how quickly they learn to build and program relatively sophisticated robots.

These exercises are similar to those found in many first year engineering seminars and can be easily adapted to these courses. We have found the open-ended exercises provide additional challenges for motivated students.

Results

Results are extremely positive, with both faculty and students highly satisfied with program activities. Participants are genuinely excited about learning new things – and they are able to quickly pick up concepts.

The participants completed evaluation forms at the end of the program that help revise session content and delivery. A focus group with the participants is conducted in the following semester to identify recruitment strategies to attract a larger audience for the program. Comments from the participants include:

- *It is great to make friends even before the first day of classes started.*
- *E^2 incorporated lots of challenges that required a lot of thinking in different ways.*
- *E^2 allowed a lot of innovation.*

There are two cohorts for analyzing program outcomes: program participants and the group of students who were invited to the program with comparable ACT scores, but did not participate. Data on program participants for both years of the program are given in Table 2.

Table 2. Program Outcomes

			First Semester		ACT		Changed Major			Left USA
		#	GPA	HRs	Comp	Math	In Eng	STEM	Non STEM	
2012	E^2	11	3.32	15.6	31.3	29.6	1	1	0	0
	Non E^2	45	2.86	15.8	29.3	28.3	5	2	3	4
2013	E^2	13	2.96	15.5	27.3	28.4	0	0	0	2
	Non E^2	69	2.64	13.4	27.5	27.3	5	3	3	1
Total	E^2	24	3.13	15.5	29.1	29.0	1	1	0	2
	Non E^2	114	2.73	14.6	28.2	27.6	10	5	6	5

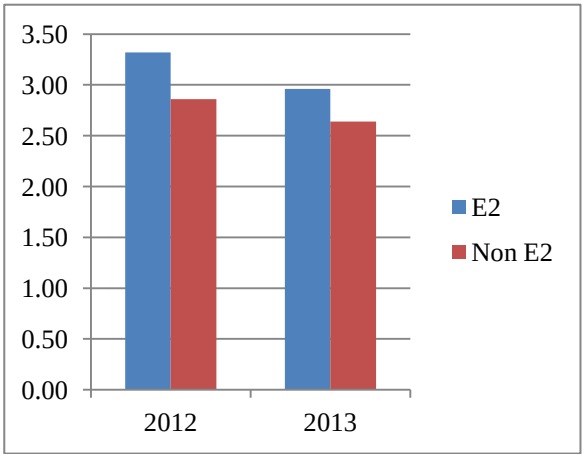

Figure 1. 1st Semester GPAs

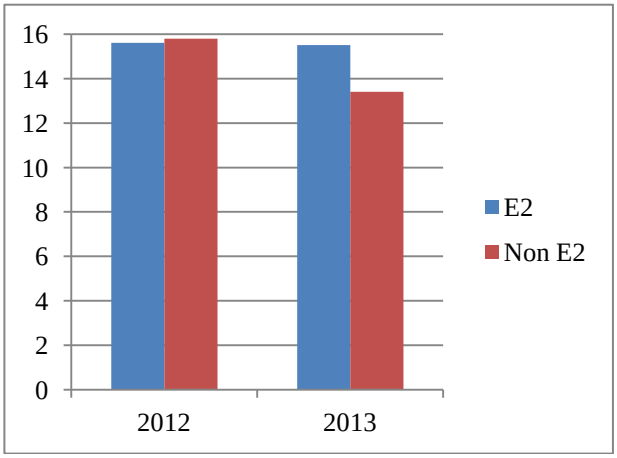

Figure 2. 1st Semester Hours Earned

This data indicates that E2 has a significant impact on student success. The participants have a higher combined first semester GPA. All of the participants have been retained in a STEM major. The difference in composite and math ACT scores for each group is not significant; however, the difference in the first semester GPA is significant (p = .03 for one tail T Test, unequal variances).

The individual attention during the program may be an important factor in these statistics. Another important outcome for the program is the relationships that are formed during the summer program that continue into the academic year. The participants develop study groups and also chose to enroll in the same sections of their courses, essential components of building a community of scholars. The 2013 participants formed even closer relationships since several were housed in the university residence halls during the program.

Obviously as the program is conducted in future summers, larger data samples will provide more conclusive results. However, these initial results are extremely promising.

Future Plans

Funding is available to again offer E^2 this summer, at no charge to the students. Enhanced recruitment efforts will reach more students. A housing option, at participant cost, will be offered so students who are not in the immediate area can also attend the program. Additional funds may be available to attract underrepresented students to the program.

Acknowledgement

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