AC 2009-1353: MODIFYING SENIOR DESIGN: A DESIGN REVIEW

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Modifying Senior Design:
A Design Review

Abstract

The Senior Design Course in Electrical and Computer Engineering at the University of Kentucky is currently going through a total redesign. The goals of the course modification are to 1) give the students a better understanding of real world problems, 2) expose the students to open-ended problems, 3) enhance the students’ professional skills, and last but not least with all the previous goals, 4) ensure compliance with ABET standards.

The introduction of new elements into the class is phase-wise. There are many different reasons for this approach: a radical change of one course without changing the overall curriculum is hard to sell to faculty and students. Furthermore, an immediate change due to ABET requests had been necessary to ensure a positive accreditation outcome. Finally, while reviewing the different successful models at other programs it became clear that none of these models would provide all aspects for a successful program needed by our students. Therefore, over the past years new elements have been introduced to the Senior Design Class remodeling it into a successful Capstone Design Class. This paper will present a design review of the current structure of the course including experiences, challenges, and successes. It will further outline future changes to the course planned for the next couple of semesters. The design review is needed at this point because it is planned to implement the next major step in the remodeling process: switching from a one-semester course to a two-semester sequence in the fall of 2009. Evaluating the status will help to define current strengths of the course, which should be kept and reinforced, as well as current shortfalls, which should not be transferred to the two-semester sequence if possible. Presenting this design review will encourage other educators to reflect on the status of their own Capstone Design Courses.

Introduction

This paper briefly describes the redesign process of the Senior Design Course in Electrical and Computer Engineering at the University of Kentucky. The redesign was initiated by the department’s 2004 ABET Accreditation visit, where an immediate change to the course had been necessary to ensure a positive accreditation outcome. Further changes have been introduced over the following semesters to strengthen the students’ experience.

The course also needed to be adapted to the fact that it now serves not only electrical engineering students but also computer engineering students, since the Computer Engineering program was formally introduced at the University of Kentucky in Fall 2005. The Computer Engineering program has gone through an ABET accreditation visit in Fall 2008 without any major comments on the status of the senior design class.

This paper is based mainly on anecdotal evidence. The author is the course coordinator for the class since Spring 2006. So far, besides the bi-annual teacher course evaluations obtained for all classes at the university, no instrument exists to formally test the effects of the introduced
changes. As the course advisor, the author gets feedback from current students, alumni, other faculty, and industrial advisors of the department and specific industrial advisors to the senior design course.

The course redesign has been an iterative process starting in the Spring 2005 semester and is still ongoing. The author started teaching the class in Spring 2006. Since then each semester between 19 and 33 students have been enrolled in the class, forming between five and nine teams.

Status before Redesign

The senior design course prior to the redesign was structured as follows:

• Each project became its own section of the senior design class.
• Individual students or a team of students would work on a project, no rule existed on how many students were a minimum or maximum number for a team.
• Each project had a faculty advisor.
• The faculty advisor decided what deliverables were necessary for the project; no consistency existed for the whole class on reports or presentations.
• The faculty advisor graded the project

This structure did not ensure that all students were exposed to the same level of content. In the following the different phases of the redesign are described.

Phase 1:

The course is restructured to have one main responsible course advisor. This advisor establishes a basic set of written deliverables, which are a proposal report and a final report. The projects must be worked on in teams, where the minimum number of team members is two. The course still has no maximum number of students per team, even though no teams were formed with more than six students in it. The student teams must give a proposal presentation. For the final presentation ECE Senior Design Day is introduced, a three-hour showcase. For this, the teams must prepare a poster describing their projects and show a product prototype. During the showcase faculty members of the department judge the projects and teams. The team members must consult with the team’s faculty advisor as well as with the course advisor to report on progress. The course coordinator also has lectures or guest speakers presenting on design-relevant topics. The course advisor assigns the final grade with input from the faculty advisors.

Improvements:

+ Requirement of at least two members per team enhances interpersonal communication skills.
+ Requirement of proposal presentation and ECE Senior Design Day presentation enhances oral communication skills.
+ Requirement of reports enhances written communication skills.
+ Enrollment in one basic course ensures all students are exposed to the same contents.
+ Grading by course advisor ensures the same grading level for all students.

