2006-25: BEYOND THE CLASSROOM: USING A LECTURE SERIES FORMAT TO GIVE ENGINEERING STUDENTS A SOCIETAL AND GLOBAL CONTEXT

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Beyond the Classroom: Using a Lecture Series Format to Give Engineering Students a Societal and Global Context

Introduction

ABET 2000[1] recognized that, in order to be successful, engineers require skills above and beyond a technical knowledge base. Among the ABET criteria that address nontechnical skills is outcome **h** which states that students must be able to demonstrate, "the broad education necessary to understand the impact of engineering solutions in a global and societal context[1]." Two publications completed since the ABET 2000 criteria were implemented also point to the need for engineers to understand the broad context and societal implications of their work. First is the ASCE body of Knowledge[2] which states that "knowledge and skill, while necessary, are not sufficient to be a fully functioning engineering… attitudes are an essential part of the BOK". Second, the National Academies of Engineering (NAE) report on the Engineer of 2020[3] points to a number of challenges facing the engineering profession in the coming decades. Few of the listed challenges are technical; most address diversity, changing demographics and the political and social impacts of technology.

ABET 2000 criteria also highlighted the need to quantitatively measure the development of nontechnical (or "soft") skills. For many programs, this created a need to develop course content specific to these outcomes. As Felder and Brent[4] state, "the work of equipping students with the attributes specified in [ABET] program outcomes must be done at the individual course level." It also created a necessity to develop assessment tools to measure non-quantitative student learning outcomes, a difficult challenge for engineering faculty far more comfortable in the realm of the technical and quantitative than in the assessment of more qualitative outcomes.

In addition to the logistical challenges related to assessment, a major challenge facing many institutions is how to balance an ever increasing technical core of knowledge with necessary nontechnical skills when state mandates are decreasing the number of credit hours that can be required for graduation. Many comprehensive institutions have an advantage in that they have fully developed liberal arts programs on campus. These programs can provide opportunities for engineering students to be exposed to a broad spectrum of course offerings and co-curricular activities related to societal and/or global issues. Of course, this alleviates neither the onus on engineering departments to place engineering in a broader context nor the need to assess the skills of their student in these areas, and providing a societal and global perspective of engineering remains a challenge in a traditional engineering curriculum. What a strong liberal arts curriculum provides is a built-in resource from which engineering programs can benefit when trying to teach and assess nontechnical skills.

Assisting in the development of a student's broader perspective becomes a larger challenge at specialty institutions where liberal arts courses are offered as "service courses" without the benefit of a comprehensive curriculum. The challenge increases yet again when such an institution has both a predominantly regional student body and a predominantly homogenous demographic.

At the South Dakota School of Mines and Technology (SDSMT), helping students develop an awareness of global issues and options is complicated by both the specialized nature of the institution and the fact that much of the student body hails from rural areas and small towns. Many of these students have little experience outside of the region surrounding South Dakota (or their respective small home towns in surrounding states), and even fewer have traveled outside of the United States. Many have limited to nonexistent exposure to cultural diversity. Adding to the difficulties, liberal arts and social science curricula are offered only to support science and technology majors, and thus are limited in scope. The lack of a major area of study in humanities or social sciences further reduces the opportunities for students to obtain a global perspective on the potential impact of their chosen careers; limited resources are available to these departments for the types of campus activities that might be available at a comprehensive university (e.g. seminars, workshops).

In order to address these limitations, a lectures series with an added classroom component was developed in the Civil and Environmental Engineering Department (CEE). The program is run collaboratively with faculty in the Industrial Engineering (IE) department; the SDSM&T IE faculty provide an expertise in assessment, including the assessment of qualitative outcomes. The primary purpose of the lecture series was to expose students to experts and topics in engineering (with an emphasis on the Civil Engineering discipline) to which they would not normally have access in their curricula. Two primary objectives were set for the pilot program of the series:

- To increase the students' understanding of their roles as engineers with respect to global and societal issues; and
- To determine if, as a mechanism, the seminar series is worth pursuing as a regular feature of the Civil and Environmental Engineering curriculum with potential portability to other engineering programs.

