

The Impact of Group Size and Course Length on a Capstone Design Course

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Abstract

In the spring semester of 2003, the School of Industrial Engineering at Georgia Tech ran an experimental one-semester version of their capstone course, Senior Design. The standard version is two semesters in the length, and the purpose of the experiment was to compare the marginal benefit of the second semester for the student (and project sponsor) to the cost of running the second semester in terms of faculty and sponsor resources. In addition, a survey was conducted on past students and sponsors of senior design to determine the impact of group size (which ranged from 5 to 12 over the study period) on the student and quality of output.

1. Introduction

For several years, the School of Industrial and Systems Engineering at Georgia Tech (ISyE) offered a two-quarter sequence in Senior Design. In the fall of 1999, Georgia Tech underwent semester conversion. It was decided during the curriculum redesign process that Senior Design should be converted to a two-semester sequence. Since that time, there has been much discussion about the appropriateness of a two-semester versus a one-semester version.

Critics of the current two-semester version of Senior Design have stated: i) the project length is too long and therefore not realistic, ii) it takes too many faculty resources, iii) group sizes have become too large, and iv) many potential project sponsors are unwilling to make a nine-month commitment. Proponents of the current version, on the other hand, argue that: i) it allows for sufficient time to do serious work, ii) it gives students more opportunities to develop the stated learning objectives such as communications skills, and iii) potential project sponsors prefer the two-semester version. The arguments for and against the current version, however, are largely anecdotal.

In the spring of 2003, an experimental one-semester version of the design course was offered (along with the standard two-semester offering), and the outputs compared to the two-semester version. The comparison included student surveys, sponsor surveys, faculty surveys, salaries, and double-blind grading of the final project reports. In addition,

faculty resource issues were studied. Finally, a survey was conducted on previous Senior Design students and their sponsors in order to determine the effect of group size on performance. In this paper, we present the findings of this experiment.

There is significant literature on capstone design courses for engineering education. The vast majority of this literature focuses on content, delivery mechanisms, and learning objectives. A survey of capstone courses given in North America is found in Todd et al. (1995) and a good review of literature concerning the teaching of engineering design through capstone courses is given in Dutson, A.J., et al. (1997). Techniques for addressing common problems in engineering design projects are discussed in Moor and Drake (2001). While there have been several studies of the impact of class size, particularly in primary and secondary education (e.g., see Hanushek (1998) for discussion), we are not aware of any literature that discusses the impact of group size or term length on capstone design courses. As this has a large impact on the student as well as faculty resources, this is an important issue to address.

In Section 2 we discuss the two-semester and one-semester course offerings along with the learning objectives of Senior Design. In Section 3, we discuss the population studied and surveys used. In Section 4 we describe the methods for the analysis. Since the experimental version of the course is offered in spring 2003 (and the completion of this manuscript was January 2003), the results are unfortunately not available yet, but will be given at the ASEE Conference in Nashville¹. Conclusions are given in Section 5.

2. Course Description and Objectives

Students work in teams of an average size of 8 (with a range of 5-12 since semester conversion). Student groups work as unpaid outside consultants satisfying their interest in a real world design experience. They work on well-defined, specific design activities. Each team picks its project, but Senior Design faculty reserve the right to veto projects that do not appear to comply with the course objectives (listed below). Senior Design groups are required to submit reports throughout each semester and a presentation is made (first to the class and then to the sponsor) at the completion of each report. During the semester, students frequently meet with their professors and with the sponsor representative. Each group member is expected to spend a minimum of 6 to 9 hours per week on the project over the course of the two semesters. This effort is focused on resolving a specific problem or completing a specific project and is not intended for carrying out day-to-day operations.

Typical of a program of this type, Senior Design offers a wide range of design projects that are generated from local companies and institutions. This accessibility provides students the opportunity to assess each project in detail and to be able to ask questions and perform site visits. Under normal circumstances, project sites are within an hour's drive of the Georgia Tech campus. Example projects have come from companies such as Home Depot, Coca-Cola, Northside Hospital and Delta Airlines, government agencies

¹ After July 2003, the results will be posted at www.isye.gatech.edu/~pgriffin/asee-results.pdf.

such as the Centers for Disease Control and the Fulton County Tax Commission, and not-for-profit organizations such as the Red Cross, Hands-On Atlanta, and Meals-On-Wheels.

2.1. Standard Two-Semester Schedule

In the first semester, students form groups and are then responsible for finding two potential projects. Both projects are presented to the class, and a faculty advisor is then assigned to the group. Working with the advisor, one of the two projects is chosen. The group then works to develop a detailed project proposal. This includes a self-contained report and a presentation. The presentation is first given to the entire class (as a means of practice) and then to the sponsor. Once the proposal is approved, the group spends several weeks collecting appropriate data. An interim report and presentation is then given (again, as in all presentations, first to the class and then to the sponsor). This is a self-contained report that discusses the findings to this point, and an outline for the remainder of the semester. At this point the group continues to collect data and then analyze the data and develop initial alternatives. A final report and presentation are then given at the end of the first semester.

During the second semester, the student groups continued to develop and evaluate alternatives. The best alternative is then chosen and an implementation plan developed. An interim and final report and presentation are given throughout the semester.

