AC 2009-882: ENGINEERING YOUR FUTURE PROJECT FOR HIGH-SCHOOL STUDENTS

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Abstract

Through a program known as, "The College Institute", Montgomery College, Rockville, offers a series of freshmen college-level courses to high schools in Montgomery County. One of the courses offered is 'Introduction to Engineering Design', also known as ES 100, which offers a wide variety of introduction topics in engineering, as well as an opportunity for students to work on a design project in teams. While the current program of study is effective in getting students excited in Engineering and its many disciplines, and in giving students a wide range of practical introductory experience in Engineering, it lacks the ability to get students to consciously develop a career path in engineering, and begin considering the necessary academic and experiential steps required in order to experience a successful career in the engineering discipline of their choice. As a result, several students find it easier or more convenient to change majors when they feel overwhelmed by the requirements for engineering students, since they never really had a planned career path initially.

To address the above concerns, an additional project, the 'Engineering your Future Project' was recently added to the curriculum for the College Institute ES 100 taught to 12th graders at Thomas S. Wootton High School in Rockville, Maryland. This project involves motivating students to develop an academic map/career plan for themselves by observing and interviewing successful engineers in different fields, creating overview profiles for each of them, and studying these profiles to determine how they connect with their career intentions.

A detailed explanation of the Engineering your Future Project and how it fits into the ES 100 curriculum is given in this paper. Results from qualitative and quantitative evaluation of the project will be presented. In addition, since the project was also added to one of the ES 100 sections taught to Montgomery College students, the outcomes of the project for the college students and the high school students will be compared in this paper.

Introduction

The College Institute was created through a partnership between Montgomery College and Montgomery County, Maryland, Public Schools as a means of providing outstanding high school students with an opportunity to not only be taught college-level courses as part of their high school curriculum, but also to earn up to thirty (30) college credits in the environment of their own school buildings. Advantages of this program to participants include the possibility of the several of the courses to count towards a college degree or satisfy some pre-requisite requirement (depending on the institution attended by the student and his/her major), enhancement of the student's college admissions profile, and motivation for early career decision making by student.
In order to be accepted into the College Institute, students must:

- be enrolled as seniors at participating schools

- have completed all high school graduation requirements
- have a cumulative GPA of 3.5 or above
- must have SAT Reading, Writing and Math scores of 550 or above (or have met the eligibility score requirement in Montgomery College's placement test)

To continue the program, students are required to successfully complete each course taken previously through the College Institute.

In response to the nation's quest to increase awareness of engineering amongst pre-college students, two freshman-level engineering courses are offered through the College Institute, one of which is 'Introduction to Engineering Design' (Engineering Science _ ES 100), a fundamental engineering course designed to provide students with a basic overview of the general engineering design process, as well as some practical experience in team-based engineering design projects. The ES 100 course is comparable to first-year introduction to engineering courses offered at colleges and universities throughout the U.S. The course is a requirement for all engineering students, and it satisfies a science requirement for non engineering majors.

Like similar introductory courses in engineering nationwide, the ES 100 model has been successful in achieving its goals of exposing students to hands-on experiences in different fields of engineering. Furthermore, courses similar to ES 100 have been offered to high school student through several programs sponsored by universities, companies and governmental institutions with a goal of stimulating an interest in engineering in high school students. Nonetheless, reports indicate that undergraduate engineering enrollment has declined in recent years[1], while the number of students who dropout of engineering early in their academic career has been shown to increase[2]. What could be the reason for this decline, which defies the efforts of renowned organizations such as the American Society of engineering Education (ASEE) and the National Science Foundation (NSF) as well as several experts in the engineering education field to recruit and retain proficient engineering students? According to a recent survey of engineering students[2], the most common reason is the fact that students fail to make a connection between the foundational material they learn in their first year of college (or last years in high school) and their future careers. Even the practical experience which engineering students are exposed to in their high school and early college years have proven inadequate for the retention of most students (about fifty percent[1]) beyond their first or second years.

In order to address the retention problem faced by engineering educators today, a new program, known as the "Engineering your Future" project (EFP) was added to the Montgomery College (MC) ES 100 program for the College Institute, as well as one of the MC sections. The design of this program is quite different from other "Engineering your Future" program created to attract pre-college students to engineering, such as the Carnegie Melon Engineering Your Future Project which brought together middle school students from the city of Pittsburgh to work on engineering related projects, and the Engineering Your Future Program organized by the Colorado School of Mines to attract minorities and women in Denver middle schools to the field of Engineering[2]. Rather, this unique program goes beyond practical engineering projects or scientific concepts to present students with career-planning and networking opportunities.

