Designing a Discipline-Specific Introductory Course for Freshmen

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Abstract

This paper discusses the creation of an introductory course in civil and environmental engineering for freshman or sophomore students. The objective of the course was to increase recruitment of undecided students and to increase overall student retention. The course was designed to stimulate excitement for the discipline and to help students develop goals for career success. The course was divided into five units that corresponded to the civil engineering sub-disciplines of structural, geotechnical, environmental, water resources and transportation engineering. A different faculty member began each unit with an overview of his or her area of expertise. A guest speaker from private consulting, government or industry followed this general overview by providing students with examples of typical projects and work environments. The third phase of each unit involved a hands-on laboratory, computer activity or site visit, which also had the purpose of instilling excitement for civil engineering. This paper will report on the assessment of these activities, which included using the West Point Bridge Design program as well as a unique water system layout project. The paper highlights other successes and failures and underscores how such a course can be designed to address accreditation requirements.

Introduction

The retention of undergraduates in the civil engineering program is a significant concern. Freshman and sophomore students are perhaps the most likely to change majors, and this is not necessarily because the students are unable to achieve academically. The Civil Engineering curriculum at Seattle University is structured so that majors do not actually take Civil Engineering courses until their junior year. As a result, many students lose focus and begin to question the selection of their major.

To address this issue, the Department of Civil and Environmental Engineering offered Introduction to Civil and Environmental Engineering (CEEGR 100) during Fall Quarter 2001. The course was partly modeled as a freshman seminar, since it focused on the use of guest speakers and active learning tools to illustrate the practical aspects of civil engineering and how it affects the daily lives of all people in the form of water conveyance, structures, transportation and beyond. Another purpose of this course was to introduce each member of the faculty by providing at least one lecture in their field of expertise. The ultimate objective was to provide the student with a real sense of why they will be taught some of the topics during their first two years that may otherwise seem to be esoteric in nature. In other words, the course was intended to demonstrate all of the interesting things that civil engineers do while framing the need for the basics. It is through this perspective that student interest and thus retention may increase.

CEEGR 100 was a 2-credit course open to all students but intended for freshman or sophomores. The course met for two 50-minute periods per week for ten weeks. The course was divided into five units that corresponded to the civil engineering sub-disciplines of structural, geotechnical, environmental, water resources and transportation engineering. Each of the five units was discussed for three class periods (except for transportation which due to time constraints was limited to two). The first two class periods for each unit were dedicated to lectures by faculty and guest speakers from industry, respectively. The third class period involved an active learning activity in the form of either a computer-based or wet laboratory or a field trip.

The design of any new engineering course should consider the criteria set forth by the Accreditation Board for Engineering and Technology (ABET) known as ABET 2000. As indicated in the course syllabus, the specific learning objectives for each student were to 1) define the sub-disciplines of Civil Engineering and provide examples of projects for each, 2) identify the steps to the engineering design process 3) utilize spreadsheets, prepare PowerPoint presentations and web pages, 4) identify current issues related to Civil Engineering, and 5) develop written communication skills. Learning objectives three, four and five were specifically mapped to ABET 2000 criteria: (g) an ability to communicate effectively, (j) identify current issues related to Civil Engineering and (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. The program assessment component of ABET 2000 was also incorporated into the course by implementing a design skills assessment tool. The purpose of this paper is to discuss the course components, which include: the baseline assessment of design skills, faculty and guest lectures, active learning tools, discussions of contemporary issues and the use of computer applications. The paper also discusses the assessment of course components with data from anonymous pre-course and post-course surveys.

TIDEE Assessment

The creation of a new freshman course provided a perfect opportunity to use an engineering design assessment tool, which was developed through a collaborative effort between Washington State University (WSU), University of Washington (UW), and Tacoma Community College (TCC). TIDEE[1] (Transferable Integrated Design in Engineering Education) is a program design assessment device that is intended to offer engineering educators a number of potential benefits such as:

1) Assessing learning that is a result of different teaching approaches,
2) Identifying a set of design outcomes,
3) Determining readiness of a class for design, thereby indicating what instructional levels are appropriate for effective learning,
4) Informing institutions about the adequacy of their educational programs to deliver expected design education outcomes.

The TIDEE approach involves a three-part process that begins with a 15-minute, short-answer pre-test that assesses individual students' knowledge of basic concepts about the design process, teamwork, and design communication. The second portion of TIDEE entails a 35-minute session where teams of three to four students apply the design process and effective communication to complete a design assignment on time. The third part of the assessment is a take-home reflective essay that is intended to allow the students to assess their knowledge and performance in terms of effective design, teamwork, and communication practices. A panel of two or more faculty who are trained to use the TIDEE scoring rubrics evaluates the completed activities.

