AC 2009-309: START EARLIER, PREPARE BETTER: AN ENGINEERING SENIOR SEMINAR COURSE

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Abstract

This paper describes a seminar course offered to senior engineering students to prepare them for their senior design projects and to prepare them for their future professional careers.

Most undergraduate curricula, especially in the field of engineering, include senior design as one of the capstone courses. Successful senior projects demonstrate the knowledge and problem-solving abilities of students as well as professionalism through the reports, posters, presentations, etc. For many traditional students, the senior design may be their first “real” project, thus students need a set of guidelines for engineering projects and they need preparation for their first milestone as professionals. Therefore, a part of this course covers the topics of defining a project, writing technical documents (e.g. proposals and reports), and preparing and delivering oral presentations. Students follow a general guideline and submit a proposal for their senior design projects to be completed in the following semester. Accordingly, a formal presentation is also required.

The other set of topics comes from the fact that most students enrolled in this course will graduate within one year and, hereby, require development of their personal and professional skills, both short term skills (e.g. resume writing, job searching, and interviewing skills) as well as long term skills (e.g. graduate study, intellectual property, entrepreneurship, and professional skills) for life after graduation. For example, as part of the short term goal, we invite a professional from the campus career center to introduce students to the job market, job hunting skills and the corresponding services the university offers. For the long term goal, class discussion plays a key role since it not only improves students’ communication skills, but also helps them understand their professional and ethical responsibilities as engineers.

The connections of this senior seminar course with the follow-up senior design course, assessment methods, and ABET outcomes are also addressed.

Introduction

In recent years, the fast-paced, competitive working environment required that the new graduates from colleges and universities transform from students to professionals within a short period of time. Evidence of this trend is that more and more employers in industry seek graduating seniors who are qualified in both “hard” and “soft/professional” engineering skills so that they can fit into the new positions without a long training session. The terms “hard” and “soft/professional” are used by Shuman et al.\(^1\) to classify the outcomes in ABET accreditation Criterion 3^2 (See Table 1). According to Shuman et al.\(^1\), the outcomes related to the problem-solving ability are categorized as “hard” skills, which include Outcome 3.a, 3.b, 3.c, 3.e and 3.k, while the other six outcomes in Criterion 3 belong to “soft/professional” skills. Such a demand from industry
challenges our educational system to provide students with adequate development of both sets of skills. Fortunately more and more colleges and universities are recognizing this challenge and are attempting to change accordingly.

Table 1. ABET Criterion 3. Program Outcomes

<table>
<thead>
<tr>
<th>3.a</th>
<th>An ability to apply knowledge of mathematics, science, and engineering</th>
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</thead>
<tbody>
<tr>
<td>3.b</td>
<td>An ability to design and conduct experiments, as well as to analyze and interpret data</td>
</tr>
<tr>
<td>3.c</td>
<td>An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability</td>
</tr>
<tr>
<td>3.d</td>
<td>An ability to function on multidisciplinary teams</td>
</tr>
<tr>
<td>3.e</td>
<td>An ability to identify, formulate, and solve engineering problems</td>
</tr>
<tr>
<td>3.f</td>
<td>An understanding of professional and ethical responsibility</td>
</tr>
<tr>
<td>3.g</td>
<td>An ability to communicate effectively</td>
</tr>
<tr>
<td>3.h</td>
<td>The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context</td>
</tr>
<tr>
<td>3.i</td>
<td>A recognition of the need for, and an ability to engage in life-long learning</td>
</tr>
<tr>
<td>3.j</td>
<td>A knowledge of contemporary issues</td>
</tr>
<tr>
<td>3.k</td>
<td>An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice</td>
</tr>
</tbody>
</table>

In the current engineering curriculum at our university, the senior design course is used to evaluate the program outcomes. Also, it has been valued by both students and future employers by demonstrating students’ abilities as engineers. However, from the comments of faculty members on previous graduates, students usually did not perform well in the first several weeks of the design course since it was probably the first “real” project for most of the traditional students. From our observations in the past, some of the major reasons for the students’ low performance were: 1) having difficulties in choosing the project; 2) not knowing how to write a professional proposal or report; 3) not being able to manage their time for the project. Often, students wandered during the initial month of the project trying to figure out what to do, and then struggled with the heavy workload in the last month in order to complete the project on time. Therefore, a preparatory course offering general guidelines for engineering projects became necessary.

The other considerations for this preparatory course arise from the fact that most students in this course plan to graduate within one year. The highly competitive job market requires a graduate to be prepared for the first professional resume, the first interview for an engineering job, the first job as a junior engineer, etc. The better he or she prepares, the higher chance he or she will have for a promising career. Hence, the senior-level students need additional exposure to some non-technical aspects of engineering.