While seminar courses have been successfully used elsewhere to meet multiple ABET goals[5], this program attempts to impact mainly ABET h through a less structured set of experiences. Constraints in curriculum expansion set by state mandates make it difficult to add additional courses as graduation requirements, even one credit hour seminar courses, so the program was specifically developed to tie into an existing course, CEE 463, "Civil Engineering Professions." The combination of a general lecture and a course component allows for impact on the entire CEE student body while imposing a required component on graduating seniors. One potential benefit of this approach is that by the time students reach their senior year, they have a better understanding of societal and global impacts than they would have if they were only exposed to a seminar class in their senior year.

Program Development

Two components were developed to address the goals of the program: the general lecture open to the entire campus and the classroom component for seniors in CEE. The two components were designed to provide a general exposure to societal and global issues for the undergraduate CEE students and a more focused, discussion based experience for the seniors. Students who expressed a specific interest in a given topic but were not enrolled in the affected senior course were invited to participate in the classroom component. By offering the lectures to the entire enrollment, it is anticipated that future senior classes will have been exposed to multiple years of

the seminar prior to enrolling in the professions class and will bring a stronger understanding of societal issues to the course.

Lecture Component

The lecture portion of the program includes four lectures over the course of the semester. The primary lecture audience consists of all seniors registered for the CEE 463 Professions class and undergraduates in CEE; additional participants included graduate students in CEE, undergraduates in other science and engineering disciplines, faculty, and guests from the community.

An important facet of developing the lectures is collaborating with the presenters to ensure that the topics are general enough to be of interest to a broad audience, and include sufficient content on the global and societal aspects. Lectures emphasizing only technical content are discouraged, or the speakers are asked to present the more technical talks in courses with that emphasis. Topics presented in the first two years of the series are presented below:

- The Impact of a National Research Collaborative (NEES)
- Engineering and Public Policy
- Earthquake Engineering: Lessons Learned in the Aftermath
- International Cooperation in Engineering
- Historic Preservation of Engineered Structures
- Tomorrow's Professional: Stewards for Quality of Life
- Sustainability – a new MegaDiscipline
- Engineering in the Developing World: Engineers Without Borders

In the context of the topics listed above, the lectures also address matters such as professional preparation and registration (domestically and internationally), specification and code development, working with governmental agencies, and the economic impact of engineering and research. Speakers are encouraged to specifically address why their topic should be of interest to South Dakota and the surrounding region, whenever possible.

The lectures are open to campus, and student participation is encouraged through three mechanisms: required attendance for seniors in the professions class; "strongly encouraged" attendance, either for class credit or extra credit in other CEE classes; and (of course) free pizza. The support of the entire CEE faculty has been extremely important in maximizing impact of the lectures. On average, over 85 students were in attendance for each lecture; the CEE program at South Dakota Tech has approximately 135 undergraduate students, indicating that well over 50% of the student enrollment in CEE has been present at any given lecture. Some lectures with broader interest have over 100 people present; the best attended lecture (on Engineers without Borders) had over 150 people present. To keep these numbers in context, the South Dakota School of Mines has a total enrollment of 2400 students; lectures at large comprehensive institutions often have great difficulty getting 100 students in a lecture outside of class.

Selection of the invited speakers is of great importance to the success of the program. First and foremost, the speakers need to be viewed by the students as experts in both their given field as

well as having significant experience in the broader impact of engineering on a national or global level. Speakers are specifically chosen based on known criteria for good teaching, including knowledge of subject matter, competence, preparation, ability to relate topics to real life, enthusiasm, and interpersonal skills[6].

In addition, the success of the program is affected by interaction between the coordinating faculty member and the speakers in order to ensure that:

- the topics are of general interest to a student audience with varying degrees of educational experience and interests;
- the body of the speech is at a technical level appropriate for the students;
- the lecture topics can be shown to have relevance to South Dakota and the surrounding region;
- the topics are suited to the overall program theme; and
- the speakers are qualified to speak informally on a large range of topics during the classroom component of the program.

Interaction with the speakers prior to their arrival proved to be one of the most critical components of an individual speaker's impact.

Classroom Component

A required course in the CEE curriculum is CEE 463: Civil Engineering Professions, offered only in the spring semester to graduating seniors. The course emphasis is on professional, personal, and ethical development of the student engineer. The class meets once a week.

The lecture series was incorporated into the professions class in the form of an interactive discussion with the guest lecturer. Students were given reading material on the lecture topic the week prior to the lectures, and the classroom discussion occurred after the general lectures. The interactive format allowed students to ask questions relating to both the lecture topics as well as professional issues directly affecting them as they prepared for graduation.

