Assessment of Providing In-Class, Hands-On, Activities to Virginia Tech's First Year Engineering Students

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Abstract

Historically, engineering has been a practical outgrowth of the need to solve physical problems. Engineering education was initially based in practical laboratory and shop experiences, as well as traditional instruction in science and mathematics. Following World War II, engineering education in the United States began emphasizing theoretical sciences and mathematics. Though a justified response at the time, this approach has evolved to one of less and less practical instruction. Today, there is a strong need to supplement traditional teaching with activities that give practical meaning to the equations presented in the lecture[1]. To partially address this problem, we presented several hands-on collaborative experiences in eight of the 36 Introduction to Engineering (EF1015) lecture classes during the 2000 fall semester.

This paper will discuss the impact of these activities on student learning and perception of learning. A questionnaire to assess student perceptions of learning was given at mid-semester and at the end of the semester to eight hands-on (HO) sections and ten traditional (TR) sections. We first compare HO versus TR mid-semester responses and final responses to see if there is any difference in the students' perception of their learning. We then compare HO mid-semester perceptions versus HO end semester perceptions to see if hands-on activities were more beneficial to latter subjects. The results of these surveys and comparisons are presented as are our conclusions concerning using hands-on activities in class.

Background

Virginia Tech requires all first semester engineering students to take Introduction to Engineering I (EF 1015); a two-credit course designed to introduce the profession and to develop problem-solving skills. The instruction of engineering has become more theoretical and our students less hands-on over the last 50 years. It is entirely possible for an engineering student to graduate without ever having built or analyzed an engineering object. A fall 2000 survey of Tech's incoming freshman students showed that they come to engineering having very little experience in practical, technical, matters. The survey showed that:

- One half do not know the location of their home's breaker box
- One half have not changed the oil in a car

- Two thirds have not worked on a car engine
- 70% did not take high school shop

Effective classroom instruction requires motivated and participating students. It is increasingly difficult to keep students focused on what may be perceived as the dry or irrelevant subjects of units, precision, geometry, graphing, mechanics, and electricity.

In the fall of 2000, approximately 240 of Virginia Tech's 1,100 first year engineering students participated in a series of in-class, hands-on exercises, designed to maintain subject interest, provide examples of fundamental engineering concepts, and to foster an appreciation of applying basic concepts over broad topics. These exercises were preformed during traditional lectures in 20 minutes time. A total of eight activities were used with the majority presented early in the semester. A description of the activities as well as the goals of scaling up this program are in another paper, in this same session, authored by Goff and Connor.

Study Design

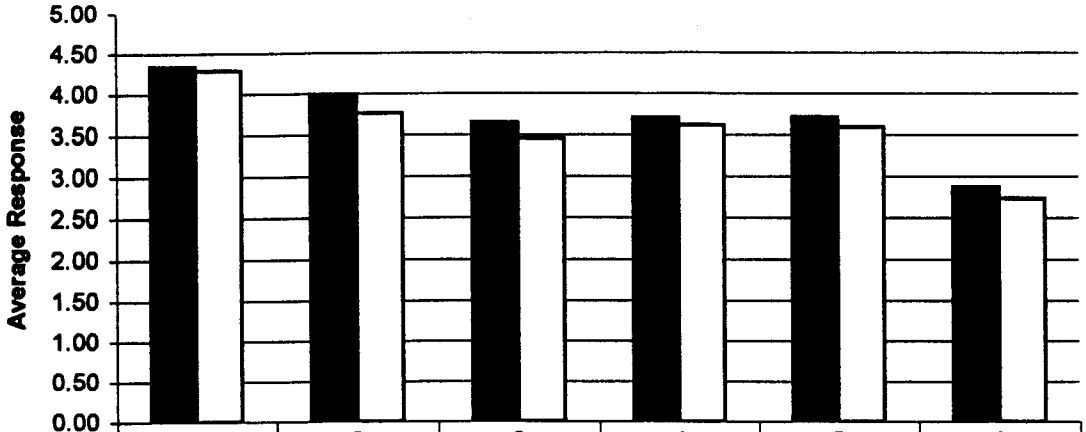
A survey was given mid and at the end of the fall semester to all eight HO sections and 16 TR sections at mid semester and 12 TR sections at the end of the semester. All students rated the first five statements on a scale of one to five (1, strongly disagree; 5 strongly agree) and responded to the sixth:

1. The thought of a career in engineering is exciting
2. I am learning in this class
3. This class has helped me understand engineering
4. This class is relevant
5. This class is useful
6. How many hours a week are you spending on EF1015 outside of class? (1= less than 3 hours, 2 = 3 to 5 hours, 3 = 5 to 10 hours, 4 = 10 to 15 hours, 5 = greater than 15 hours)

Results

We first looked at the differences in mean responses between the HO and TR students at mid-semester. The results are presented in Figure 1 and Table 1.

