Student Perceptions of a Theme-Based Introduction to Engineering Course

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Abstract

Recently, the curriculum in our Introduction to Engineering course was redesigned to include hands-on, theme-based projects with the hopes of increasing attendance and engagement of our first-year engineering students. Students were presented with four theme descriptions and asked to choose a theme for investigation during the Fall semester. In the Spring, students were asked to select a different theme for investigation. Each theme was comprised of two hands-on, team-based projects. In this paper, we present the eight projects developed for the course along with an assessment of students' perceptions associated with the theme-based projects.

Introduction

The Freshman Engineering Program (FEP) at the University of Arkansas (UofA) was established in 2007 with the primary objective of increasing the retention of new freshman in the College of Engineering (CoE) to their sophomore year. This objective supports college-wide retention and graduation rate goals. Thus far, there have been increases in both retention and graduation rates as shown in Figures 1 and 2. Therefore, we believe we are providing our students with a solid foundation for success in engineering study.

A key component of the FEP is the Introduction to Engineering (Intro) course sequence which serves as the first year experience course for new students in the CoE. The course sequence is offered as two, one-credit hour courses each semester of the first year. The students meet for two 50 minute lectures and one 50 minute drill section each week, as well as a 30 minute peer mentor meeting. This results in a total of 180 minutes of weekly contact. In general, lectures focus on engineering problem solving, drill sections focus on major selection and professional development, and peer mentor meetings focus on personal and academic success.

Recently, the content of the Introduction to Engineering course sequence was restructured to include a series of hands-on, team-based projects aimed at improving student engagement within the course. The sections of Intro were divided into four themes: biomechanical, computing, robotics, and structures. Students spent about half the semester working on activities and assignments associated with "essential topics" [1], and the remainder of the semester was spent on the theme-based projects.

		Cohort Year					
		1998 – 2006 COE	2007 FEP	2008 FEP	2009 FEP	2010 FEP	2011 FEP
2nd-Year Retention	College of Engineering	61%	62%	69%	71%	71%	**69%**
	University of Arkansas	82%	81%	85%	83%	86%	**83%**
3rd-Year Retention	College of Engineering	47%	50%	59%	56%	**55%**	
	University of Arkansas	75%	74%	77%	75%	**76%**	
4th-Year Retention	College of Engineering	44%	47%	55%	**52%**		
	University of Arkansas	71%	70%	73%	**70%**		
5th-Year Retention[1]	College of Engineering		45%	**55%**			
	University of Arkansas		68%	**72%**			
6th-Year Retention[1]	College of Engineering		**45%**				
	University of Arkansas		**65%**				

1 – includes students who already graduated

Figure 1. Freshman Engineering Program Retention Report

		Cohort Year					
		1998 – 2006 COE	2007 FEP	2008 FEP	2009 FEP	2010 FEP	2011 FEP
4-Year Graduation Rate	College of Engineering	17%	29%	**26%**			
	University of Arkansas	26%	39%	**34%**			
5-Year Graduation Rate	College of Engineering	35%	**39%**				
	University of Arkansas	53%	**55%**				
6-Year Graduation Rate	College of Engineering	38%					
	University of Arkansas	58%					

Figure 2. Freshman Engineering Program Graduation Report

Theme and Project Descriptions

When students arrived for summer orientation in June 2012, they were presented with a brief description of each theme and allowed to select their Intro course based on either theme preference or the time the course was offered. Then, in the fall semester, students were required to register for a different theme to investigate for the spring semester. Sixteen sections of Intro were offered in Fall 2012 – four sections of each theme. In Spring 2013, there were four sections of robotics and structures and three sections of biomechanical and computing for a total of fourteen sections.

The original theme descriptions and project idea were presented in last year's proceedings[1]. Below is an updated description of each theme and its associated projects. To better reflect the

essence of the themes, the biomechanical theme has been renamed biosystems, and the computing theme has been renamed electronics.

Biosystems

One of the grand challenges from the National Academy of Engineering[2] is to **provide access to clean drinking water**. In this theme, students' first project is to develop a water filtration device using inexpensive materials that would be readily available in most places around the world. Before building a working prototype, students research methods for combining the given materials to make an effective filter to remove turbidity from a dirty water supply.

The second project in this theme follows the grand challenge to **engineer better medicines**. In this project, students develop a mock drug delivery[3] system and perform experiments to understand diffusion and the effects of mixing. Students use a photometer and a programmable microcontroller to analyze the effects of the various mixing techniques.

Electronics

In this theme students build a series of simple circuits and control outputs using an Arduino Uno R3 Microcontroller. Students learn about basic programming paradigms including variables, input, output, loops, and conditional statements by modify existing code. In addition, students learn basic theory from electrical circuits, including total resistance calculations, Ohm's Law, Kirchhoff's Laws, and Voltage Division, and then verify their calculations in a laboratory setting. This theme concludes with the implementation of a Button Hero game that involves the use of buttons, LEDs, wires, and resistors.

