AC 2011-2118: MINI-PROJECTS AS PART OF A FRESHMAN SEMINAR FOR MECHANICAL ENGINEERING TECHNOLOGY STUDENTS

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Mini-Projects as Part of a Freshman Seminar For Mechanical Engineering Technology Students

Abstract

First year experience courses are mainstays in the curriculum for freshman engineering technology students, as well as for students in other fields. There are several general types of seminars in use today. These range from general information about the school (known as extended orientation types) to discipline specific, pre-professional types. All of them offer advantages for first year students trying to get acclimated to college life. In addition to advantages for the students, other positive outcomes have been shown to result from having a formal first year program for students. For example, improved peer connections, increased use of campus services, and increased out of class faculty/student interaction have been attributed to these programs.

Almost half of the first year seminars are offered as one credit courses. It can be challenging to design a course with such tight time constraints. The course instructors must carefully balance the course load and content with the one credit the course is worth. The instructors must carefully select the content to make the most of the available time.

The course for mechanical engineering technology students at the authors school is designed with several goals. They include transitioning the students from high school to college life, providing information on the logistics of scheduling, introduce the students to the campus and student life and providing opportunities for the students to participate in activities which challenge their creativity and other skills.

This paper first presents a general overview of the course, including some of the reasoning behind the selection and timing of certain topics. The primary focus of the paper is on a description of various mini projects or activities designed to help meet the course goals listed above.

Introduction

Freshmen seminar courses have become commonplace in most engineering and engineering technology programs throughout the country. There are several types of courses that are offered ranging from extended orientation courses to discipline specific, pre-professional types. The catalog description for the course at Penn State Erie, The Behrend College (PSB) states that it should “facilitate student's adjustment to the high expectations, demanding workload, increased academic liberties, and other aspects of the transition to college life”. This general description leaves a lot of room for individual instructors to design their own version of the course. The course for the mechanical engineering technology students at our school has been designed as a hybrid course combining elements of both extended orientation courses and discipline specific courses. At the core of the course is a series of mini projects designed to help acclimate the students to college life, and to give them a taste for what engineering is all about.

The mechanical engineering technology freshman seminar at PSB is team taught by the two authors. It is a one credit course, as are most of the other freshman seminars on campus. Most of them are taught in one class period a week during the fifteen weeks of the semester. It was decided to offer the MET seminar during two class periods a week over only half of the semester. The main reason for this is that much of the material is time sensitive. For example, students need to learn how to schedule their classes before the date that they must do that for the next semester. Another reason for this format is that it was felt that students would stay more involved in the course if they had to attend more than just one class a week. This paper does not deal with the course as a whole. The purpose of this paper is to describe several mini projects that are used as part of the class to promote interest in the engineering arena.

Studies have shown that "positive self-perceptions of social acceptance and scholastic competence" are linked to a sense of belonging at the university[1]. Two of the projects described in this paper are designed to help students find their way around the campus, and hopefully help them begin to develop a sense of belonging. They are both listed under project 1 – scavenger hunts, and will be described below.

Others have also suggested that freshmen seminars should contain topics that stimulate the students to think, and to provide opportunities to learn through collaborative environments[2,3]. Two of the projects described in this paper deal with the design and building of mechanical devices while working in teams. They are projects 2 and 3 described below. These projects step the students through an engineering design process from concept through prototype. A key element in each of these projects is a surprise specification change half way through the process. Invariably these specification changes require at least a modification to the design, if not a complete redesign. These changes are in place to make the projects mirror real life projects which almost always involve design changes along the way.

Engineering technology students take many courses containing laboratory components. Students need to be prepared to deal with the data collection and presentation challenges that many of these labs involve. Project 4 involves some mildly challenging data collection and data reporting designed to help students get a feel for what will be expected of them during their many laboratory classes they will have to take.