Since semester conversion, student group sizes have ranged from 5 to 12, with an average of 8. Faculty assigned to the course will typically advise 5 groups (though this has ranged from 3 to 6 groups). Groups stay together for both semesters, and keep the same faculty advisor over this time. Grades are also given for each semester. Typically (but certainly not always) each group member receives the same grade.

2.2. Experimental Senior Design Schedule

As mentioned previously, the experimental version was run in the spring semester in 2003. In order to ensure that students had the full term to work on their design project, it was required that students form their group during the fall of 2002 along with identifying a sponsor and a sponsor representative committed to working with the group. Groups of size 4 or 5 were allowed.

Due to the reduced length of the course, the number of written reports and presentations were reduced compared to the two-semester version. For the experimental case, each student group was responsible for a project proposal with a presentation, an interim presentation, and a final report with a presentation. The sequence of data collection, alternative development, alternative selection and implementation plan remained the same.

2.3. Course Objectives

Senior Design is intended to provide:

- a problem analysis and system design experience similar to ISyE professional practice, and
- an opportunity to practice and perfect the skills of technical report writing and oral presentation

In particular, Design is intended to significantly improve skills in²:

1. Systems Analysis and Design - Including the ability to:
 - a. Define a problem
 - b. Identify and analyze relevant factors
 - c. Develop a model of the problem
 - d. Choose and apply appropriate methodologies and computational tools
 - e. Generate and evaluate alternative approaches for accomplishing the desired objective
 - f. Design the needed system
2. Technical Writing - Skill in documenting the results of a student's work will determine to a large extent the value of that work. In addition to developing good writing skills, students should explore the possibilities offered by computing and networked information systems (subject to any constraints imposed by the sponsor).
3. Public Speaking - It is not enough to do good work, one must also convince others, who may be apathetic or even antagonistic, that the work is good. Skill in making a clear, concise, and convincing presentation may make the difference between a successful project and fruitless effort.
4. Team Work - Life in the real world entails working together with people from different backgrounds, interests, styles, and temperaments. The student will learn to cooperate with a diverse group of individuals and coordinate activities with others in the group and the sponsor, even when there are conflicting priorities. Successful groups learn to work harmoniously, complete the work on time, and prepare effective and well-written reports.
5. Project and Time Management - Interacting with a diverse group of individuals, completing tasks satisfactorily and on time even as problems develop, and preparing various reports and presentations will sharpen project and time management skills.

3. Populations Studied and Surveys Used

In order to compare the impact of term length, six populations were studied. The first three populations consisted of the students in the experimental design class in spring 2003 (n=60) along with the sponsor representatives (n=12) and faculty advisors (n=2).

² The skills description was taken from a syllabus developed by Dr. Craig Tovey in ISyE.

The second three populations consisted of students that took senior design starting in the fall semester of 2002 and ending in the spring 2003 (n=172) along with the sponsor representatives (n=20) and faculty advisors (n=4).

Three surveys were conducted for this analysis: a student survey, a sponsor survey, and a faculty survey. Two survey examples are:

Current Student Survey

Personal Data

Name:

e-mail address:

Most recent overall GPA:

Most recent ISyE GPA:

Have you interviewed for jobs this semester?

If so, How many interviews did you have?

How many job offers did you receive?

If you accepted an offer, who is the employer?

If you accepted an offer, what is the starting salary?

Group Data

Average number of hours I worked per week:

Number of group members (include yourself):

Section of Senior Design enrolled in:

Sponsor Data

Sponsoring Firm:

Sponsor Representative:

Sponsor Representative's Title:

Estimate the savings (if any) for you sponsor if they implemented your results:

Estimate the additional revenue generated (if any) for your sponsor if the implemented your results:

Answer the following by circling the closest response: (1=strongly agree, 2=agree, 3=neither agree or disagree, 4 disagree, 5=strongly disagree)

- | | | | | | |
|---|---|---|---|---|---|
| 1. Our group size was appropriate: | 1 | 2 | 3 | 4 | 5 |
| 2. Our group size was too large: | 1 | 2 | 3 | 4 | 5 |
| 3. Each member did their fair share of work: | 1 | 2 | 3 | 4 | 5 |
| 4. I did more work than other members in my group: | 1 | 2 | 3 | 4 | 5 |
| 5. This course helped develop my technical presentation skills: | 1 | 2 | 3 | 4 | 5 |
| 6. This course helped develop my technical writing skills: | 1 | 2 | 3 | 4 | 5 |
| 7. This course helped me to better work in groups: | 1 | 2 | 3 | 4 | 5 |
| 8. This course helped me to develop my analysis skills: | 1 | 2 | 3 | 4 | 5 |
| 9. This course helped me to develop my problem definition skills: | 1 | 2 | 3 | 4 | 5 |
| 10. This course helped me to develop my time management skills: | 1 | 2 | 3 | 4 | 5 |
| 11. Our faculty advisor was helpful: | 1 | 2 | 3 | 4 | 5 |
| 12. Our sponsor representative was helpful: | 1 | 2 | 3 | 4 | 5 |
| 13. Our sponsor will implement our findings: | 1 | 2 | 3 | 4 | 5 |
| 12. The faculty advisor evaluated my work appropriately: | 1 | 2 | 3 | 4 | 5 |
| 13. I found this course to be valuable: | 1 | 2 | 3 | 4 | 5 |
| 14. I found this course to be the most valuable I have taken at Tech: | 1 | 2 | 3 | 4 | 5 |
| 15. The course length was appropriate: | 1 | 2 | 3 | 4 | 5 |
| 16. Our group final result would have been better with more time: | 1 | 2 | 3 | 4 | 5 |
| 17. The required number of presentations was appropriate: | 1 | 2 | 3 | 4 | 5 |
| 18. The required number of reports was appropriate: | 1 | 2 | 3 | 4 | 5 |
| 19. We spent too much time on reports/presentations: | 1 | 2 | 3 | 4 | 5 |
| 20. A larger group would have helped our results: | 1 | 2 | 3 | 4 | 5 |