In this paper, we will discuss a development of a senior seminar course designed to help students in both of the two sets of professional skills mentioned above.
Literature Review

Other programs use a year-long senior design sequence, with a seminar course first, followed by the senior project. For example, in the three-quarter Electrical Engineering senior design course at the Milwaukee School of Engineering, “the first portion focuses on team building, leadership development, problem identification and certification, and design feasibility determination …” (William et al.\(^8\)). Other programs use a class in parallel with the design project, in which the lecture portion covers such topics as “team building, conflict resolution, time and stress management, resources availability, communication skills, and leadership.” (Wilk and Anderson\(^9\); Ray\(^10\))

The courses described in the literature differ in their emphasis on two goals: (1) providing information and practice on skills that help students perform better in the senior design project and (2) providing information that helps students transition from student to professional. We were concerned about including too many topics in the seminar course because some seminar courses seem to have a long list of topics that we felt could not be covered well. In our seminar course we chose to incorporate both goals, but with more emphasis on the first goal, that is, on providing knowledge and skills to enhance performance on the senior design project. The capstone course that follows the seminar course focuses more on the second goal, helping the student transition to being a professional. In the second course we treat the class as a job, as described in Fraser et al.\(^6\).

Course Overview

The senior seminar course at our university is a pre-requisite course for the senior design project course. It meets for two 50-minute sessions each week during a 15-week semester. Roughly, the content is divided into two aspects: students are provided with information related to their senior design projects (which should be done within the upcoming semester) during one half of the semester while the selected topics on career and professionalism are covered during the rest of the semester.

Course Objectives and Design

The objectives of this course are to provide students with (1) the sufficient information on engineering projects (especially for their senior design projects) and (2) the necessary “soft/professional” skills so that they gain a better understanding of engineering projects and professionalism.

For the first objective, the lecture series includes: defining project objectives, writing technical proposal, writing logbooks and reports, and making professional presentations. The case study problems in the related lectures are chosen both from the industry and from the previous senior projects. Students are encouraged to join the class discussion and analyze those examples using the guidelines given in the lectures. Furthermore, we invite potential project advisors (in most cases, faculty members) to present their ideas or research interests. Subject to faculty approval, students are also welcome to propose their own ideas for senior projects. In the next few weeks, each student is required to choose a topic for the senior design project, select a faculty member.
as the project advisor, collect the background information and prepare a proposal. During the final week, a formal oral presentation session is held by the students to both the faculty members and other students.

For the second objective, a wide range of topics are covered in the class, such as job hunting methods, graduate study, intellectual property, ethics, team work, and entrepreneurship. Although some of these topics are discussed in different courses from various aspects within the four-year program, explicit attention is given in this preparatory course emphasizing their importance to graduating students and reinforcing the students’ understanding. For instance, ethics has been specifically covered in a first-year engineering course and this seminar course, but the former one focuses on understanding the basic concepts of engineering ethics while the latter one concentrates on analyzing more complicated case studies. In general, the criterion for topic selection is the perceived benefit to students for their careers, both short and long term. For instance, since students in this class are from the two programs (i.e. Bachelor of Science in Engineering with a specialization in Mechatronics and Bachelor of Science in Industrial Engineering), one important topic they will encounter in the workplace is intellectual property, such as patent law, copyright, trademarks and trade secrets. Providing such information before they enter the industrial environment could help them protect their own intellectual property as well as avoid legal problems.

Due to the broad scope of the course, guest speakers are invited for special topics so that students are provided with up-to-date and valuable information. For example, one or two weeks before the on-campus job fair, a guest speaker from the career center joins the class and discusses resumes, interviews, free career services offered by the university, and other job hunting skills. Furthermore, students are provided with current job opportunities in the career center database and are encouraged to submit their resume for suggestions. Then, when they attend the job fair few weeks later, they have professional resumes in hand and are well prepared for the interviews.

Undoubtedly, it is critical to find appropriate guest speakers for the class. Our intention is to select speakers who are able to offer the students the most valuable information based on their knowledge and experience. One example of such a selection is related to the topic of entrepreneurship. Since students come from engineering programs, the speaker we invited was also an engineer, had been working as an engineer in industry and now manages his own company as well as is teaching the related topics in an MBA program. Therefore, the speaker’s presentation dealt with a topic on how an engineer becomes an entrepreneur. The speaker’s own experience is attractive to the students.