Since the discussion is driven by the students themselves, they are able to key in on the aspects of the material most relevant to the students' chosen career paths. Students are able to personalize the information in this manner, thus allowing for greater ownership of the process by the students. In addition, for those seniors in the major area of the speaker, this discussion could be more technical and discipline specific than in the general lecture. In a few instances, students with a specific interest in the speaker's area of expertise are provided with one-on-one time to address highly specific questions.

Program Assessment

To discern the level to which the seminar series met the two objectives stated in the introduction, a formative evaluation was conducted each year. This evaluation consisted of a pre-survey and a post-survey given to the members of the senior professions course as well as a brief survey conducted at the conclusion of each lecture in the series that was completed by all in attendance.

Students' Understanding of Their Roles in the Larger Society

The pre-survey and post-survey listed a series of statements connecting the civil engineering students to social and global responsibility. The students marked their agreement with the statements on a scale of 1 (strongly disagree) to 5 (strongly agree). The cycle one, or first year, pre-survey demonstrated that the students felt they already had a nominal confidence in their understanding of their role as a civil engineer in the larger society. There was, however, some increase in their confidence after their participation in the seminar series. Table I summarizes the questions and the mean data from the cycle one surveys.

Table I. Cycle One Student Confidence Questions from the Senior Professions Course

Statement	Pre-Survey	Post-Survey
As a civil engineer, I can describe how my work contributes to society.	4.6	4.5
I can explain how my senior design project impacts the society in which I live.	4.4	4.3
I have taken other classes that require me to consider how civil engineers impact the larger society.	3.7	3.8
For any given project in my work as a civil engineer, I can identify sources where the global and societal impacts of my project are discussed.	3.6	4.0
I can identify the appropriate governmental regulatory bodies and general policies concerning the global and societal impact of my work as a civil engineer.	3.2	3.6

The cycle two, or second year data presented in Table II, show that while the students still entered their final undergraduate semester with a nominal confidence in their understanding of their role as a civil engineer in the larger society, there was an increase in confidence after the seminar series. There was a drop in their initial confidence levels as opposed to the students in cycle one. Many of the students in the cycle two data attended the lectures in the cycle one seminar series. Therefore, it is likely that the decrease in cycle two pre-survey confidence is highly related to the students' improved understanding of what they did not already know about the global and societal impacts of their work as civil engineers. The reduction of pre-survey scores from cycle one to cycle two is a likely indicator of the success of the first year of the program in raising their awareness of some of these issues.

Assessment of the cycle two data was improved by coding the surveys in order to perform a paired t-test. The paired t-test allows for the statistical testing of change by comparing individual pre- and post-survey responses. The paired t-test is a more powerful test of the data as it removes the variability between subjects. The t-test ratio and the degrees of freedom were then used to find the associated one tailed P-value. A low P-value means that it is unlikely that the difference in the samples is due to coincidence. In the case of all four questions summarized in Table II, the P-values are small enough to conclude that there is a significant increase in student

confidence in their understanding of their role as a civil engineer in the larger society after attending the lecture series and participating in the classroom component.

Table II. Cycle Two Student Confidence Questions from the Senior Professions Course

Statement	Pre-Survey	Post-Survey	P Value
As a civil engineer, I can describe how my work contributes to society.	3.6	4.4	< 0.0001
I have taken other classes that require me to consider how civil engineers impact the larger society.	3.1	4.0	0.00080
For any given project in my work as a civil engineer, I can identify sources where the global and societal impacts of my project are discussed.	3.2	4.2	< 0.0001
I can identify the appropriate governmental regulatory bodies and general policies concerning the global and societal impact of my work as a civil engineer.	2.8	3.8	0.00011

Each Speaker's Contribution

Using the same 1 to 5 scale, the seniors in the Professions course were asked, in the post-survey, to rate the degree to which they agreed with statements reflecting the individual speakers' aid in increasing the students' understanding of global and societal issues, as summarized in Table III. Speakers one through four spoke in cycle one; speakers five through eight in cycle two (it is useful to note that these numbers are not in the same order as the list of subjects). It is useful to note that the speakers who received the least positive evaluations from the students were often the speakers about whom the coordinating faculty member had the least personal knowledge and with whom she had the least pre-visit interaction. Also, speaker six spoke on a topic that was particularly divisive and was unable to participate in a classroom discussion.

