Development of a Joint BME, ME, and EE/CE Senior Engineering Design Seminar

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Abstract

In the spring term of 2003 the design instructors from the departments of Biomedical Engineering (PK), Mechanical Engineering (DK, JB) and Electrical and Computer Engineering (LM, JB, AD) met to discuss the possibility of collaboration on interdisciplinary design projects and the development of a common design lecture for all four majors. There had been previous limited student exchanges between ME and BME and EE/CE began offering the first standalone design project courses during the 2003-2004 academic year.

A common design seminar series was agreed upon, this was launched as a required interdisciplinary design one credit course in fall 2003. Both the ME and BME design courses were decreased from 3 credits to 2 for the fall term only. The EE/CE sequence (AD) is in its first full term offering, it remains a 3 hour course. DK was initially designated "instructor in charge".

The ability to meet with senior design students from all four majors at a common time has given weight to our ability to bring in a good speaker once, to talk to all classes. The common meeting time also provided an excellent meeting forum to bring in sponsors of interdisciplinary projects to discuss these matters with a single gathering, rather than being required to meet with two or more classes. The fact that many of the core design lectures are now spread over the term in the seminar has allowed us to start student design projects earlier (mid October rather than late November). This change has facilitated coordination with future fall offerings of a course sequence in marketing, both in the Engineering School and outside, with the Owen School of Management at Vanderbilt. Other advantages which arise from this common seminar format are: the ability to form interdisciplinary teams, the ability to build partnerships through projects involving business, law and medical school(s) components, the ability to discuss engineering professionalism in a multidisciplinary format, the ability to discuss safety as a generic rather than a disciplinary issue, etc.

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This paper will discuss our development and first experience with a common design seminar, and will explicitly discuss feedback from the student body regarding the design seminar evaluation.

Introduction

The senior design courses at Vanderbilt University in the departments of Biomedical and Mechanical Engineering have long been stand-alone full year courses (3-3). Student exchanges between the two courses first took place in the 2002-2003 school year, when 6 ME students joined BME teams and 1 BME joined a ME team. This exchange was negotiated basically as a gentlemen's agreement between the two instructors in charge (King in BME and Barnett in ME). The EE/CE (Electrical Engineering & Computer Engineering) department that year offered an optional senior design class. This course was taught by Massengill (EE/CE) with the assistance of Barnett and Dozier (and G. Cook). The EE/CE offering was to be a trial run before an EE/CE curriculum change required all EE/CE majors to take the course. Since a new design instructor was appointed for ME (DK) and the EE/CE instructor was also to change, the current and future instructors decided to get together in order to consider means by which interaction between the departments could be facilitated to the benefit of both the faculty and the students.

The primary design effort that resulted from this effort was the initiation of a senior design seminar[i]. The catalog description for the course was posed as: "Elements of Professional Engineering Practice. Professionalism, licensing, ethics and ethical issues, intellectual property, contracts, liability, risk, reliability and safety, interdisciplinary teams and team tools, the role of codes, standards and professional organizations, career, entrepreneurship, human factors and industrial design." The stated intent of the seminar was "… the development of design skills through lectures about elements of the design process. This course will include seminars on: professionalism, licensing, ethics and ethical issues; intellectual property, patents and VU patent policies; contracts and liability; risks, reliability, safety and the work environment; career issues including jobs; graduate and professional studies; entrepreneurship; use of the www and other information resources; and others. "

There were several motivating factors for development of this course. The BME and ME courses had, prior to the introduction of this course, begun student design projects in November, after the formal lecture material had been covered in class. By having the design seminar continue for the entire term, the design projects could be started earlier. (The goal for next year is October 15.) Design credit in BME and ME was dropped to 2 credit hours, the 3rd hour becoming subsumed in the design seminar. A second motivating factor was the desire to facilitate multi-disciplinary projects. By having the students in a common seminar, and by inviting faculty presentations of projects requiring interdisciplinary teams, it was hoped that a mix-and-match of majors might be accomplished. Another goal was to be able to bring in quality speakers one time, rather than requiring three speakers for each of the three majors. To further facilitate students' ability to participate in interdisciplinary design projects, a common guideline was developed for senior design projects (see Appendix 1). In a related endeavor, the

primary faculty negotiated with the University administration in a successful attempt to allow outside companies sponsoring projects to maintain their intellectual property rights in exchange for submission of and supervision of senior design projects.