Need for further improvement:
- Currently the course advisor allows individual students to hand in their own reports if they were not happy with the team report. This was contradictory to the overall goal to enhance the team experience.
- Teams with only two team members tend to struggle more often than teams with more students working on one project. Two-student teams seem to have as many team difficulties as all the other teams, but they have more problems recovering from them.
- Some teams do not manage to build a prototype by the end of the semester; other teams definitely are underperforming even though some kind of prototype was presented.
- All teams underestimate the time needed for the design of their prototype. Senior Design seems to be very susceptible to procrastination, being one of the only courses in the curriculum not asking for homework, quizzes, or exams each week.
- There is a lack of enforcement of a professional poster format for ECE Senior Design Day resulting in “posters” more of the style of elementary school science fair displays with papers glued onto tri-fold display boards.
- The duration of ECE Senior Design Day results in unequal judging for the different teams:
  - The judges walk through the showcase as one group
  - The judges tend to spend a lot of time with the first teams and do not have an equivalent amount of time to spend with the teams they interview at the end of the event.

The structure of the course is improved, but most teams still do not take ownership of their projects. Projects are more treated like an extended homework and not like a “major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints.”

Phase 2:

The next set of changes to the course introduces a minimum (three) and maximum (four) number of students for each team. More reporting is introduced: each student must keep a design notebook to show individual work on the project. Furthermore, each individual student must write a weekly email report to show work progress. For the teams a pre-proposal is introduced to have a first written report earlier in the semester to give the students feedback on their writing skills. Also a design review report around midterm is introduced to check the teams’ progress. The design report also gives the students the opportunity to reformulate parts of their proposal which where not suitable for their project. The teams also must give a design review presentation, where they must present the new scope of their project. Self/Peer-Reviews are introduced to gain more insight into the team dynamics. The Self/Peer-Review measures three skills (Quality of Work, Team Membership, Communication) on a seven point Likert scale. The review is given twice per semester, at midterm and at the end.

Improvements:
- Restricted team size helps to level out scopes of projects.
- Teams still break apart during crunch time, but with the restricted team size most of them still are able to deliver some basic parts of their prototype.
- Self/Peer-Reviews at midterm tend to have high (positive feedback) results. Teams
breaking apart in crunch time can also be identified with the review at the end of the semester; at least one team member on these teams will get considerably lower ratings (for example dropping from a rating of 6 down to 3).

Need for further improvement:
- Team dynamics are still an issue. At least one team per semester (out five to seven) breaks apart during crunch time.
- The amount of reporting is overwhelming for the students and the course advisor.
  - The weekly emails from individual students cannot be read in such detail that the course advisor can step in when it would be needed. In the amount of emails actual problems get lost.
  - On top of all the other reporting, the weekly emails only frustrate the students and do not give them a positive feedback of having weekly deliverables as in all other courses.
  - Pre-proposal, proposal, design review, and final report are too many reports for the teams within one semester.
- Self/Peer-Evaluations give insight into the team dynamics, but do not help to resolve any conflicts yet. Especially at midterm (first evaluation) teams tend to give each other very high ratings. It is assumed that the students have not yet reached their storming phase in the forming, storming, norming, and performing sequence of team development. The harsh peer reviews at the end of the semester suggest that the teams have only reached their storming phase and never enter the last two phases of the team dynamics cycle.

The new set of changes to the course is not as effective as had been hoped. The amount of bookkeeping is tremendous due to all the reports and presentations. Students are unable to work efficiently on their technical project due to the overload on report writing. Students also complain that one semester is not enough time to produce a professional prototype. The basic feedback from the Self/Peer-Reviews also indicates that one semester might not be enough to give the students a positive team experience, which would include the last to phases of norming and performing.

**Intermediate Conclusion:**

All changes in phase 2 have been introduced in the author’s first semester teaching the senior design course. Even though the amount of reporting seemed to be overwhelming for students and the course coordinator, all reporting still had been kept. The course coordinator assumed that inexperience in guiding the students in the reporting had been the main cause for the student complaints and the author’s trouble to keep up with all emails and reports.