Robotics

Robotics plays an integral role in many aspects of engineering including manufacturing, medicine, space exploration, and more. The use of robotics contributes to the National Academy of Engineering's grand challenge to **engineer tools of scientific discovery**[2]. In this theme, students use the Lego Mindstorm kits to build and program a simple robot. Though a series of tutorials, students learn about basic programming paradigms including loops and conditional statements. Students then apply their programming and problem-solving skills to solve engineering challenges related to renewable energy.

Structures

The focus in this theme is on the National Academy of Engineering's grand challenge to **restore and improve urban infrastructure**[2]. According to the 2009 Infrastructure Report card[4], more than 26% of the nation's bridges are "either structurally deficient or functionally obsolete". Therefore, the first project in the structures theme involves the use of simulation software to create a bridge that meets a set of design specifications while minimizing the cost of construction. Students then use the concepts they learn about structural members in tension and compression to complete a second project in which they build a balsa-wood structure. Students are given an opportunity to test and revise their designs prior to a competition.

Perceptions Assessment

To assess students' perceptions associated with the projects in the course, a survey was created and administered electronically via BlackBoard. Students were asked to complete the survey at the end of both the fall and spring semesters. To ensure a high response rate, students were given bonus points for completing the survey. The survey questions and student responses are shown below.

Question 1: Which theme-based Introduction to Engineering course did you participate in for the current semester? How did you select your Introduction to Engineering course for the current semester?

Theme	Unanswered	Based on theme descriptions	Based on the time the course was offered	Total
Unanswered	-	-	-	1
Biosystems	-	84	34	118
Electronics	-	59	47	106
Robotics	1	69	29	97
Structures	-	75	28	103
Total	1	288	136	425

Table 1. Results for Question 1 for Fall 2012.

Theme	Unanswered	Based on theme descriptions	Based on the time the course was offered	Total
Biosystems	-	62	58	120
Electronics	-	40	43	83
Robotics	-	121	48	169
Structures	-	95	41	137
Total	1	318	190	509

Table 2. Results for Question 1 for Spring 2013.

For the next set of questions, students were asked to respond to the statements using the following 5-point Likert scale:

5 Strongly Agree
4 Agree
3 Neither Agree nor Disagree
2 Disagree
1 Strongly Disagree
N/A Not Applicable

Question 2: Consider the following statements:
The projects associated with my Introduction to Engineering course theme:

a) improved my engineering problem-solving skills
b) improved my ability to communicate solutions to engineering problems
c) provided me with a meaningful experience working on a diverse team
d) helped me appreciate the multi-disciplinary nature of engineering
e) helped me appreciate the role of engineering in modern society
f) assisted me in selecting my engineering major

Statement	5	4	3	2	1	N/A	Average
a	72	219	73	42	17	1	3.68
b	69	229	78	32	14	1	3.73
c	111	211	62	29	12	0	3.89
d	84	217	77	32	14	0	3.77
e	114	209	62	27	11	0	3.92
f	51	120	106	65	34	49	3.24

Table 3. Results for Question 2 for Fall 2012

Theme	a	b	c	d	e	f
Biosystems	3.28	3.42	3.74	3.62	3.74	2.95
Electronics	3.97	3.87	3.92	3.89	4.01	3.47
Robotics	3.72	3.76	3.88	3.73	3.75	3.15
Structures	3.81	3.90	4.06	3.86	4.20	3.39

Table 4. Average Response for Question 2 by Theme for Fall 2012

Statement	5	4	3	2	1	N/A	Average
a	63	272	99	46	28	1	3.58
b	72	271	114	30	19	0	3.69
c	86	255	108	35	23	0	3.68
d	66	268	116	37	19	1	3.64
e	71	236	140	39	20	2	3.59

Table 5. Results for Question 2 for Spring 2013

Theme	a	b	c	d	e
Biosystems	3.27	3.59	3.57	3.66	3.54
Electronics	3.83	3.77	3.72	3.87	3.84
Robotics	3.67	3.75	3.80	3.58	3.43
Structures	3.60	3.63	3.61	3.57	3.68

Table 6. Average Response for Question 2 by Theme for Spring 2013

Question 3: Consider the following statements with regards to Project 1.

a) I enjoyed the first theme-based project
b) I enjoyed working with my partner or teammates on the first project
c) I would have enjoyed the first project more with a different partner or team

Statement	5	4	3	2	1	N/A	Average
a	113	218	39	41	13	1	3.89
b	115	223	54	23	9	1	3.97
c	32	63	134	144	50	2	2.72