Deliverables from the students were 1. Attendance (fulfilled by a sign-in sheet) and 2. A term paper on one of the lecture topics presented (with the exception of the careers and graduate school seminars.) The final grade for each student was based upon the term paper (graded by one of the instructors) discounted 5% for each class missed. The class met weekly from 4:10 to 5:00. Seminar speakers generally kept to the 50 minute time limit. The period just after the speaker, for the first half of the term, was reserved for group meetings between interested students and persons needing interdisciplinary teams for their projects. Seminar speakers generally presented using PowerPoint slide shows, two used a transparency projector. Two lectures originally planned for could not be filled (Entrepreneurship and Prototyping Processes), local speakers filled in (Contracts and User-Centered Design) for these missed sessions.

The joint design seminar was offered in the fall of 2003. It was taken by 66 BME students, 50 ME students, and 20 EE/CE majors. Classes were held in a newly renovated chemistry lecture hall, one of the few rooms on campus adequate for such a large class size (136.) The hall was a two level amphitheatre design. Students typically entered on the upper level, grabbed a drink, signed in, then took places in the room.

During a few of the lectures, several students exited class during the lecture using the upper level exit. Attempts to remedy this lead to students expressing dissatisfaction with the conduct of the course. We report below the results of a questionnaire[ii] given to the students to assess their feelings regarding this matter. We also report the result of personal interviews of students with a learning scientist.

Results and Discussion

This section will report on and discuss five main results of the above mentioned questionnaire (n=60) and will conclude with an overall summary statement based upon this analysis and that of the learning scientist.

1. The students were asked which of the given lectures should be continued (1) or eliminated (0). The summary statistics for this are given in Table 1, next page.

Table 1: Student questionnaire results: rank ordered seminar lectures for fall 2003 and number of term papers written on each topic

Lecture Topic	Topic Mean Score	Probability "p"	# of term papers
Graduate and Professional Schools	0.98	< .001	na
Intellectual Property and Patents	0.98	< .001	32
Career Issues: Jobs and Placement	0.95	< .001	na
Ethics	0.86	< .001	49
Reliability and Testing	0.80	< .001	8
Product Liability	0.80	< .001	2
Design Safe and Risk Management	0.79	< .001	11
Safety Issues in the Workplace	0.77	< .001	0
Contracts	0.74	< .001	2
Finance and Accounting for Engineers	0.73	< .001	0
Manufacturing	0.63	<.050	0
Teams and team development	0.58	<.200	15
Labor and labor issues	0.48	ns	3
Building the User into the Development Cycle	0.40	ns	5
p is the probability that the result is due to chance ns indicates not significant na=not allowed as a topic			

Discussion: Eleven of the fourteen lecture topics given this past fall were strongly recommended by the class as topics to continue in future years course offerings. This data will be taken into account when next year's schedule is being planned. Also of interest is the significance of the data. When comparing the number of term papers written on each topic with the recommendations to continue, the popularity of each topic seems to parallel student interest in retaining the lectures.

2. Students were asked to respond to questions regarding their understanding of material presented in the seminar on a scale of 1-5, with 5 being true and 1 not at all true. Results from this question are tabulated below in Table 2, next page.

Table 2: Class statistics for the series of questions "the seminar enhanced my …" on a scale of 1-5, with 5 being very true.

The BME-EECE-ME 297 seminar enhanced my	average	p
understanding of intellectual property	3.84	< .001
capability to deal with ethical issues you listed above	3.42	<.001
skills in integrating the customer or client into the design process	3.25	<.05
skills in engineering team work	3.25	ns
risk management and safety skills	3.23	ns
skills in organizing safety programs for the workplace	3.17	ns
ability to plan my career	3.11	ns
ability to plan a product test	3.05	ns
strategies which will permit you to navigate the shoals of product liability	3.04	ns
capabilities to deal with supervisor/employee issues in the workplace environment	3.02	ns
understanding of contracts in engineering projects	3.00	ns
understanding of manufacturing issues related to product design	2.95	ns
skills and insight into strategies for entrepreneurship	2.82	ns
p indicates the probability that this average is due to chance ns indicates not significant		

Discussion: Only two items appear to be significant in this survey, that the students achieved a better understanding of intellectual property and ethical issues. As this is generally the first exposure of the class to a situation where they might generate intellectual property, this is understandable. Almost half of the class wrote their term papers on ethics in engineering, this indicated to us that there is a need for more exposure of the students to ethical questions.