The main goal of the EFP is to recruit, retain and graduate more and better prepared engineers. The objectives of the EFP were as follows:

- To increase students' interest in a career in engineering
- To give students a broader and more in-depth perspective of engineering as a career
- To motivate students to consciously plan for a successful career in engineering
- To help students make a connection between their engineering educational experience and their future career as engineers

The rest of this paper is organized as follows. First, an overview of the general ES 100 program is given. Then a detailed description of the EFP is presented. Results from an evaluation of the project based on student responses and decisions are then presented, followed by a concluding discussion.

Montgomery College's General Curriculum for Engineering Science 100

The ES 100 course is a two-hour lecture, two-hour lab per week course in which students are given an overview of the application of the basic tools and techniques of engineering design and graphic communications, the fundamentals of solid modeling, engineering reports, cost analysis, and the use of software tools. Students are also required to work in teams to design and produce a working device that provides a solution to a real world problem, and then present it to their classmates and the department's representative at the end of the semester.

At the beginning of the course, students are given a lesson on three-dimensional graphics as the language of the engineering profession. This is followed by an introduction to solid modeling and detailed practical experience on the operating principles of parametric modeling using the ProEngineer software. Students are usually assigned several laboratory assignments, as well as a project on solid modeling using the ProEngineer software. A common example of a solid modeling project would be to model an automobile and print it out using a Rapid Prototyper (three-dimensional printer).

The next aspect of the ES 100 course is the presentation of a simple design problem. At this time students are made to begin considering working in teams with other students to create a working solution to the problem, which will be evaluated as a product of the team and not individually. Students are expected to work in teams throughout the project. As students work on their project, they are given lessons of the basic laws of mechanics and energy which enable engineers develop structures that can withstand the static and dynamic loads of the operating environment, or design machines that run both on the earth and in space. The use of computer application software such as Microsoft Word, Excel, and Power Point is also introduced to them.

As the end of the semester approaches, students are given time to complete the design, building and testing of their project, which they have to present to their peers and the department representatives for evaluation.

The Engineering your Future Project

The schedule for the Engineering your Future Project is divided into the following three phases:

Phase 1: Presentation of engineering as a career
In this phase, the students are given a comprehensive and interactive presentation on engineering as a career based on the book, "Engineering Your Future" by Oakes, Leone and Gunn[3]. This presentation, which requires at least four hours of class to complete, covers the following topics:

- A detailed description of all the engineering disciplines, including computer, electrical, chemical, industrial, mechanical, civil, aerospace, biological, materials, marine, petroleum, nuclear, manufacturing, systems, environmental, geological and management engineering.
- A discussion about engineering as a major, which involved topics such as characteristics of students who may be interested in engineering, course requirement for different engineering majors and how these courses relate to typical job descriptions for engineering majors, where to ho to find information about careers for engineering majors.
- A comprehensive overview of engineering functions (possible tasks of working engineers), including research, development, testing, design, systems, manufacturing, operation/maintenance, technical support, customer support and sales.
- A statistical overview addressing questions such as
  - How many people study engineering each year?
  - What are the most common majors?
  - What kind of job market is there for engineers?
  - How much do engineers earn?
  - How many women and minorities study engineering?
- General comments from employers of engineers

At the beginning of the phase, students are usually surprised just to learn the number of engineering disciplines that exist. By the end of phase 1, students are excited about planning their career in engineering.

Phase 2: Interviews and Profiles
This phase involves students interviewing working engineers and preparing career profiles of their interviewees, and a career plan for themselves. The tasks associated with phase 2 are as follows:

- After the completion of Phase 1, students are asked to study profiles of several engineers, presented by Oakes, Leone and Gunn[3], and generate questions which they might ask an engineer while developing a similar profile

- Students are then asked to interview at least three engineers (preferably in person, but possibly by phone if that is the only option). These engineers could range from family members to people whose contact information they found on the web (some student actually walked into an engineering firm and asked to interview one of their engineers). The questions generated in the previous step are compiled and made available for use in the interview.
- Each student must then build a career profile of his/her interviewees, containing at least the following information:
  - current occupation
  - employer (the name of the company where s/he works
  - academic background – colleges/universities attended, degrees obtained
  - career preparation – steps taken while in college to ensure a successful career internships, Research, volunteer work, and so on)
  - studying engineering – why did s/he choose engineering, and/or graduate school? s/he choose that particular engineering major? Is his/her career directly related to his/of study? Why or Why not?
  - Job profile – what has been his/her occupation(s) from graduation till date?
  - Life at Work - What is a day at work life for him/her?
  - Life outside work – does s/he have a family? What does s/he do outside work? Hobbies?