Figure 1
Mid-term Results



Statement	1	2	3	4	5	6
HO	4.345	3.993	3.643	3.708	3.718	2.871
TR	4.292	3.765	3.451	3.617	3.590	2.734

As Figure 1 shows, the HO students responded more positively to each of the five statements and indicated that they studied longer than the non-HO students. In order to see if the differences were significant, a pooled t-test was performed comparing the mean responses of the HO students (n=240) to the mean response of the non-HO students (n=449). For all t-tests, the null hypothesis was that the difference in means was zero versus the research hypothesis that the means differed significantly from zero. The results are presented below.

Table 1
Mid-semester Responses

	HO mean	TR mean	HO varience	TR varience	t-statistic	p-value
Statement 1	4.342	4.294	0.728	0.699	0.704	0.482
Statement 2	3.988	3.788	0.958	1.042	2.506	0.013 [a]
Statement 3	3.638	3.458	0.952	1.032	2.272	0.023 [a]
Statement 4	3.704	3.635	0.912	1.018	0.891	0.373
Statement 5	3.717	3.615	0.940	1.050	1.289	0.198
Statement 6	2.875	2.737	0.712	0.691	2.061	0.040 [a]

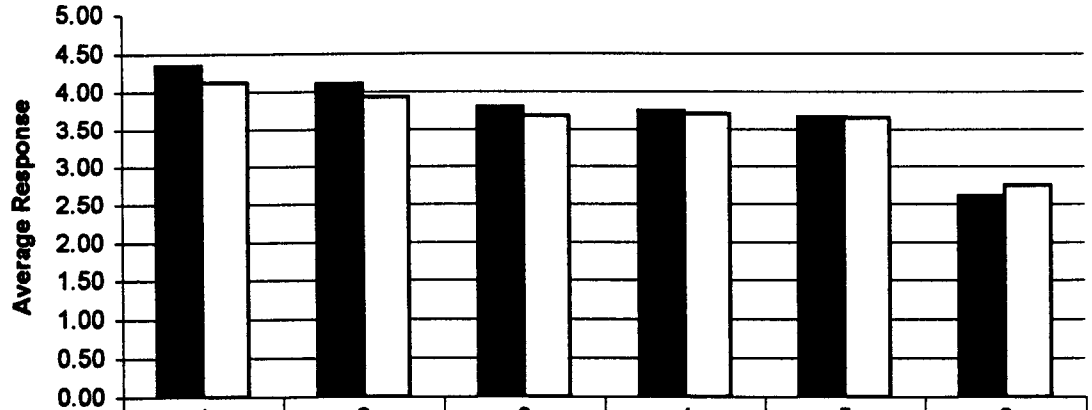
Note: "a" implies significant at the 0.05 level and "b" is significant at the 0.10 level

The conclusions from the mid-term responses were that, when compared to TR students, HO students:

- Perceived themselves to be learning more (# 2)
- Perceived a greater understanding of engineering (# 3)
- Worked longer hours on their engineering class than the TR students (#6)

We next looked at the differences in mean responses between the HO and TR students at end of the semester. The results are presented in Figure 2 and Table 2.

Figure 2
End of Semester Results



Statement	1	2	3	4	5	6
HO	4.345	4.108	3.803	3.754	3.670	2.606
TR	4.128	3.938	3.683	3.707	3.659	2.741

As Figure 2 shows, the HO students again responded more positively than the TR students to each of the five statements at the end of the semester. However they now indicated that they studied less than the non-HO students. A pooled t-test was again used to compare the mean responses of the HO students (n=203) to the mean response of the non-HO students (n=290). The results are presented below.

