An Adaptive Senior Design Course with an Emphasis on Undergraduate Course Curriculum

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Abstract- The senior design course is a typical indicator of the success and productivity of the undergraduate course curriculum. Senior design course bridges the gap between the theoretical and practical domain along with providing hands on experience. Hence, it is crucial to have a concrete and highly productive course structure. This paper provides a quantitative evaluation of the outcomes i) to determine the merit of the curriculum and ii) to offer a crucial assessment of student competencies. Accordingly, this paper discusses a framework of the senior design course at the University of South Florida and the iterative work it underwent over the span of three semesters resulting in a significant improvement in the students' performance. This study focuses on a database of the undergraduate students from the last three semesters and underlines the facilitation of assessing an undergraduate course curriculum through a senior design project.

Index Terms- senior design project, capstone course, undergraduate curriculum.

INTRODUCTION AND BACKGROUND

Senior design course is an integral part of the undergraduate course curriculum. It helps to enhance the students' design skills which are of a great prominence while transitioning from the academic to the industrial space. While attempting to bridge the gap between theoretical and practical abilities, it also aids in cultivating other necessary skills such as teamwork, creative engineering and critical thinking [1]. The senior design course sequence at USF's department of electrical engineering tries to embed the abilities to analyze and design complex systems while measuring the student's knowledge of math, science, and engineering.

Since the senior design project is an innate reference to the design skills and other academic proficiencies which are a part of the undergraduate curriculum, a definite correlation can be established between the student's expertise during the other undergraduate courses and the design course. However, this correlation is largely factored on the success of the course, that is how successfully the course converts the academic skills into practical skills. Now that we have established how important the course is, it can be inferred that a noticeable improvement in the course improves the quality of the projects to a considerable extent. Hence, continuous monitoring and analysis of the course and its structure are conducted over a period of time and there have been efforts to enhance the learning experience and improve the quality of students' projects with progressive modifications. Quantitative evidence from a database of students is gathered and the results are noted to ensure that the efforts are successful. Several paradigms have previously been developed to enhance the learning experience in senior design courses [3]. Todd *et al.* propose a course by considering the recommendations from all of the stakeholders involved in the course and try to implement them towards a succesful course [4]. Hanna *et al.* propose an improvement in the design course by using the continuos feedback from the students. We propose a more comprehensive feedback evaluation and implementation method along with a few other relevant modifications. The course specifics and structure is described in the following section. The changes administered in the course during the span of three semesters are provided in Section III followed by the assessment of outcomes and the conclusion.

COURSE SPECIFICS AND RATIONALE FOR THE STUDY

The senior design course sequence at the University of South Florida is composed of two courses, Design 1 and Design 2, spanning two semesters, as shown in Figure 1. While Design 1 deals with the nascent phases of the project that include selecting and planning a project, Design 2 deals with the execution and presentation of the final project. This paper primarily focuses on the changes introduced in the Design 2 course and the related impact on the final outcome.

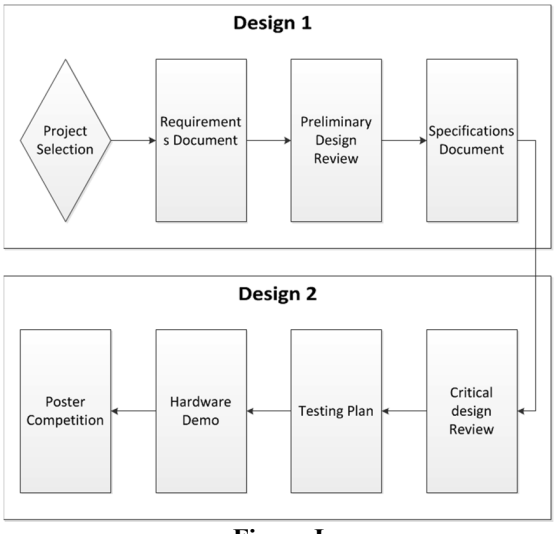

Figure I
SENIOR DESIGN COURSE SEQUENCE AND STRUCTURE

During Design 1, students form a team and present their progress through three review sessions as well as through weekly updates. These weekly updates are extended through to Design 2 which uses the same format for the reports. During Design 1, students formulate their team dynamics and find a faculty advisor. Each team has a faculty advisor who is different from the instructor of the course. The project requirements and resources are established and presented towards the mid semester during Design 1. A preliminary design review session is scheduled at the end of the semester to present the students' preliminary design ideas.

