AC 2011-579: HYBRID LESSONS IN MULTIDISCIPLINARY SENIOR DESIGN: A STUDY

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Abstract

Under the Alfred E. Jenni Fellowship, a study was undertaken on the use of on-line materials to replace some of the multidisciplinary engineering senior design lessons which were in lecture form. The research question was: Will on-line delivery of Senior Design lesson material be as effective for student learning, or even more effective, than the present method of lecture-based instruction? Baseline data was first collected with a class-wide assignment of a pre-test at the beginning of the fall semester to assess student knowledge. The standard lecture course was presented and at the end of the semester, a post-content knowledge assessment was administered. Next, a series of the lectures was converted to on-line format using Blackboard. This lecture series was made available to the new senior design faculty along with a discussion of its use and of the research study. Again a pre-course content assessment was administered. Once more a post-assessment was given in the middle of the spring semester. However, the new faculty and the new format for senior design involved even more lectures and the on-line lessons were not put to use. The results show that there was less gain in content knowledge during the second year with even more lecture time. In talking to the faculty member in charge of the second class, he indicated that the material contained in the pre-/post- assessment was covered in the lecture portion of the course, but that it was perhaps diluted because of the large amount of additional information that was presented. In conclusion, the hybrid on-line and in-class format was not utilized even though it was developed. Although the research in the literature is clear that experiential- and self-learning techniques are more effective learning tools, many professors still rely on lecture as is evidenced in this senior design example.

Rationale for a Change

In the first semester of our senior design program, the student feedback concerning lectures has been quite critical. The criticisms have been constant for at least a decade as reported by the end-of-semester surveys designed for the class. Many of the concerns arise from the presentation of material which is often in the form of facts and lists. Though adjustments in class lectures have been made in an attempt to address these criticisms, little improvement in student response has been observed. The information provided requires only low levels of cognitive processing (as described by Bloom[1]), as students are asked to define, list, and describe (cognitive skills involving knowledge and comprehension) and are also asked to schedule their anticipated activities (which uses the cognitive level of "application"). In the senior year, and especially in Senior Design, it would be desirable to develop the *higher* levels of cognitive skills of synthesis and evaluation.

The work of Pavelich, Miller, and Olds[2] in the area of Perry Models has application in Senior Design as well. As educators, we would like to help students achieve higher levels of intellectual

development as measured through the Perry Scheme[3]. At these higher levels, students do not rely on authority to make decisions; rather, they use logic and evidence to make decisions in ambiguous real-world circumstances. More discussion time with faculty supervisors and less time in lectures could help to accomplish these many goals. The first step was to attempt to create an environment in which student teams can spend in-depth time with faculty. Replacing the traditional lecture with on-line lessons would allow an extra class time to be spent with teams and would allow the students to become better at self-learning (an ABET expectation). Some lecture time, for example guest lectures and team oral presentations, would remain.

With modern technology, the concept of a hybrid course in which a portion is on-line and the remainder is face-to-face is growing in popularity. Aycock[4], et al, of the University of Wisconsin – Milwaukee, studied numerous hybrid courses and reported that the integration of on-line with face-to-face learning facilitates interaction among students and between students and their instructors. McFarlin[5] of University of Houston, found an increase by one letter grade in student performance from standard lecture to hybrid instruction. Riffell[6] of Michigan State University found that minorities, in particular, increased their laboratory performance in a hybrid environment. Perhaps the most compelling argument can be made by Landers[7] in his doctoral thesis where a large number and variations of hybrid courses were analyzed. He states (p. 61): "it appears that online instruction is more effective than traditional instruction when seeking knowledge and problem solving gains". In creating a hybrid Senior Design offering, faculty members would have more opportunities to make connections with the on-line material and the team project.

Many of the present lecture topics apply directly to the design and construction of an object or structure and dissemination of knowledge (lists and facts). The teams that work on projects such as design and construction of a vehicle or robot quickly see the application of lecture topics to projects. Although the topics such as Quality Function Deployment and Failure Modes and Effect Analysis have broader applications, many students working on paper designs or humanitarian projects had difficulty relating the importance of the topic to their project. The added communication time that a hybrid class can offer will aid the students in making these connections.