Table 2 shows the approximate time spent on each topic in this course.
Table 2. Senior Seminar Topical Time-Table

<table>
<thead>
<tr>
<th>Topics</th>
<th>Suggested No. of Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>How to define a “good” project objective</td>
<td>2</td>
</tr>
<tr>
<td>Review of previous senior projects</td>
<td>2</td>
</tr>
<tr>
<td>Presentations by possible project advisors</td>
<td>1</td>
</tr>
<tr>
<td>Guidelines for engineering proposal, logbook, and final report</td>
<td>6</td>
</tr>
<tr>
<td>How to give a successful oral presentation</td>
<td>1</td>
</tr>
<tr>
<td>Graduate studies and certifications at our university</td>
<td>1</td>
</tr>
<tr>
<td>Job hunting methods and procedures</td>
<td>1</td>
</tr>
<tr>
<td>Ethics</td>
<td>4</td>
</tr>
<tr>
<td>Intellectual Property</td>
<td>2.5</td>
</tr>
<tr>
<td>Teamwork</td>
<td>3</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>2</td>
</tr>
<tr>
<td>Which characteristics should an outstanding employee/manager have?</td>
<td>2.5</td>
</tr>
<tr>
<td>Final presentations of senior design proposals</td>
<td>2</td>
</tr>
</tbody>
</table>

Course Assessment

The course assessment began with a pilot class in fall 2007. Since then, some of the assessment activities have been improved. At the end of each course semester, the students are expected to have the following knowledge, attitude or skills:

- Understand the steps leading towards a successful engineering project given a design topic. (3.c)
- Be prepared for the senior design project by acknowledging the different research interests of each professor in the Department of Engineering, writing and presenting the proposal for their senior design projects. (3.e & 3.g)
- Acknowledge graduate programs and certifications offered by the university. (3.i)
- Be prepared to be a successful professional by learning resume/interview skills and entrepreneurship. (3.h & 3.i)
- Acknowledge teamwork skills, especially with team mates from multidisciplinary fields or team mates having different skills. (3.d)
- Understand the basic concepts of intellectual property (IP). (3.f & 3.j)
- Understand the social and organizational implications of engineering actions. (3.f & 3.j)

The code in parentheses indicates the related ABET Criterion 3 listed in Table 1.

A flowchart of the outcome assessment is shown in Figure 1. The sources used for assessment data include the following:

1) Proposals for senior design projects

As a preparatory course for the senior design, one of the most important assessments in this course is the proposal report. Since the instructor of EN493 Senior Seminar may not be the
instructor of EN488 Senior Design, the instructor of EN488 was invited to join the senior seminar course at least three times (as shown in Figure 1):

Phase 1 - At the beginning of the semester, a presentation from the senior design instructor was given to explain how he or she would conduct the senior design course the following semester and what kind of performance he or she would expect in that class;

Phase 2 - During the topic selection section, the instructors of both courses discuss and evaluate every student’s idea and determine if it is appropriate;

Phase 3 - At the end of the semester, the instructors of both courses discuss and evaluate the proposal reports and decide if the student should continue with this project. Such a quality review works as a check point to ensure every student knows what to do and how to do it when the senior design begins. Currently, a grading form presented in an ECpE Senior Design course is being considered for adoption.

Through these three phases, the students’ performance was supervised by the instructors of both courses, which ensured a smooth transition from the preparation course to the capstone one. In the future, we plan to establish further collaboration between the two courses, such as enforcing the group activities and teamwork.

2) Oral presentations for the proposals
Oral communication is one of the soft skills required by ABET. In the seminar course, besides the lecture on the professional presentation skills, we try to encourage students to express their ideas orally through class discussions as well as presentations. For the assessment purpose, the oral presentation of the proposal is the most important event since this is the last presentation and is hosted as a public presentation session. During the presentation, students will face not only the instructor and the classmates in this course (with whom they are familiar), but also other faculty members and students from different levels. For most of the students, this event may be the first time to give a presentation to more than one professor in the same classroom. Since the class in fall 2008, a grading form was introduced to evaluate each presentation by both faculty and students. Table 3 summarizes the results of the fall 2008 class. All items evaluated by the faculty and the students averaged above 4 (Agree) out of 5 (Strongly Agree), which shows a quite positive result concerning students’ oral communication skills. Interestingly, the students tend to be tougher evaluators than the faculty.
Fig. 1. Flowchart of outcome assessment for Senior Seminar course

- Introduction
- Knowledge about engineering projects & professional skills
- Presentations from possible project advisors
- Topics selected by students
- Project advisor selected by students
- Project topic approved?
  - No
  - Yes
  - Literature search & data collected
- Draft for project proposal
- Instructor's approval?
  - No
  - Yes
  - Final proposal
- Power Point file for presentation
- Instructor's approval?
  - No
  - Yes
  - Oral presentation
- Unsatisfactory
  - Grade by instructor?
  - Satisfactory
  - Re-take the course
- Proposal modification in Senior Design course
- Faculty feedback
  - Unsatisfactory
  - Proposal approved & continue the project in Senior Project course
- Presentation skills