Table 7. Results for Question 3 for Fall 2012

Theme	a	b	c
Biosystems	3.58	3.95	2.60
Electronics	4.15	4.11	2.66
Robotics	3.89	4.00	2.75
Structures	3.98	2.94	2.89

Table 8. Average Response for Question 3 by Theme for Fall 2013

Statement	5	4	3	2	1	N/A	Average
a	86	245	90	58	28	0	3.60
b	106	280	71	30	21	1	3.83
c	40	75	175	152	58	9	2.77

Table 9. Results for Question 3 for Spring 2013

Theme	a	b	c
Biosystems	3.90	4.01	2.58
Electronics	3.75	3.73	2.90
Robotics	3.47	3.93	2.68
Structures	3.40	3.59	2.99

Table 10. Average Response for Question 3 by Theme for Spring 2013

Question 4: Consider the following statements with regards to Project 2.

a) I enjoyed the second theme-based project
b) I enjoyed working with my partner or teammates on the second project
c) I would have enjoyed the second project more with a different partner or team

Statement	5	4	3	2	1	N/A	Average
a	157	159	39	40	29	0	3.88
b	146	176	46	34	23	0	3.91
c	40	61	126	128	69	1	2.71

Table 11. Results for Question 4 for Fall 2012

Theme	a	b	c
Biosystems	3.50	3.88	2.58
Electronics	4.21	3.94	2.65
Robotics	3.50	3.75	2.94
Structures	4.36	4.09	2.66

Table 12. Average Response for Question 4 by Theme for Fall 2012

Statement	5	4	3	2	1	N/A	Average
a	96	221	69	70	53	0	3.47
b	128	261	65	32	20	1	3.88
c	44	57	166	153	81	7	2.66

Table 13. Results for Question 4 for Spring 2013

Theme	a	b	c
Biosystems	3.01	4.01	2.49
Electronics	3.86	3.74	2.95
Robotics	3.31	3.82	2.59
Structures	3.82	3.93	2.73

Table 14. Average Response for Question 4 by Theme for Spring 2013

Discussion of Results

For the 2012-2013 school year, 798 students were enrolled in GNEG 1111 – Introduction to Engineering I in Fall 2012, and 667 students were enrolled in GNEG 1121 – Introduction to Engineering II in Spring 2013. The response rates for the end of semester surveys were 53% and 76%, respectively. As mentioned earlier, students were offered bonus points to complete the survey. As shown in Tables 1 and 2, the vast majority of students selected their Introduction to Engineering class based on the theme description as opposed to the time the course was offered.

The statements associated with Question 2 from the survey relate directly to the course objectives listed in the syllabus. For each of the statements, the vast majority of students either *Agreed* or *Strongly Agreed* that the projects associated with the Intro course had a favorable impact on the course objectives. In Tables 3 and 5, the student responses are tallied by statement and Likert-scale response. In Tables 4 and 6, the average response by statement is provided by course theme. In general, the students rated their satisfaction with the projects higher in the Fall semester than in the Spring semester. For example, in the Fall semester approximately 76% of students either *Agreed* or *Strongly Agreed* with the statement "The projects associated with my Introduction to Engineering course theme provided me with a meaningful experience working on a diverse team" while only 67% of the students in the Spring either *Agreed* or *Strongly Agreed* with that statement.

The statements associated with Questions 3 and 4 relate directly to the students' enjoyment of the theme-based projects. In Tables 11 and 13, the student responses are tallied by statement and Likert-scale response. In Tables 12 and 14, the average response by statement is provided by course theme.

Again, the student responses indicated that overall they enjoyed the projects more in the Fall semester. 78% of students in the Fall semester indicated that they either *Agreed* or *Strongly Agreed* with the statement "I enjoyed the first theme-based project" compared with 65% of students from the Spring semester. With regards to the statement "I enjoyed the second theme-based project", 74% of students responded favorably in the Fall semester compared with 62% of students in the Spring semester. On average across all themes and projects, students rated their enjoyment in working with their partners or teammates higher than they rated working on the projects themselves.

Conclusions and Future Work

In this paper, we have presented a set of theme-based, hands-on projects for an Introduction to Engineering course sequence along with the results from a students' perception survey related to the class projects. Based on the survey, the majority of the students seem to enjoy the projects and are relatively satisfied with their assigned team members. In general, students rate the projects from the Fall semester higher than the projects in the Spring semester, but we believe that this is because many students are working on their second-choice of theme during the Spring.

We will continue to offer the theme-based sections in the Intro course, and we will begin to incorporate theme-based examples for the "essential topics"[1] covered within the course. We will continue to monitor student perceptions of the course and modify project details and deliverables as appropriate. Specifically, we are interested in enhancing the mechanism by which students provide feedback on their assigned project team members

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