Current Sponsor Survey

Name:

Position:

Years at Firm:

E-mail address:

Firm Name:

Has your firm (to your knowledge) participated in Senior Design in the past?

Estimate the number of hours per week you spent on this project:

Estimate the total number of person-hours per week your firm spent on this project:

Estimate the total cost to your firm (ignore benefits, if any) of participating in this project:

Estimate the savings (if any) that would result from implementing the group results:

Estimate the additional revenue generated (if any) that would result from implementing the group results:

Will you make any job offers to any of the senior design members?

Answer the following by circling the closest response: (1=strongly agree, 2=agree, 3=neither agree or disagree, 4 disagree, 5=strongly disagree)

- | | | | | | |
|---|---|---|---|---|---|
| 1. Being a senior design sponsor was beneficial to our firm: | 1 | 2 | 3 | 4 | 5 |
| 2. The senior design process was of appropriate length: | 1 | 2 | 3 | 4 | 5 |
| 3. The senior design process was too long: | 1 | 2 | 3 | 4 | 5 |
| 4. The senior design group was the appropriate size: | 1 | 2 | 3 | 4 | 5 |
| 5. The senior design group was too large: | 1 | 2 | 3 | 4 | 5 |
| 6. Our firm will participate again in the future: | 1 | 2 | 3 | 4 | 5 |
| 7. Our firm participated in Senior Design for the assistance: | 1 | 2 | 3 | 4 | 5 |
| 8. Our firm participated as a service to Georgia Tech: | 1 | 2 | 3 | 4 | 5 |
| 9. Our firm participated to recruit students: | 1 | 2 | 3 | 4 | 5 |
| 10. The group presentations were effective: | 1 | 2 | 3 | 4 | 5 |
| 11. The group reports were effective: | 1 | 2 | 3 | 4 | 5 |

In order to compare the impact of group size, previous students of Senior Design ($n=3$), filled in a web-based survey.⁴ The survey questions were similar to the previous survey and so not included here.

4. Methods

We computed the sample statistics for all of the survey questions given in all of the survey types. In order to determine the impact of term length on Senior Design, we focused on three areas: i) how well the learning objectives were met, ii) how useful the sponsor found the results, and iii) how good an independent evaluator felt the results were. To address the first part, we tested if there was a significant difference between the two Senior Design offerings based on the student survey questions (perceived ability) and the sponsor survey questions (actual ability) that have to do with the learning objectives between the two class-type offerings. We also tested how well perceived ability correlated with actual ability. To address the second issue, we ran a set of similar tests on those survey questions that had to do with cost savings and revenue generation. Finally, to address the third issue, a group of volunteer faculty members for other Industrial Engineering departments were used to grade the final reports. Each volunteer was given

³ At the time of the writing of this paper, the survey results were not yet available.

⁴ An alumni list is maintained in the ISyE Development Office, and all previous students on that list were e-mailed and link to a web page that contained the survey questions.

four reports, two from the 2-semester version and two from the 1-semester version and asked to grade the reports based on content and writing effectiveness. The grader did not know how many students were in the group (or their names), the grade assigned by the group advisor, or the version of Senior Design that the work was performed in.

In order to determine the impact of group size, we used the survey results from previous students. We ran statistical tests to test if there is a significant difference between group sizes and then computed the marginal benefit.

As mentioned previously, this paper was written before the data was collected. However, the complete results and implications will be available at the time of the conference (July 2003) at www.isye.gatech.edu/~pgriffin/asee-results.pdf.

5. Conclusions

When designing an Engineering curriculum, it is not only important to determine what content to include, but how that content should be delivered. Faculty resources are expensive, and there is normally strong competition for them. It is important, therefore, that they be used effectively. In addition, delivery will effect what the student takes away from the curriculum at graduation.

While there has been much work recently in teaching strategies (e.g., active learning techniques), little or no work has been done on group size or term length issues. Decisions on their specification are normally based on anecdotal evidence at best. In this paper we have given a systematic method for determining the impact of these factors. The results will be used for specification of delivery of Senior Design in ISyE at Georgia Tech. In addition, we plan on studying the impact of other curriculum design issues such as flexibility.

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