  Students are given the option to include their interviewees' names and pictures if permitted.
- Students are also required to build a career plan for themselves using a combination of information from their interviewees, the presentation given at the beginning of the EFP and some personal research on colleges, majors, companies, and other aspects of engineering as a career. The plan is required to be similar to their interviewees' profiles, but projected towards the future. Thus, the required information for this career plan is:
  - Desired major and why
  - Desired occupation
  - Possible employers (list of companies where s/he would like to work and why)
  - Academic requirements (list of possible colleges/universities s/he are considering attending and why)
  - Required career preparation – steps s/he needs to take while in college to ensure a successful career (e.g. internships, Research, volunteer work)
  - Projected job profile – an overview of the kinds of engineering functions s/he might perform; career growth profile, job changes, and so on

- Projected life at work – what would be an ideal day at work life for him/her?
- Projected life outside work

Phase 3: Presentation of profiles

This is usually the most exciting phase of the project from the students', as well as the instructors', perspective. In this phase, students are required to present a profile of one of the interviewees, and also present their career plan to the entire class. They are allowed to be as creative as possible, with the minimum requirement of a PowerPoint presentation of all the information gathered in phase 2. Some students have gone as far as creating videos of their chosen interviewee's life at work, or showing videos of companies they would like to work for. This phase is usually a great learning experience for the instructor as well as the students, as everyone is exposed to a different aspect, function or lifestyle of engineering.

These three phases of the EFP were designed to meet the objectives of the project as listed in the introduction. At the completion of the project, it is expected that students would not only have increased the breadth and depth of their knowledge of the engineering field, but also have succeeded in making more solid decisions about the majors, and in developing a feasible plan for a successful engineering career.

Evaluation and Results

Evaluation of this project for the first semester (Fall 2008) was carried out in two stages: pre-project evaluation was carried out before the project began to determine students' knowledge of engineering as a career and what stage they are in their career decision. Post-project evaluation was carried out at the end of the EFP to determine the impact of the project on the students, and the extent to which the project goals were met.

Pre-Evaluation: Students were given a set of statements and asked to indicate how much true they were on a scale of 1 to 5, 1 being absolutely false and 5 being absolutely true. Table 1 shows the statements and the average numerical response of the College Institute students to each of them. Table 1 also shows the objectives, among those listed in the introduction, addressed by each question. There were 13 students enrolled in the course.

Table 1: Pre-project Evaluation of the Engineering your future project.

	Statement	Objectives Addressed	Average Response
1	Engineers make a strong impact in our world today	• To increase students' interest in a career in engineering • To give students a broader and more in-depth perspective of engineering as a career	4.3
2	I am certain that I want to become an engineer	• To increase students' interest in a career in engineering • To motivate students to consciously plan for a successful career in engineering	3.1
3	I know exactly what engineering discipline I would like to be in	• To motivate students to consciously plan for a successful career in engineering	2
4	I know what universities offer the engineering discipline I am interested in	• To motivate students to consciously plan for a successful career in engineering	2.5
5	I know what kind of company I would like to work for	• To motivate students to consciously plan for a successful career in engineering • To help students make a connection between their engineering educational experience and their future career as engineers	3.3
6	I have an understanding of all the engineering disciplines	• To increase students' interest in a career in engineering • To give students a broader and more in-depth perspective of engineering as a career • To help students make a connection between their engineering educational experience and their future career as engineers	2.1
7	I know what kind of internships are required for my chosen discipline	• To motivate students to consciously plan for a successful career in engineering	2.5
8	I know how much engineers in	• To motivate students to consciously	1.5

	several disciplines earn each year	plan for a successful career in engineering	
9	I would like to get a graduate degree in engineering	• To motivate students to consciously plan for a successful career in engineering	3.7
10	I am well prepared for a career in engineering	• To motivate students to consciously plan for a successful career in engineering	1.5

Post-Evaluation: At the end of the project, students were given two sets of statements to respond to in the same manner as the pre-project evaluation. The first set of statements was an exact replica of the pre-project evaluation. The aim of this set was to determine how much of a change the EFP brought about on the students perspective of and preparedness for an engineering career. The second set of statements was designed to enable the students directly judge the impact of the EFP on the choice of and readiness for engineering as a career.