3. "What do you think might be done to improve attendance and participation?" was the next major inquiry made of the class. A variety of responses were recorded, several of the most common are detailed below:

- Involve the audience more, make the class more interactive, don't dim the lights (15 responses)
- Have the class earlier in the day (12)
- Give us snacks, not just drinks (7)
- Make us do more (quizzes, assignments, in-class exercises) (7)
- Give us computerized attendance using a PRS[iii] (personal response system), let us interact with the system during class (6)
- Give us more real-life examples (2)

- Give us videos (1)

Discussion: Interaction by the class with most lecturers did appear to be a problem. Participation had to be actively sought out by the lecturers; it was not forthcoming on the part of the students. In interviews with students many felt that the material covered in the lecture could just as well have been learned by a review of the lecturers' PowerPoint slide show (which was posted to the class web site.) It is worth noting that several students suggested adding assignments to the class, rather than having a grade dependent solely on attendance and a term paper. The suggestion regarding use of the personal response systems system should also be considered a viable, since it can double for use in interactive sessions and for attendance purposes.

4. One of the major concerns that we wished to address with this seminar was to increase interaction between majors, especially on design teams. We therefore asked: "What can be done with this seminar to better serve as a vehicle for formation of multidisciplinary teams?" Responses included:

- Have a team building activity – have an icebreaker/mixer/in class exercise/chat time/mix teams … (19 responses)
- Add more multidisciplinary projects and indicate that they are multidisciplinary, do a better job of advertising, combine current lists (7)
- Present projects in class, brainstorm them in class (3)
- Integrate design class schedules better (2)
- Have a seminar on multidisciplinary teams and skills, role play (3)
- Involve non-engineering majors (1)
- Require it (1)

Discussion: Students seemed to sit with their classmates, rather than mixing in the seminar. The strong response regarding team building activities and better advertising will be taken to heart. This seminar is the only chance for mixing all four majors in the post freshman years. It appears from the data that the students needed to be reintroduced. Multidisciplinary teams were formed (currently 4 of 23 in BME, 2 of 11 in ME, and 1 of 4 in EE/CE), but additional teams could well have used a mixed major composition.

5. The students were last asked "What topic(s) would you suggest adding? A sampling of the primary responses follows:

- Project management, project engineering, management lecture (5 responses)
- R&D, Medical Engineering lecture (3)
- What else can I do with an engineering degree besides engineer? (2)
- Have more interesting talks regarding personal experiences (2)
- Marketing (2)
- Case studies, case management review (2)
- Entrepreneurship (2)
- Environment (1)

- Public Policy (1)
- Consulting (1)
- Have recent grads come in and talk (1)
- Review of jobs and job offers taken by grads (1)
- Bring in real people, not VU employees (1)

Discussion: No area of interest clearly stands out in this list, but several of the topics should be considered for next year. Topics regarding jobs taken and career paths other than engineering should be included in next years' career counseling seminar. An entrepreneur was scheduled to speak this year, but other obligations (several million of them) took precedence. A comprehensive lecture (perhaps a case study) on project management would appear to be in order.

Learning Scientist Input:

A learning science faculty member[iv] has been interacting with the BME design course through her role on an NSF sponsored Bioengineering Education grant. Her comments (slightly edited) on this class and recommendations follows:

"issue 1: students said they wanted the class to be more interactive; addressing this issue will also address their second primary concern, the lack of multidisciplinary interaction.

possible solutions: in general, it appears that students feel "invisible." while their presence is required, it doesn't seem to be necessary for the course to function. how can we address this? it's hard to lead a horse to water when you don't know where it is, so....
1. find out what they know about the subject
2. ask what they want to know about the subject
3. ask them how the issue at hand relates to their work and interests
4. throw out an issue for them to think about, allow them to discuss it with one another and then require that they generate a solution. these can then be shared to see the diversity of opinion among the group.

how can we do this in a lecture class of 100+ students?