**Phase 3:**

For ECE Senior Design Day the students now must prepare a professionally-looking poster. For the design day, poster stands have been purchased so the students can demonstrate their posters in a conference-like setting.
In 2006, a two-semester option is offered to the students. Students can choose to work as a team for two semesters on a project, enrolling in the Senior Design course in fall and enrolling in an individual study course in spring. Students must select the two-semester option at the beginning of the fall semester and must enroll in the spring; otherwise, their senior design grade will be a failing grade. Four students out of 32 choose this option. Three students form one team; one student is a double-major EE/ME and works as the team leader of a mechanical engineering design team, which needs additional electrical engineering expertise. The mechanical engineering department has switched to a two-semester design sequence the year before.

Improvements:
+ The course coordinator gained insight into a project of two-semester length.
+ The poster displays gained in professionalism.

Need for further improvement:
- Since only one team worked on the two-semester schedule, keeping track of progress was not a top priority for the course advisor, which proved to be a drawback because the team underperformed in their final prototype.
- Having one single student in a mechanical engineering team also did not work as well as expected:
  o ME teams are allowed to be much bigger (the team in question had 10 team members)
  o The reporting schedules of the EE and ME design course are not in sync.
  o ME has no Self/Peer-Evaluation in place, therefore the peer evaluation was absolutely ineffective.
- All the problems with the amount of reporting mentioned in phase 2 still exist.

The course coordinator had drafted a proposal for a two-semester senior design sequence during the first semester of the initial offering of the two-semester option. This proposal needed further refinement after this experience. Also, the reporting issues needed to be addressed before the transition to the longer design experience.

**Phase 4:**

The amount of reporting is decreased: The students do not need to send weekly emails anymore. More emphasis is now put on proper note-taking in the individual design notebooks. The midterm design review is reduced to an executive summary instead of a full report. The pre-proposal is eliminated from the list of deliverables; the proposal report is now closer to the beginning of the semester instead.

A third Peer/Self-Review is added at around three quarters of the semester. The students also receive feedback from these reviews. Also, a one-hour workshop on team dynamics is introduced into the course.

The ECE Senior Design Day is changed from a three-hour event and now spans a full day. This makes it possible for judges (faculty, graduate students, industrial advisors) to spend an
appropriate amount of time with all teams. Also the judges are encouraged to not form one big group, but to work in teams of two or three and to start with different senior design teams.

Improvements:
+ Encouraging the students to write their proposal earlier in the semester improves their final project prototypes immensely. Students are forced to work on the projects from day one.
+ The change to an executive summary format offers the students to learn another form of reporting and yet frees up time for them to work on their projects.
+ The longer duration of ECE Senior Design Day allows more faculty to spend time with the projects teams. The judging is more equalized for all teams.
+ The longer duration of ECE Senior Design Day sparks the interest of local industry. The event is now an industry-sponsored event.
+ The students are proud to present their projects, and are enthusiastically explaining their displays.
+ The combination of the introduction to team dynamics as well as the improved feedback to the students on their Self/Peer-Evaluations seems decrease the probability of ending up with dysfunctional teams at the end of the semester.

Need for further improvement:
- The students still do not regard their design notebooks as a useful tool and do not use it consistently.
- Most prototypes at the ECE Senior Design Day are working. But most students wish for more time to debug and make final improvements on their projects.
- There are still teams dysfunctional at the end of the semester, even though at a reduced rate. When changing to the two-semester sequence the approach on how the student teams are build (currently self-chosen by the students) has to be looked into and might need more course advisor influence.2

This is current state of affairs. The word has spread about the changed format of the Senior Design Course and students start to work earlier on their projects. Most students take ownership of their projects and want the project to be successful in the end.

The Two-Semester Sequence:

The proposal for the two-semester sequence has been revised based on the experiences described above. The positive outcome of the ABET accreditation with respect to the Senior Design Course for the Computer Engineering program last Fall encouraged the Department to initiate the course change proposal within the regular administrative channels. The start of the new two-semester sequence is anticipated for Fall 2009.

Conclusions:

The redesign of a course can be viewed as a design process just like the students are asked to perform. It is an open-ended process. No matter how many changes are introduced, there will always be ample opportunity to still improve the course. This point can be considered a design
review to track changes and their effectiveness. The author hopes that this paper will help others in the need of changing their courses.

References