As part of the TAC-ABET accreditation requirements for engineering technology programs outcome h calls for "an understanding of and a commitment to address professional and ethical responsibilities, including a respect for diversity"[4]. The topic of ethics in general is introduced in this seminar course as part of the need to meet this TAC-ABET requirement. Students are introduced to the differences between legal, moral, business and ethical decisions that they may face in their careers. The final mini-project is a series of ethical decisions they must make as part of a game. These will be described below.

Project 1 – Scavenger Hunts

The students taking this course are asked to participate in two scavenger hunts. The first of these is a short, one class period hunt in which they are asked to find various things in the engineering building, which is where they will spend much of their time while in school. The other one takes them across the campus to learn a little bit about the history of the school and to help them learn where various departments and other places are on campus.

There are several important things they need to know about the engineering building. The class is split up into teams of 2, and asked to spend the class period roaming the halls and finding various things. The first section is a list of the various labs. They must find the lab and record the room number. This section alone takes them on a tour of just about the entire building. There are five main engineering programs offered at the school. The second section contains a list of programs by their common abbreviations. The students are asked to find out what each abbreviation stands for, the name of the program chair and the program chairs office numbers. Finally, there are several other things in the building the students will need to be familiar with. These include the computer help desk, administrative offices, the location of important forms they will eventually need for various things, tutoring services, etc. They are asked to locate all of these as part of the hunt.

The second scavenger hunt is campus wide. Students work alone on this project. They are given a list of twenty-five questions pertaining to various aspects of campus life. They are required to answer twenty of the twenty-five questions. One of them is required. Everyone must get a signature from their advisor to force them to find out where their advisor is located and who it is. Some of the items are straightforward questions about the mechanical engineering technology program. For example, they are to name 3 courses that are approved as technical electives for the program. Others are trivia questions designed to get them to visit various places around the campus. An example is "how many flags are hanging on the first floor of the library?". Others require photos, such as "get a picture of yourself with one of your teachers". Students have two weeks to complete this scavenger hunt. A copy of the scavenger hunt form is shown in appendix A.

Project 2 – Robot Arm

The robot arm is their first introduction to working in teams on a design project. This project was adapted from the "Build Your Own Robot Arm" exercise published by TryEngineering[5]. The original exercise is designed for students from 8-18 years old. Many college freshmen are 18 years old, so the original exercise would be appropriate; however some changes have been made to make it a little more challenging. This project is completed during two class periods plus homework assignments.

There are several objectives for this project:

- Learn that engineering is not a "Junkyard Wars" endeavor. Engineering involves a design and planning stage which many first year students want to skip.
- Learn teamwork.
- Learn that design specifications can change at any time, and engineers need to be able to deal with those changes.
- Learn about cost trade-offs that engineers have to deal with.

The students are given a functional specification. They must design and build an arm that is capable of picking up and setting down an empty Styrofoam cup that could be placed either right side up or upside down. They may manually manipulate the arm, but they are not allowed to touch it within 18 inches of the cup. It is to be built from simple materials that are provided.

The teams are only allowed to use materials that are listed on table 1. Figure 1 shows some of the materials that students are allowed to select from for making the robot arm. Notice that they also have access to a limited number of tools to use in the construction phase. The parts for the wind power project (project 3) are very similar.

Materials	Maximum allowed	Unit cost
Binder clips – large	4	$0.35
Binder clips – medium	4	0.11
Binder clips – small	4	0.07
Binder clips – mini	4	0.05
Brads – long	10	0.05
Brads – short	10	0.02
Corrugated cardboard – assorted sizes	5 pieces	0.07
Corrugated cardboard – 3 x 22	3 pieces	0.15
Clothespins	6	0.06
Craft sticks	10	0.05
Fish line	5 feet	0.01/ft
Metal clothes hanger	1	0.08
8-1/2 x 11 sheets of paper	3	0.01
Paperclips – large	6	0.02
Paperclips – small	6	0.01
Rubber bands – assorted sizes	15	0.01
String	5 feet	0.01/ft
Tape - clear	unlimited	0.15/ft
Tape - masking	unlimited	0.17/ft

Table 1 – Material List For Robot Arm

The students are given a photo similar to figure 1 of the materials they can choose from, the list shown in table 1 and the functional specification. As a homework assignment they must meet as a team to brainstorm ideas and to create a concept sketch of their design. During the next class period they must build their device and show that it works. They do not have to strictly follow their concept sketch. If something does not work they are allowed to make modifications to make it functional. They must document any changes they make, and create a new "final" sketch as a homework assignment before the next class. Part of the project is to track the costs, so the students must also provide a list of materials they used, and the overall cost for the device.