Table III. Senior Professions Class Attitudes Toward Pilot Project Value

Statement	Speaker							
	1	2	3	4	5	6	7	8
This speaker's presentation increased my understanding of global and societal issues.	3.8	3.6	4.1	4.4	3.3	3.4	4.2	4.4
This speaker's classroom discussion was a valuable addition to the lecture.	4.0	3.8	4.0	4.3	3.3	n/a	4.5	4.2

Over 150 individual students, six percent of South Dakota Tech's total student population, attended at least one of the four lectures in cycle one. The attendance was similar for the second four lectures, or cycle two. The evaluation instrument given at the end of each lecture was coded to separate the seniors in the professions course from the general audience. The speakers received generally positive evaluations, though, as already noted, the speakers who spent the

least time in communication with the coordinating faculty member often received the least positive set of responses, and speaker six spoke on a topic many students considered to be divisive. Table IV summarizes the mean response toward the eight speakers from the seniors in the Professions course; Table V summarizes the same questions including results from the non-members of the Professions course.

Table IV. Mean Responses from the Professions Course Students

Statement	Speaker							
	1	2	3	4	5	6	7	8
I would like to hear this speaker give another talk.	4.2	3.6	4.1	4.0	3.8	3.7	4.8	3.2
I would like to learn more about this subject.	4.1	3.5	4.1	4.0	3.7	4.0	4.3	3.3
I would be interested in hearing this speaker on another topic.	4.3	3.4	3.9	4.1	3.5	3.4	4.7	3.1
Number of Surveys Returned	22	18	22	20	26	24	23	24

Table V. Mean Responses from the Overall Audience

Statement	Speaker							
	1	2	3	4	5	6	7	8
I would like to hear this speaker give another talk.	4.1	3.6	4.2	4.4	4.0	3.6	4.7	3.4
I would like to learn more about this subject.	4.0	3.6	4.1	4.2	3.8	4.0	4.4	3.5
I would be interested in hearing this speaker on another topic.	4.2	3.5	4.0	4.3	3.8	3.5	4.6	3.4
Number of Surveys Returned	58	45	46	47	64	85	62	50

Open-ended questions were presented to the seniors in both pre- and post-surveys. These questions addressed the students' knowledge of the types of global and societal issues faced by civil engineers. Analysis of the open-ended questions revealed increased breadth of awareness after completion of the lecture and discussion series. Student comments from the various lectures included:

> "His openness about personal thoughts and beliefs helped me to realize what I should consider when it comes to where I should go from here. It's nice to hear something non-technical and non-academic."
> "His statistics about children at the beginning of the talk were mind-blowing. He made me think a lot about how good we have it in the US"
> "Great things don't happen in your comfort zone!"
> "I have never looked at Civil Engineering in this way"
> "I never really knew how big an impact professional societies actually had."
> "He opened my eyes to international opportunities."

A final assessment tool involved a comparison of senior exit surveys in Civil Engineering. These surveys indicated that the graduating seniors from cycle two in 2005 (after initiation of the lecture series) had significantly higher confidence in their knowledge of societal and global context than those graduating in 2003, prior to development of the lecture series.

Institutionalization of the Lecture Series

The pilot program for the lecture series was funded as a small component of campus wide Bush Foundation grant aimed at undergraduate education. One of the goals of the program was to determine if this was an appropriate mechanism for raising student awareness of their roles in society and in a global context. Beyond the student assessments that indicate the success of the program, faculty, administration and the CEE industrial advisory board have all enthusiastically supported the continuation of the program. As a means to extend the lecture series beyond the pilot program, corporate sponsorship has been secured, and the lectures series has been added as a component of the department's capital campaign. The faculty and administrative support, particularly with respect to securing student participation and raising campus awareness of the series, has been a major factor in the overall success of the program.

Conclusions

The formative survey results, as well as qualitative survey comments and personal comments from students, faculty, administration and the community, indicate that the seminar series met both of its objectives: it was beneficial in addressing ABET outcome h, and it is worthy of continuation. The lecture series has received broad based support from multiple constituencies and is planned to continue in its current format. A longitudinal study of the students' global and societal awareness is currently under development. This longitudinal study will allow better assessment of the students' attitudes over their entire college career. The added dimension of phenomenological component will assist in determining which elements of the seminar series are the most vital for potential future portability.

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