Background on the Senior Design Courses

The Multidisciplinary Capstone Design Program in the Engineering Division encompasses a two-semester course sequence. Students from Civil, Environmental, Electrical, and Mechanical Engineering specialties from the CSM Division of Engineering participate in a single course. The program has an annual average enrollment of 250 students (approximately 2/3 begin the sequence in the fall, 1/3 begin the sequence in the spring) working on 45-50 externally-sponsored projects/year guided by a faculty team of eight members. In the 2008/9 academic year, weekly meetings included ten lectures in the first semester and provided systematic design tools that supported engineering design, project management, workplace issues, and communications. The major objective of the first semester was the preparation of a formal design proposal. During the second semester, students implemented their designs through the construction of working prototypes or preparation of a design/build bid package for the project that was designed during the first semester. With a change of senior design faculty in the

2009/2010 school year, a change in schedule and format was introduced. Two sessions of weekly lectures and/or laboratories were begun. The number of lectures was doubled from ten to twenty. For the first semester, the student worked on a reverse-engineering project. Teams were formed in late October and the actual project began with a more compressed time schedule.

Research Methodology

During the fall semester of 2008, Senior Design lectures were presented in the traditional manner. Students were given a pre-test (see Figure 1) as part of a class assignment on the facts presented in the lecture material on the first day of class. Students then completed a post-test at the end of the semester. This provided a baseline for comparison with the proposed hybrid offering. The plan was to repeat the process with the 2009 offering of Senior Design I. However, the portions of the lectures were to be presented on-line using Blackboard. Introductory course material, team oral presentations and guest speakers would continue to use class time. At the end of the semester, a post-test of the hybrid model would again be administered. A comparison between the growth from the 2008/2009 group and the 2009/2010 group could show the effectiveness of a hybrid class that could replace much of the lecture portion of senior design. Even though there was a difference in the number of lecture topics in the two semesters, the topics covered in the content assessment were discussed in both years.

Pre and Post Content Assessment Questions and Value

1. (1 pt)What is the difference between a memo and a letter?
2. (4 pts)List four of the steps in Quality Function Deployment
3. (1 pt)According to the Code of Ethics for Professional Engineers, what is the first duty of an engineer?
4. (4 pts)List at least four of the steps in the engineering design process.
5. (3 pts)List at least 3 items that should be included in a monthly progress report.
6. (1 pt)A design review should occur during what phase of a project?
7. (1 pts)What is a Work Breakdown Structure? How is it used?
8. (4 pts)List four items that should be included in a budget for a design project.
9. (1 pt)Can software be patented?
10. (1 pt)Give one method in which engineering design can be communicated to the assembly or construction team.
11. (4pts)List four items that should be included in a proposal.

Figure 1. Content Assessment Questions for the pre- and post- tests.

One of the goals of this study was to convert a selection of the current instructional units to

- Engineering Design Process
- Leadership
- QFD and House of Quality
- WBS/Scheduling/CPM
- Safety and Liability
- FMEA
- Budgeting/Communication
- Engineering Ethics

Figure 2. On-line Lecture Topics

online units using the Blackboard educational software. Blackboard is a program designed to support the development and delivery of on-line courses. Each online unit included embedded assessment activities which the students would be required to complete. Figure 2 lists the topics which were converted to Blackboard format.

Pre- and Post Content Assessment Data Results

A thorough analysis of the pre and post test for each year was undertaken. The statistical results obtained from both of the pairs of pre-and post-content assessment are discussed in detail in this section. The same assessment consisting of 11 questions, with a total of 25 points, was given both at the beginning and the end of each course.

For the 2008/2009 AY group pre-content assessment, 210 students participated and the data had no incomplete or invalid entries. Figure 3 below shows the overall average of 9.3 out of 25. Figure 4 shows the details of average per question and includes the maximum points available for each question.

Figure 3. Summary statistics
Count: 210

Min	1st Quart	Ave	3rd Quart	Max	STDEV
0.0	7.0	9.30	12.0	17.0	3.68

Figure 4. Average points by question:

Question	1	2	3	4	5	6	7	8	9	10	11
Average	0.15	0.03	0.61	2.29	1.98	0.14	0.40	1.22	0.74	0.62	1.27
Max	1	4	1	4	3	1	1	4	1	1	4

Similar information is available for the Post-Content Assessment. 192 students completed the post-test online and the data had no incomplete or invalid entries. Figure 5 shows the overall average while Figure 6 details the data question-by-question.

Figure 5. Summary statistics
Count: 192

Min	1st Quart	Ave	3rd Quart	Max	STDEV
0.0	13.8	15.31	18.0	21.0	3.58

Figure 6. Average points by question

Question	1	2	3	4	5	6	7	8	9	10	11
Average	0.68	2.47	0.85	3.31	2.73	0.19	0.35	1.35	0.85	0.79	2.41
Max	1	4	1	4	3	1	1	4	1	1	4

The T-test rejects that the the two means are equal ($p << .001$), and therefore the assumption must therefore be that the higher average result from the post-test is statistically valid. More gain was shown on questions 2 and 5, but interestingly, a negative gain resulted for question 7.