Table 2
End of Semester Responses

	HO mean	TR mean	HO varience	TR varience	t-statistic	p-value
Statement 1	4.345	4.128	0.781	0.894	2.609	0.009 [a]
Statement 2	4.108	3.938	0.780	1.055	1.971	0.049 [a]
Statement 3	3.803	3.683	0.832	1.027	1.375	0.170
Statement 4	3.754	3.707	1.008	1.066	0.503	0.615
Statement 5	3.670	3.659	0.955	1.215	0.120	0.904
Statement 6	2.606	2.741	0.735	0.753	-1.718	0.086 [b]

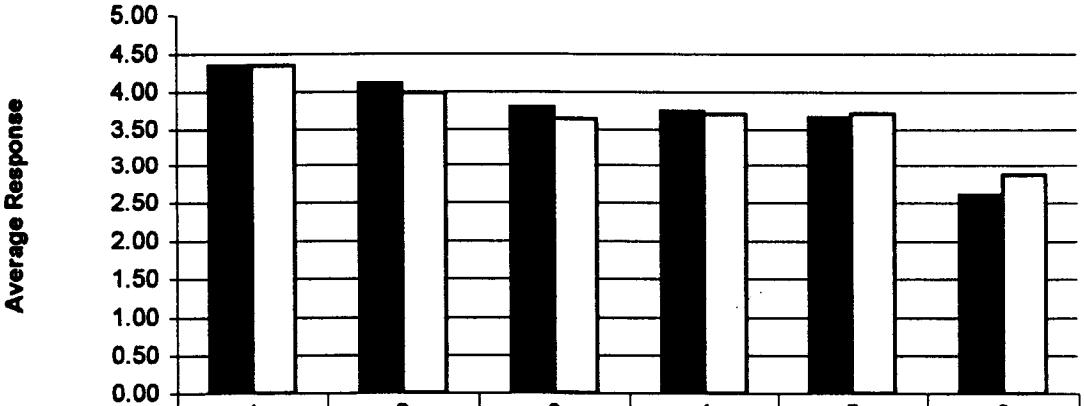
Note: "a" implies significant at the 0.05 level and "b" is significant at the 0.10 level

The conclusions from the end of semester responses were that, when compared to TR students, HO students:

- Were now significantly more exited about engineering (#1)
- Continued to perceive that they were learning more in class (#2)
- No longer perceived a greater understanding of engineering (# 3)
- Now reported themselves to be working significantly less (#6)

Lastly we looked at the differences in mean responses between the HO students at the end of the semester and mid-semester. The results are presented in Figure 3 and Table 3.

Figure 3
HO Final and HO Mid-semester Results



Statement	1	2	3	4	5	6
HO-Final	4.345	4.108	3.803	3.754	3.670	2.606
HO-Mid	4.342	3.988	3.638	3.704	3.717	2.875

Figure 3 shows that, comparing the end of semester responses to the mid semester responses, the HO students responded more favorably to the first four statements. They reply less positively to the fifth statement regarding the usefulness of the class however.

Interestingly, they reported working fewer hours outside of class at the end of the semester.

Table 3
End of Semester Responses

	HO-Final mean	HO-Mid mean	HO-Final varience	HO-Mid varience	t-statistic	p-value
Statement 1	4.345	4.342	0.781	0.728	0.038	0.970
Statement 2	4.108	3.988	0.780	0.958	1.366	0.173
Statement 3	3.803	3.638	0.832	0.952	1.842	0.066 [b]
Statement 4	3.754	3.704	1.008	0.912	0.529	0.597
Statement 5	3.670	3.717	0.955	0.940	-0.503	0.615
Statement 6	2.606	2.875	0.735	0.712	-3.310	0.001 [a]

Note: "a" implies significant at the 0.05 level and "b" is significant at the 0.10 level

The conclusions when comparing to HO students final response to their mid-semester responses were that at the end of the semester:

- Their perception the class giving them an understanding of engineering increased significantly (#3)
- Their time spent on engineering studies outside of class decreased significantly.

Summary

The hands-on activities met the goal of increasing motivation and appeared to meet the goal of increasing student learning. At the end of the semester the hands-on students were significantly more exited about a career in engineering than the traditionally taught students. Throughout the semester the hands-on students, in comparison to the traditional lecture students, felt they were learning more.

Bibliography

[1]Colb, D. A. Experiential Learning : Experience as the Source of Learning and Development, Prentice-Hall. (1984).

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