A better understanding of the projects and the team dynamics by the instructor is vital for a successful course. Design 2 starts with individual meetings between the instructor and each team. All of the members of a team are required to be present during these individual meetings. The instructor uses these meetings not only to learn the details of the projects but also to assess any issues in the work division among the team members. A specific attention is paid to ensure a balanced work division among the team members. These meetings are followed by a critical design review presentation session two weeks later. The students are required to come up with a website that keeps track of their progress which is supposed to be continuously updated. The deliverables of Design 2 are evaluated based on the presentations, reports, and assignments. The interim reports such as the Test plan document, weekly reports, and the critical assessment document are evaluated by the instructor and certain presentations such as the critical design review and the YouTube video presentations are graded by a group of faculty judges. The final presentation requires the students to present their projects to the department's advisory board and other invited engineers from the industry. The breakdown of the grading structure is shown in Table 1.1.

TABLE I
WEIGHTS OF GRADING COMPONENTS

Project Website	5%
Essays	5%
Weekly Status Updates	10%
Faculty Advisor meetings	5%
CDR	20%
Test Plan Document	10%
Prototype demonstration Video	15%
Critical Assessment Document	10%
Final Poster Presentation	15%
Final Documents & capstone Assessment	5%

CHANGES ADMINISTERED IN THE COURSE STRUCTURE AND OTHER DEPENDENCIES

I. Efficient Grading Techniques

Although efforts have been made to ensure the maximum amount of faculty participation, it has to be seen that the participation of the faculty is always limited due to their hectic schedules. To ensure a high level of participation to the grading, each faculty member in the department is encouraged to send their graduate students as judges. The feedback provided by all of the judges are compiled and a report is prepared based on the feedback that is shared with the students along with their grades.

II. Feedback through Essays

The students are provided with a questionnaire to share their opinion on the course structure and the instruction which includes identifying and describing the best and the worst things of the course. It also asks the students opinion on the changes made in the course and the alterations they wish too see in the course. This essay is due towards the later part of the semester. The feedback from the students is gathered and analyzed every semester and the necessary changes have been made to reflect the students' opinion. This feedback combined with the data gathered at the end of the semester is a perfect reflection of the success of the course.

III. Make course and other Capstone Courses

Project based courses in the curriculum provoke a necessary shift towards stimulating the students interest in design and its application to real world problems. Student can learn basic hardware implementations such as 3D printing and use of Arduinos through these courses. Apart from the changes made by the instructor, the department has also been instrumental in providing necessary stimulus to the senior design project. The other departmental courses such as the 'Make' course and few other capstone courses helped the students to equip themselves with the necessary design techniques and some hands on training well before they were supposed to take the senior design course.

IV. Re-evaluation of Rubrics

The rubrics used for the course are re-engineered and re-modeled. Although the essence of the existing rubrics is not overlooked, a dedicated grading rubric for different presentations and documentations have been designed and provided to the students. This includes arguments ranging from quality of the project to understanding scientific and engineering concepts along with the knowledge of subsystems they are working on.

V. Instructor's Role and Related Transformations

As mentioned earlier, the instructor meets the student groups at the beginning of the semester. These meetings are continuous throughout the semester and the instructor typically takes this opportunity to learn about the team dynamics, familiarize the students with the course requirements, and provide necessary feedback to their presentations and the related documentation. Apart from a few lectures which familiarize the students with design and career opportunities, the guest lectures in the course are restricted in order to allow the students to have more number of in class work days. The students are also encouraged to meet with their faculty advisor at least once every two weeks.

ASSESSMENT OF THE OUTCOMES

As a part of this study, the data metrics of 118 students from Fall 14, Spring 15, and Fall 15 is analyzed and their ability to convert their academic skills into practical skills is studied. The variations in the poster competition grades and the critical design review grades over the course of three semesters are depicted in a couple of graphs and a trend line is settled.