For the 2009/10 group, the same assessment consisting of 11 questions was given both at the beginning and the end of the course. Because of a misunderstanding of question 1, the second faculty member changed the wording. Therefore that question was removed from the analysis.

For the Senior Design class beginning in the Fall 2009, the Pre-Content Assessment Results are shown in Figure 7. 193 students completed the pre-test, the data had 11 incomplete or invalid entries. The assumption was that these 11 had missed the fact that there was a second page of the test and they were therefore removed from the analysis. As stated above, Question 1 was removed from the statistics as well due to an inconsistency in the wording between the pre and the post test. Figure 8 illustrates the details of each question.

Figure 7. Summary statistics
Count: 182

Min	1st Quart	Ave	3rd Quart	Max	STDEV
0.0	8.0	9.54	12.0	17.0	3.73

Figure 8. Average points by question

Question	1	2	3	4	5	6	7	8	9	10	11
Average	-.--	0.02	0.58	1.66	1.99	0.29	0.23	1.91	0.74	0.55	2.33
Max	-	4	1	4	3	1	1	4	1	1	4

Finally, the data for the 2009/2010 Post-Content Assessment results are presented in Figures 9 and 10. 195 students completed the post-test, the data had 15 incomplete or invalid entries. The assumption was that these 15 had missed the fact that there was a second page of the test and they were therefore removed from the analysis. Question 1, again, was removed from the statistics as well due to an inconsistency in the wording between the pre and the post test.

Figure 9. Summary statistics
Count: 180

Min	1st Quart	Ave	3rd Quart	Max	STDEV
6.0	12.0	13.86	16.0	23.0	3.41

Figure 10. Average points by question

Question	1	2	3	4	5	6	7	8	9	10	11
Average	-.--	1.30	0.66	2.41	2.51	0.45	.55	1.98	0.68	0.82	3.23
Max	-	4	1	4	3	1	1	4	1	1	4

Statistical validy was again confirmed as the T-test rejects that the the two means are equal (p << .001). Once again, the most gain was made with questions 2 and 5.

Due to the differences in point distribution with the removal of quesiton 1 for the second year, it is not possible to perform direct statistical anaylsis between the two years. However it is still possible to make some observations. It is surprising to see all the 0's on question 2 when looking at the points distribution for the 2010 post-test. The amount invalid samples (incomplete tests) for 2009/2010 was also remarkable. Both years showed improvement on questions 2 and 5. Question 2 addressed Quality Function Deployment while question 5 addressed the content of progress reports. These are both topics that are directly applied to design projects in this course sequence. The reduction in score in year one and a poor showing in year 2 of question 7 indicates that more efforts should be made in the topic of scheduling. This could be done either through lecture, or by application directly to projects. In general, a pre-post test sequence should be used more often to adjust lecture topics in any format.

If an adjustment is made to the year-one data by removing question #1, the average pre-test score is 9.15 and the average post score is 14.63. For year-two, the average pre-score was 9.54 and the average post score is 13.86. A growth of 5.48 points is seen in year one while a growth of 4.32 points is seen in year two. Note that about 8% of the post-tests from year two were declared invalid because of lack of response for half of the questions. No statistically significant analysis can be made to further compare these two data sets. However, it does appear that more lecture does not yield better scores. When hearing this result, the second year instructor commented that because of more lecture, perhaps the topics in the content assessment had been diluted.

Challenges

An educational research project is difficult to evaluate in one academic year. More commonly, years of data should be collected to verify trends. However, initial data can be gained by this study. Two common challenges often occur with educational research. The students change over time and the instructors change over time. In this study, the change of faculty had a direct impact on the study. As is often true at the university level, faculty are reluctant to give up lectures. They teach as they were taught. A change of culture is necessary in order to instigate different teaching techniques that the literature indicates are successful, such as hybrid course delivery. Landers[7] states (p. 61): "At the very least, it can be concluded with a great deal of confidence that web-based instruction is generally as effective as traditional instruction".

Success of a hybrid class could impact large numbers of students. Students could have more available time with faculty to work at a deeper level on their senior design project from both the technical and project management points of view. Among the ABET criteria is a desire to foster "life-long learning." Practice in using on-line resources to learn can provide a conduit for self-education after graduation.

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