Table 2 shows both sets of questions and the average numeric response of the students.

Table 2: Post-project Evaluation of the Engineering your future project.

	Set 1 - Statement	Average Response
1	Engineers make a strong impact in our world today	5
2	I am certain that I want to become an engineer	4.2
3	I know exactly what engineering discipline I would like to be in	3.7
4	I know what universities offer the engineering discipline I am interested in	3.7
5	I know what kind of company I would like to work for	4.2
6	I haven an understanding of all the engineering disciplines	3.8
7	I know what kind of internships are required for my chosen	3.1

	discipline	
8	I know how much engineers in several disciplines earn each year	4
9	I would like to get a graduate degree in engineering	4.2
10	I am well prepared for a career in engineering	3.4
	Set 2 – Statement	Average Response
1	This project helped me realize my potentials of becoming an engineer	4.3
2	This project helped me focus on a particular engineering discipline	4
3	This project helped me know more about different disciplines in engineering	3.7
4	This project helped prepare me for a career in engineering	4
5	I learned about aspects of engineering I had never known before from this project	4
6	This project increased my interest in engineering	5
7	This project increased my knowledge about fundamental concepts and ideas in engineering	3
8	This project was of great value to me	4.8
9	I believe I have a better chance of attaining my career goals as a result of this project	3.2

10	I would recommend this project for all introduction to engineering courses	4.9

In addition to the statements above, students were also asked a set of questions to which they had to provide written answers. The questions and a brief discussion of summarized responses are given below.

1. What engineering discipline were you interested in before participating in this project and why?
   Six (6) of the students listed more than one discipline, 3 of them weren't sure, and 4 of them listed a single discipline.

2. What engineering discipline are you interested in now and why?
   Eight (9) students decided on one discipline, 3 students listed two disciplines, and one student was still unsure.

3. Why did you or didn't you change your mind?
   Some students stated that they only made up their minds, some changed their mind because of more money or more interested in the career opportunities, while some made no changes because they had researched on the field previously.

4. What was the most important fact you learned from this project T
   There were several responses to this question, but the most common was the importance of enjoying one's career (4 students wrote this).

5. How likely is it that you will pursue engineering as a career?
   Most students were almost certain.

A graphical comparison between the pre- and post-project evaluation responses is given in Figure 1.

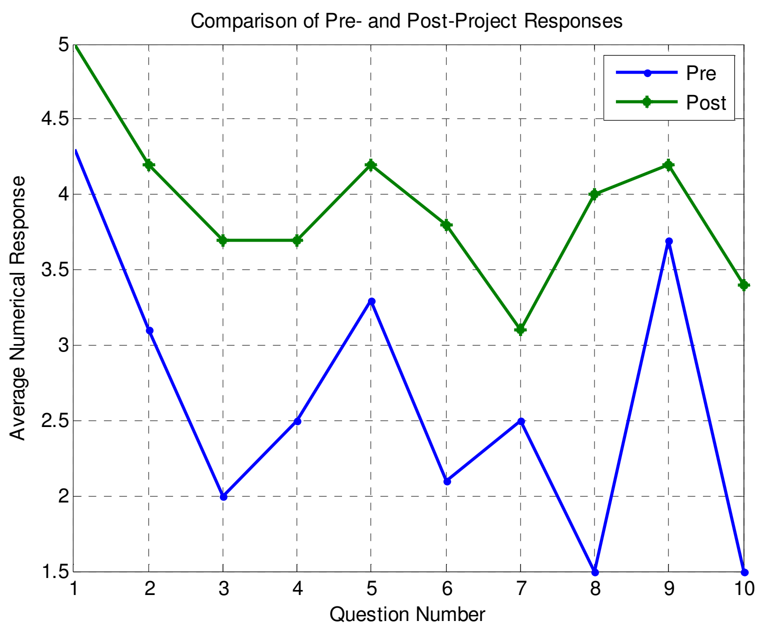

Figure 1: Average Numerical Responses to Pre- and Post-Project Evaluation Statements

From the above figure, it can be clearly observed that students had a more positive response to statements about their knowledge of the engineering discipline, as well as their preparedness for a career in engineering after the EFP than before. The statement with the most significant change of response was Statement 8: "I know how much engineers in several disciplines earn each year", with a 2.5 increase in numerical response. This indicates that several students are unaware of how lucrative a career in engineering is. The least significant change in response was Statement 9: "I believe I have a better chance of attaining my career goals as a result of this project", with a 0.5 change in numerical response. On average, students remained neutral on that point. Statement 1 also had a low numerical increase, as several students knew before the project that engineering has a strong impact on our world.