Fig. 1. Flowchart of outcome assessment for Senior Seminar course
3) Group discussion of previous reports

Every year, when students begin to think about their senior design projects, one of the most common questions students have is what a senior design project looks like. In this senior seminar course, two sessions were assigned to discuss the previous student reports from EN488 Senior Design. Each student group selected one report, reviewed and discussed the successful and not so successful parts of the report, and then presented their results as a group to the whole class. According to students’ feedback, such discussion helped their understanding of the senior design in many aspects, such as, what kind of topic could be chosen, how complicated it should be, and how detailed the report should be. For the following course session, the instructor used these discussion results.

Table 3. Student Presentation Grading Form

<table>
<thead>
<tr>
<th></th>
<th>Class Average from students' evaluation</th>
<th>Class Average from faculty evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>The presentation is well organized.</td>
<td>4.4</td>
<td>4.3</td>
</tr>
<tr>
<td>The transition from one part to the next of the presentation is smooth.</td>
<td>4.2</td>
<td>4.4</td>
</tr>
<tr>
<td>The presenter interacts well with audience throughout presentation, e.g. attracting audience’s focus by asking questions, etc.</td>
<td>4.2</td>
<td>4.2</td>
</tr>
<tr>
<td>The presenter presents himself/herself well physically, e.g. facing audience, having good eye contact, having good use of hand gestures, etc.</td>
<td>4.2</td>
<td>4.2</td>
</tr>
<tr>
<td>The presenter uses visual aids well, e.g. readable size font, clear and right amount on each slide, etc.</td>
<td>4.3</td>
<td>4.5</td>
</tr>
<tr>
<td>The presenter has a good delivery style, e.g. good pace, project voice, or great enthusiasm, no “uh” etc.</td>
<td>4.1</td>
<td>4.3</td>
</tr>
<tr>
<td>The presenter has a professional appearance.</td>
<td>4.1</td>
<td>4.2</td>
</tr>
<tr>
<td>The presenter handles questions and problems well, e.g. answering questions effectively and smoothly.</td>
<td>4.2</td>
<td>4.7</td>
</tr>
</tbody>
</table>
4) Students’ feedback

At the end of the course, an anonymous student survey with a number of open ended questions was conducted. The students’ feedback to each question in the survey will be discussed in the following paragraphs.

According to the above mentioned assessment sources, all students finished the first phase of the senior project design from choosing a project topic to finishing the corresponding proposal and an oral presentation to faculty and students. Students felt more comfortable and better prepared for the senior design course. As shown in the student survey, the response to “Is this course helping you prepare for the senior design project?” in the survey was positive. All of the students answered “Yes” except for one who did not answer the question.

The instructor of EN 488, who has taught that senior design course both before and after the creation of the senior seminar, stated that the students who have taken the senior seminar are able to begin their projects quicker and are better prepared to complete a good project than students who have not taken the seminar.

It is also found that students deemed most of the topics in the course interesting and useful for their professional development. All responses to the question “Is this course helping you prepare for your future career” were positive, except the following two neutral or partially negative comments:

- “Yes, but it is hard to tell since I already have a job.”
- “No, the course has no bearing on my lack of career direction.”

As for the comments on the overall course, one student suggested “work in more group activities and group discussion,” and another wanted to get a regular grade instead of an “S/U” grade; all other comments were positive. Some answers were

- “The ethics section was done well.”
- “Everything was great. Thank you very much!”
- “Overall if I was to have had this class before my design project, I would not have had a hard time getting started.”

The last comment was from a student who, for various reasons, took the senior seminar course after completing the design course, so this comment bears special weight in judging whether the course is helpful for students.

Conclusion

The new senior seminar course was designed and initially implemented as a part of the engineering senior design course sequence at Colorado State University - Pueblo. As a preparatory course, senior seminar provides general guidelines for engineering designs to help students prepare the senior design project proposal, and also improves students’ written and oral communication skills. In addition, the course covers a broad range of topics dealing with career development and professionalism so that the “soft/professional” skills required by ABET Criterion 3 are developed and assessed. Both students’ feedback in an anonymous survey at the
end of the course and the feedback from the instructor who taught the senior design course in the following semester are positive.

Bibliography

7. [http://seniord.ece.iastate.edu/notes/f.htm](http://seniord.ece.iastate.edu/notes/f.htm)