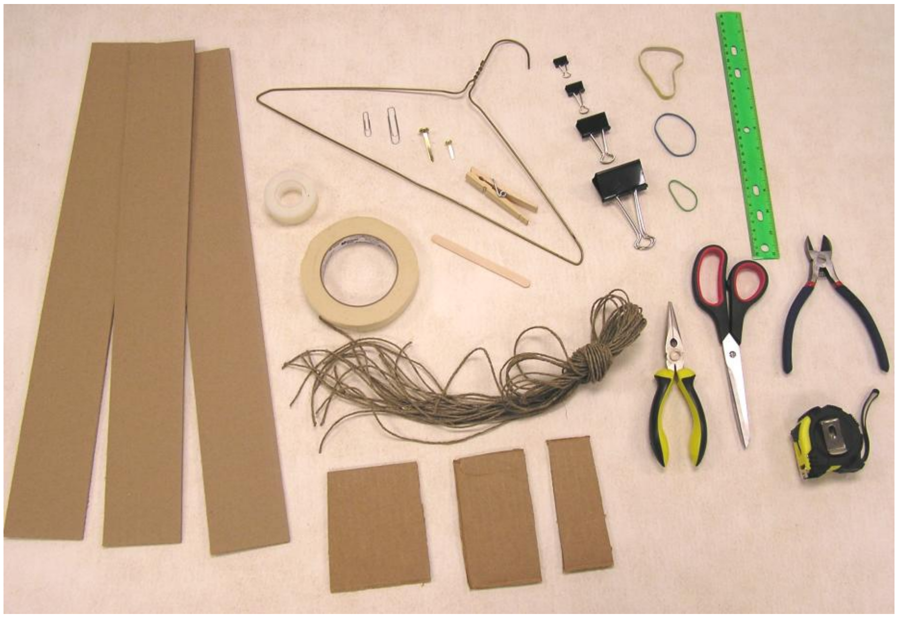

Figure 1 – Robot Arm Parts

Once the device is operational the students are informed that the customer has asked for a change to the specification. The arm must now be capable of lifting and setting down a 1/2 liter bottle of water. As a homework assignment they are required to once again meet, brainstorm ideas and determine what modifications need to be made to add this new capability. A sketch must be produced to show their proposed changes. During the next class the team makes the modifications, tests the new design and makes more modifications if necessary to make the device functional. Finally, as homework they must document what they did and determine the final cost of their device. They are also required to write a brief report on their experiences with this project.

Project 3 – Wind Power

The wind power project follows a similar approach to the robot arm. This project was also adapted from the "Working with Wind Energy" exercise published by TryEngineering[5].

There are several objectives for this project:

- Learn that engineering is not a "Junkyard Wars" endeavor. Engineering involves a design and planning stage which many first year students want to skip.
- Learn teamwork.
- Learn that design specifications can change at any time, and engineers need to be able to deal with those changes.
- Learn about cost trade-offs that engineers have to deal with.

The functional specification for this device is that it must be capable of lifting a standard size teabag a minimum of 2 feet off the table using nothing but the stream of air from a stationary hair dryer running on high. Once the teabag has been lifted it must stay in that position for at least 15 seconds. The hair dryer remains on for the entire operation. Once the hair dryer is turned off the teabag must return to the table. The original specification from TryEngineering requires that the design be some type of windmill. For this project that is left open ended to encourage the students to be as creative as possible. Table 2 shows the materials that are available for this project.