- the PRS system is one possibility. if instructors would prepare "thought questions" in advance, then students could respond to them before and after the class session. or they could respond in ways that help the lecturer know where students are coming from.
- another interactive technology we might leverage is the silicon chalk software[v] which was recently demonstrated at a learning forum.
- another possibility is the use of instructional materials that don't just *tell* students about an issue, but also help them *experience* the issue. (video materials.)

issue 2: students said the course wasn't demanding enough. if you set the bar low, students will "rise to the occasion" as it were.

possible solutions: assignments needn't be lengthy or difficult; however, they should be *meaningful*. two primary purposes of homework are to rehearse/reinforce new knowledge and to prepare students to receive new knowledge. reading assignments are okay but to make what they've read "stick", students need to apply it to a real problem.

- perhaps students could generate a personal example of the problem? perhaps they could be asked to find an example of the problem in the contemporary literature/media?
- perhaps students could complete homework in multidisciplinary teams?
- whatever the nature of the assignments, they should be discussed in class and students should receive timely and thorough feedback about their performance.
- if that's too onerous for an instructor, then perhaps students could critique one another's work? assessing others is a great way to learn to think critically about an issue.

bottom line: the assignments should not be put off until the last of the semester nor should they disappear down a black hole never to be seen again. students need to feel like their time and energy is valued by the faculty."

Conclusions:

Our first offering of a common engineering design seminar was not without "growing pains". Many students disliked the timing, the form of the presentations (lecture), the lack of interaction between the lecturers and each other, the "low bar" regarding requirements. The students expressed an interest in most of the lecture topics and recommended keeping most of them. This was largely reflected in the number of term papers written on each of the given topics.

The faculty in charge of this course will meet and study the above reported results. The year 2004 will see some innovation in the course structure.

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[i] http://vubme.vuse.vanderbilt.edu/design/ for the course web site.
[ii] The questionnaire was drafted by the authors with the collaboration of Dr. Joan Walker and John Rakestraw
[iii] See http://www.educue.com/ for details
[iv] Joan Walker , PhD, joan.walker@vanderbilt.edu
[v] http://www.silicon-chalk.com/ for additional information.

Appendix 1

Guidelines for Vanderbilt Senior Engineering Design Projects

1. Project should solve a specific need of the client.
2. Project should not be time critical as client should assume a project cycle of two semesters September 2003-April 2004
3. Projects should involve design and prototype or manufacture. For example:
   a. Physical prototype for a new product or product advancement including associated manufacturing processes.
   b. Redesign of an existing product including a physical prototype and associated manufacturing process modifications.
   c. Physical prototype for new or redesigned test equipment or manufacturing process.
4. Projects should involve design, modeling and analytical requirements.
5. Students select their own projects and team members hence some projects may *not* be selected. Students select their project hence clients will be working with interested motivated teams.
6. Projects may be software oriented. Projects requiring interdisciplinary teams are strongly encouraged.
7. Project scope should be 1,000 to 1,200 engineering hours (250-300 hours for 4 students) distributed over the period 9/2003-4/2004.
8. Interdisciplinary student teams of three to five will be mentored by experienced engineering faculty who will provide guidance and evaluation; and coordinate use of Vanderbilt equipment and/or facilities
9. Client must be willing to dedicate time of a liaison engineer to the project (approximately 1 hr/week)
10. Liaison engineer should:
    a. Have management support
    b. Have vested interest in the success of the project
    c. Be willing to work with students
11. Projects should not be classified or highly proprietary. Students and faculty will, if requested, sign nondisclosure agreement
12. Students should be able to publicly present their work with the mutual agreement of client. In the event a client wishes to avoid linkage with the work their identity may be withheld.
13. Vanderbilt's intellectual property policy is that student projects employing university facilities and/or personnel are governed by Vanderbilt's intellectual property policies, which means that Vanderbilt will negotiate issues of intellectual property ownership on a project to project basis. More detail is available at: http://www.vanderbilt.edu/technology_transfer/. A new policy is in place as of 2003 for IP concerns with industry and this class. The tech transfer/engineering agreement is here.

14. Benefits to client include the opportunity to solve problems outside their own human resource capabilities as well as work with students which can provide fresh problem solving approaches and recruiting opportunities.
15. Vanderbilt benefits by expanding student horizons through early exposures to real world business constraints.

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