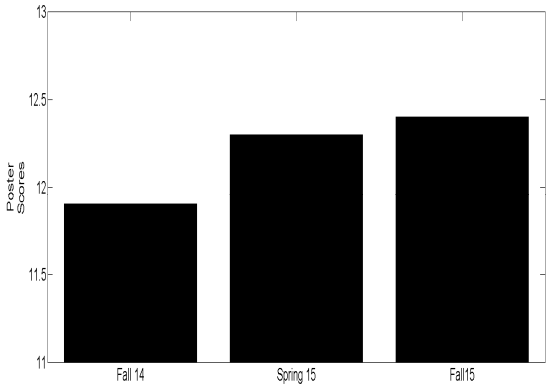

FIGURE II
POSTER SCORES

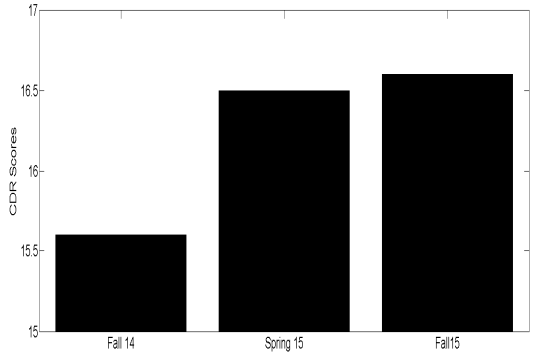

FIGURE III
CDR GRADES

Figures 2 and 3 demonstrate that there is a significant improvement in the average grades over the semesters. This reflects that the changes made in the course are not only useful for the enhancement of the course structure but also play a deterministic role in the student success. The trend is continually increasing and a significant jump can be seen from Fall 14 to spring 15, the time when most of these changes were implemented. This shows that the effect that the mentioned changes had on the course is highly significant.

TABLE II
GPA, FINAL SCORES CORRELATION

Semester	GPA	Grades
Fall 14	3.24	11.9
Spring 15	3.34	12.3
Fall 15	3.34	12.4

Now that, we have effectively demonstrated an incremental change in the scores, the next task would be to establish a metric that shows a transformation of theoretical skills to design skills. To assess the effectiveness of the senior design course and the merits of the undergraduate course curriculum at USF, an effort to correlate the undergraduate course curriculum and the design course statistics have been done. This has been established by bringing out a relationship between the Student's overall GPA and their final grades from the Design 2 course. From Table II, it can be inferred that the relationship between the final grades from the Design 2 course and the GPA is largely proportional. Interestingly, the semesters with similar average GPA's also accounted to have similar final grades. Also, a statistical test has been employed during the Fall 15 semester to determine the ability of each individual student, as shown in Figure IV. A MATLAB program has been written such that it returns a 'hit' if the GPA correlates with the Design 2 grade and a 'miss' if it does not.

```
    If (GPA >3.3 & scores >12 || GPA < 3.3 & scores < 12 )
       disp("Hit")
    Else
       disp('miss');
    end;
  Hits==30
  Misses==9
  Ratio= 3.33
```

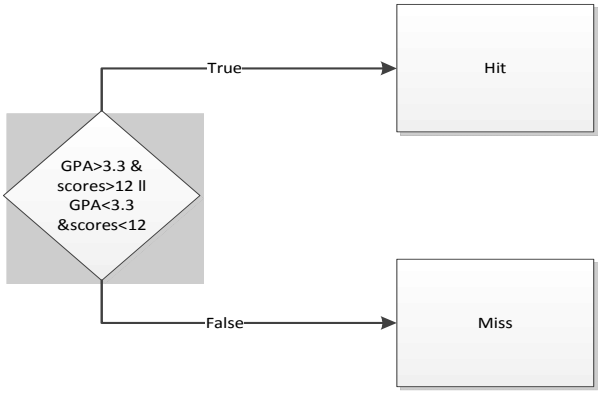

FIGURE IV
FLOWCHART FOR GPA CORRELATION.

The results proved to be quite encouraging. Thirty students have been able to convert most of their skills they have learned through their undergraduate curriculum into practice at the design course. Most of the remaining students excelled at senior design course albeit their low grades. Effectively, from the remaining 9 students, a majority of them have low GPA and better grades. This proves that the senior design sequence effectively boosted the student's practical ability in spite of not having the best grades during their undergraduate program. Also, from the data collected and the results obtained, it can be inferred that a high correlation exist between the undergraduate GPA and the design course scores.

CONCLUSION

The primary objective of a senior design project is to improve the design skills of an engineering graduate. Efforts to do so have been channeled and the results are tabulated. From the data gathered and the statistical analysis performed, we can infer that the changes made in the design course resulted in a significant surge in the student performance. It can also be inferred that the senior design course is a measure of a student's ability to convert their theoretical skills to practical design skills. The changes made in the course are continuously implemented and possible ways to further improve the effectiveness of the course are being evaluated.

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