The general procedure is exactly the same as for the robot arm. The modification to the specification after the original design is that it must be capable of lifting a small baggie with 5 pennies in it as well as the teabag.

Materials	Maximum allowed	Unit cost
Aluminum Foil	24”	$0.05/ft
Bendable wire (0.78” or .062” diam)	30”	0.02/ft
Binder clips – large	4	$0.35
Binder clips – medium	4	0.11
Binder clips – small	4	0.07
Binder clips – mini	4	0.05
Brads – long	10	0.05
Corrugated cardboard – assorted sizes	5 pieces	0.07
Clothespins	6	0.06
Craft sticks	10	0.05
Dowels (.125” x 12”)	2	0.20
Fish line	4 feet	0.01/ft
Metal clothes hanger	1	0.08
8-1/2 x 11 sheets of “heavy” paper	3	0.03
Paperclips – large	2	0.02
Paperclips – small	10	0.01
Plastic wrap	24”	.01/in
Rubber bands – assorted sizes	10	0.01
String	5 feet	0.01/ft
Tape - clear	unlimited	0.15/ft
Tape - masking	unlimited	0.17/ft
Toothpicks	20	0.01
Wooden spoons - large	1	0.40
Wooden spoons - medium	1	0.30

Table 2 – Material List For Wind Energy

Project 4 – Data Collection and Presentation

Mechanical engineering technology students are often placed in lab situations where they need to take a relatively large amount of data. They must design data sheets that not only provide a place to record the data, but also are laid out in a logical, easy to understand format. One such experiment that is used in the thermal and fluid sciences lab at PSB is a first law of thermodynamics energy balance of a hair dryer[6]. As part of this experiment the students must measure the temperature of the air leaving the nozzle. The problem is that the temperature varies dramatically across the outlet. To account for this variation the students use a fixture with five thermocouples to measure the temperature in seventeen different zones across the outlet. The center temperature is recorded four times during this process, so an average of the center readings is used for the calculations. Figure 1 shows the zones in which the temperatures are to be taken, and figure 2 shows the device that is used to take the readings mounted to a hair dryer.

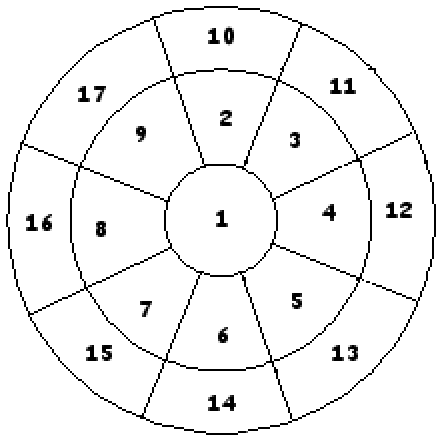

Figure 1

Figure 2

The objectives for this project are:

- Learn to design an effective data collection sheet.
- Collect temperature data from the outlet of the hair dryer in a methodical way.
- Record all of the data in a neat, well organized manner.
- Report the data so that someone who is unfamiliar with the device can easily understand what the values represent.

Students work in teams of two for this project. The hair dryer, hair dryer stand, thermocouple fixture and digital thermometer are provided. The entire project is completed during one class period.

Project 5 – Ethics

Ethical decisions are a part of every engineers' career. This project involves the students in a series of ethical dilemmas in which they need to make decisions based on their own ethical and moral standards. The scenarios are not necessarily engineering based. The students are asked to role play as part of a game in which they are trying to accumulate as many points as possible. They face several ethical dilemmas along the way. Each student first plays individually against another student. After a while they team up with their original opponent to play against another pair, and finally those pairings team up for a four on four competition. The point system is set-up to encourage somewhat unethical decisions for maximum points. However, these decisions can also result in bad consequences depending on what your opponent does. As the game continues it is important to learn about your own moral attitudes toward the dilemmas, but also those of your opponent. Each scenario is played several times, and at some point the opponents are even allowed to discuss what they will do. The question becomes "do you trust your opponent to do what they say they will do?". This game was originally published by Lorraine Ukens in a book titled "What Would You Do?"[7]. Because of time constraints only some of the scenarios are used in this course. Some of the ones that are used have been slightly modified, primarily for time reasons.