On the second set of questions, were students had to personally judge the impact of the project on their career plans and engineering knowledge discipline, an overall positive response was obtained. All questions received a rating of 3 or greater, with the greatest rating (of 5) being that the EFP increased their interest in engineering, and the least (of 3) being that the project increased their knowledge about fundamental concepts and ideas in engineering.

On the third set of questions, for which students had to write short answers, again, positive feedback was obtained, as most students indicated that they either changed or their minds toward an engineering discipline, or strengthened their decisions on one. Almost all students stated that they were almost certain to pursue a career in engineering.

The same evaluation was carried out in one section of the ES 100 course taught to students at Montgomery College who were engineering freshmen, undeclared majors, or non-science majors taking the course as a natural science requirement. About 19 students completed the evaluation, and while the results were similar to that of the College Institute in terms of an overall increase in rating, some differences were observed due to the fact that, on average, the college students were more decided about their careers than the high school students. It maybe worthwhile to note that as a result of the project, two undecided majors at MC changed their majors to an engineering discipline. Figure 2 below shows as comparison between the responses of MC students and those of College Institute students.

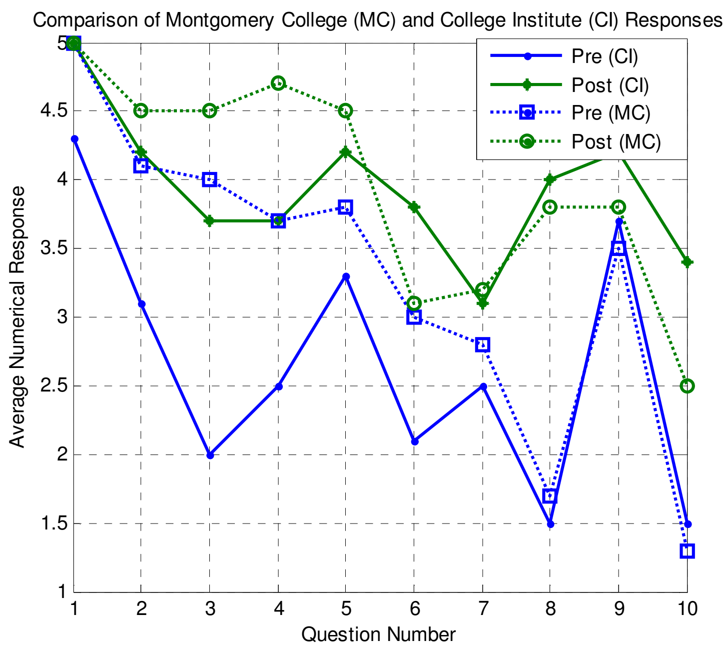

Figure 1: Average Numerical Responses to Pre- and Post-Project Evaluation Statements

Concluding Discussion

Pre- and post-project evaluations indicate that this project, even at its initial stage, has been successful in meeting its objectives, as indicated by the increase in average responses from pre- to post-project evaluations. The goal of recruiting more and better prepared engineers could also be said to have been met; however time will tell if the ultimate goal of retaining and graduating more engineers will be fulfilled, although results from the evaluations indicate so. Of the thirteen College Institute students, seven students enrolled in the subsequent engineering course, Statics, which is a requirement for mechanical, civil or aerospace engineers. Not all seven of them needed the course for the particular engineering disciplines, since the majority of them were considering a career in computer or electrical engineering, but they enrolled as a result of increased interest in the engineering field. For the first time since the College Institute was established at Thomas S. Wootton High School, a second section of the course has been created to accommodate the increase in the number of students who wish to enroll. The project is currently being carried out in a Spring 2009 college section of the ES 100 course, with modifications made based on formative evaluation responses from students.

While several publications,[1, 5, 6] and even websites,[7] exist that expose students, especially those in their pre-college years, to engineering careers and present them with specific guides and paths for successful futures in all engineering disciplines, the idea of making engineering career preparation part of a course curriculum is quite novel, hence the scarcity of publications reporting findings from similar projects. This paper presents the preliminary outcomes of a simple effort to formalize engineering career preparations in the classroom and increase the retention of students in engineering disciplines, with anticipation that this effort will be replicated by engineering educators, and ideas for enhancing the program will be shared, until the ultimate goal of attracting students into engineering and retaining every one of them until they obtain at least a bachelors degree is achieved.

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