Before playing this game the students are taught about ethical dilemmas. Ethical dilemmas occur when a choice could conflict with a law, policy or code of conduct, when the choice could embarrass an individual or a company or when the persons individual interests conflict with those of others. This game focuses on the latter. What steps might a person take to help make ethical decisions?

- Analyze the actions
- Analyze the consequences
- Make a decision.

An individuals' family, religious and educational background can weigh heavily when these kinds of decisions must be made.

Four total scenarios are used from the book: training consultants, quarterly report, whistle blower and auto company. The first two pit students one on one with each other. The third scenario is two on two, and the final scenario is four on four. Each scenario is scored five times forcing the students to study their opponents behavior, and to try to adapt their own behavior to receive maximum points. Training consultant scenario is described here. See reference 7 for the other three, as well as others.

<u>Training consultant scenario</u> – you are a training consultant who has been hired at the last minute to put on a workshop for a company that gives you a lot of business. You reluctantly agree to do the workshop because of your long relationship with the company, but you're a little worried about being fully prepared. You do not have enough copies of the training manuals for everyone who will be attending the workshop. These manuals are copyrighted, so you cannot run copies without first obtaining permission. Your problem is that without these manuals you will have to stay up all night to either create your own training manuals or create a whole new activity. Therefore the dilemma you face is whether or not to go ahead and copy the manuals.

Students are competing against one other person in this scenario. Each of them must decide which of your options to go with. There are four possible combinations of decisions, each resulting in a different consequence. Table 3 gives this information. Notice that you get maximum benefit from being unethical if your opponent decides to be ethical. It can be a difficult decision to make. Each scenario is scored five times. The first two times the opponents make their decisions without any discussion. During the last three rounds they are allowed to discuss their options with their opponent, and agree to how they will decide. Unfortunately, you do not know if your opponent is being honest. As the game proceeds you learn more about yourself and your opponent to aid you in your decisions. Some students simply have high ethical standards and will take the most ethical path regardless of the scoring. Others will exhibit a competitive nature, and do anything to win.

You	Opponent	Your Consequence	Your Points
Copy	Don't copy	You get all of the future contracts from this company	10
Don't copy	Don't copy	Both of you share in future contracts	0
Copy	Copy	You have to pay for all the materials, and you lose all contracts for the next 6 months	5
Don't copy	Copy	You lose all of the future contracts	-10

Table 3 – Ethics Scenario 1

Assessment:

Presently there is not very much assessment data available. A brief survey was conducted among the eleven students who took this course during the spring, 2011 semester. They were asked to rate each of the projects on a scale of one to five, with five being the best. They were to rate them in three areas: "was it worthwhile?", "was it interesting?" and "did you learn something?". Six of the eleven students only rated the worthwhile question. Five of the students rated all three. The average of the ratings was considered to be the students overall feeling about the project. Table 4 shows the average ratings for each of the projects.

Project	Worthwhile?	Interesting?	Learn something?	Overall
Scavenger Hunts	3.55	3.00	3.60	3.45
Robot Arm	3.82	4.20	3.60	3.85
Wind Power	4.00	4.00	3.20	4.00
Data Collection	4.00	3.20	4.20	3.85
Ethics	2.82	3.60	3.80	3.09

Table 4 – Assessment Ratings From One Semester

Surprisingly the wind power and data collection projects rated the highest for the students. Why was this a surprising result? The wind power exercise was so similar to the robot arm that there was some concern that it might be boring for the students. The data collection project was expected to be the least liked of all of them. Below is a brief description of the student reactions to each of the projects.

The scavenger hunts were designed to be a fun way for the students to learn about places and things around the campus and in the engineering building. It was intended for students in their first semester on campus. The group that rated the exercises were second semester freshmen, so most of them were already fairly familiar with the campus. In general, they considered these exercises as the least interesting of all. We will reassess this with first semester freshmen to see if there is a significant difference in the attitudes of the two groups.

The robot arm was apparently the most interesting, but considered to be one of the least worthwhile projects. The wind power exercise was considered more worthwhile, but a little less interesting than the robot arm. These exercises are very similar. Not enough data is available to explain the differences in their attitudes, but a couple of possibilities need to be investigated further. The wind power may be a little less interesting than the robot arm because they had already done a similar exercise. However, they may have rated more worthwhile because they were more familiar with what was expected. They were much better able to deal with the cost accounting and a design change. The robot arm designs tended to be very simple, and did not show a lot of creativity. The wind power designs were much better. This may have been because they were expecting a performance requirement change, so they overdesigned from the beginning.

The data collection exercise did not seem to go well, but the student attitude showed this to be one of the better received projects. They felt it was worthwhile, and that they learned something. However, it rated poorly in the "interesting" category. All of the students did poorly on the data presentation part of the exercise. A better way to present the data was shown to them after the exercise, and they seemed to have a "oh, I see" moment. This exercise needs to be revised to increase the interest factor.

The ethics exercise was rated poorly by the students. This was somewhat expected. Even though the exercise is adapted from published exercises, the students felt that they could be made to be much more realistic. Work needs to be done to improve on this.

Conclusions:

The projects described above have only been used twice as part of the freshmen seminar for mechanical engineering technology students at PSB. They were used during the fall, 2010 and spring 2011 semesters. The exercises used during the spring were slightly different than the ones used during the fall. They were modified to try to improve their effectiveness in this class. The descriptions in this paper were the exercises used during the spring. No assessment data is available for the fall semester. The data given above is for a small class during the spring, 2011 semester. The students seem to like the exercises, but feel that some improvement needs to be made in order to improve their overall effectiveness. The general sense of the instructors based on in-class interactions with the students and informal feedback after class is that the students enjoyed doing these, and seemed to learn something from each one. The plan is to continue to incorporate them in the freshmen seminar class, to look at other similar activities to add to the list or to replace some of the exercises on the list and to look for ways to improve each project.

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Appendix A – Campus Wide Scavenger Hunt

1. Everyone must get a signature from your advisor.

   Advisor signature____

2. Who is the Chair of the MET Program at "___________"?
3. Name 3 courses that are approved Technical Electives for the MET degree.
4. What is the web address for the MET Course Flowchart?
5. What year was one of the first Reed Injection Molding machines built?
6. Where is the Fernleaf Buckthorn Tree?
7. Get a picture with the GE train cab.
8. How many " ____________" statues are there on campus?
9. In the Erie Hall Gym, what restaurant is advertised under the scoreboard?
10. How many planks are on the wooden bridge by Turnbull Hall?
11. How many flags are hanging on the ceiling in the first floor of the library?
12. Take a picture of the millstone on campus.
13. What animal is on the door of N68 (Nick Building)?
14. What is the name of the farm that was donated by "__________" in 1948?
15. How many soccer balls are in display cases in the Junker Center?
16. What is the price of a medium cappuccino in the Clark Café?
17. Name the 8 interconnected building at the west end of the campus

    (looking at the map is no fun – go out and find out for yourself)

18. Take a picture of the plastic yellow boy with a red hat… look for the word "Slow!"
19. What kind of dog was Bruno?
20. What year was Dobbins Dining Hall constructed?
21. What was the fuel mileage of "___________" Supermileage Car last year?
22. Get a picture with one of your faculty members.
23. What color is the wind tunnel on campus?
24. Get a picture of the windmill on campus.
25. Get a signature from the MET Freshman Interest Group mentor, Peter, at Club Rush on September 2nd in McGarvey commons. I'll be with the Auto Club.

    Mentor signature____

Bonus: Guess the average number of cycles the big elevator in the middle of campus goes through in one day.