The designers of TIDEE originally intended it to be used as a mid-program assessment tool that would be given to students at the beginning of their junior year. Hence, programs can evaluate the quality of the first two-years with respect to teaching design concepts, teamwork and communication. The approach for CEEGR 100 was to develop baseline information for freshman design, teamwork and communication skills and track student performance over time. All of the students in CEEGR 100 were given the TIDEE assessment during the second and third class periods. Non-freshman were grouped together, so that the freshman cohort could be tracked when the assessment is performed again at the beginning of the senior year. This continuous tracking will be used to assess the engineering program outcomes and will provide a feedback mechanism for program improvement.

Faculty and Guest Lectures

A different faculty member began each unit with an overview of his or her area of expertise. The lectures in structures and water resources engineering also included short primers on statics (tension and compression) and the Bernoulli equation, respectively, as these concepts were directly related to the hands-on activities discussed below. A guest speaker from private consulting, government or industry followed this general overview by providing students with examples of typical projects and work environments. Post-course surveys asked students to rank the guest speakers on a scale of 1 to 5 (1 = Poor, 2 = Fair, 3 = Good, 4 = Very Good 5 = Excellent). The average score for speakers ranged from 3.1 to 4.3. This assessment will help determine future choices for guest speakers.

Active Learning Tools

The approach in designing CEEGR 100 assumed that if a Freshman course was to be successful, active learning tools must grab the student's imagination and demonstrate a fundamental concept. The course must also focus on technology by introducing the students to engineering-related software at the crucial, early-stage of their careers[2]. A review of the literature indicated that a number of engineering programs across the country have begun to develop freshman oriented classes similar to the one described here[3,4]. For example, faculty at the New Jersey Institute of Technology have developed a compilation of Civil Engineering laboratories that were designed for Freshman students that have yet to be exposed to engineering fundamentals[3].

The West Point Bridge Designer[5] was used to introduce the students to structures and the concepts of compression and tension. The program and accompanying manual helped the students through the iterative design of a bridge. The students' deliverable was a bridge design that cost under $2500 and nearly all of the students were able to successfully complete this task. As Table 1 indicates, the West Point Bridge Designer was well perceived and many comments alluded to how it sparked interest. However, many students commented that more class time was needed to truly understand the program.

WaterCAD (Haestad Methods, Waterbury, CT) is one of industry's leading software programs for modeling water distribution systems, and it was used to illustrate to the students how water systems work. Students first drew a water system configuration with ten nodes or points of water withdrawal. They then set the elevations of these nodes to 100 feet above sea level. The source of the water was at sea level. The objective of the exercise was to supply a minimum pressure of 50 psi to the water system. When the students first ran the model, they realized that the system pressure was negative. Thus, the students had to either increase the elevation of the reservoir or add a pump. In general, the reception for this exercise was moderate (Table 1) and comments indicated that the program was not as fun to use as West Point Bridge Designer.

The environmental engineering activity involved the removal of lead from a water sample. In this laboratory, a water sample containing 100 μg/L of lead was measured several times using a colorimetric kit (Hach Company, Loveland, CO). A portion of the water sample was poured through a common home water filter the makers of which claimed 98 percent removal of lead. The treated samples were then measured for lead and a student's t-test was performed with spreadsheet statistical functions to determine the significance of the lead removal. Table 1 clearly shows that this activity was the least successful in terms of student perception. During the laboratory, it became clear that more than 50 minutes was necessary to work through both the procedures and the data analysis.

Table 1: Student evaluations of active learning activities (1 = Poor, 2 = Fair, 3 = Good, 4 = Very Good 5 = Excellent), n = 18.

Activity	**Average Score (± 1 standard deviation)**
West Point Bridge Designer	4.16 ± 0.83
WaterCAD Water System Layout	3.44 ± 0.85
Lead Removal Laboratory	3.00 ± 1.17
Earthquake Engineering Construction Site Visit	4.17 ± 0.73

The field trip to a local construction site to learn about the geotechnical aspects of the construction received the highest scores. Students enjoyed seeing the project up-close, walking through the site, asking questions and listening to stories about the day-to-day construction activities. Most of the students were inspired by the visit, and since this is one of the objectives of the course, future efforts must include more field trips. To do so, more class time will have to be budgeted to accommodate travel.

Contemporary Issues

Over the course of the term students were given six current articles from *Civil Engineering* magazine, five of which discussed specific projects related to structural[6], geotechnical[7], water resources[8], environmental[9] and transportation[10]. The sixth article "Rebuilding America's Infrastructure"[11] was the first article in the series, and it provided an excellent backdrop for the remainder of the course. The article summarized the grades that a panel of experts gave to America's infrastructure, from airports to sewers. Students quickly realized how dilapidated much of our infrastructure is and as a result the need for civil engineers really hit home.

After reading each article, students wrote one to two page essays addressing:

- A brief summary of the article
- Things they learned
- Things they did not understand
- Socioeconomic implications
- Environmental implications

In the post-course survey, students were asked to rate each of the articles and how well the articles increased their awareness of contemporary civil engineering issues. Table 2 summarizes these results. Although the student comments were generally favorable, the primary difficulty associated with the articles was that the students often had trouble with the jargon. Anecdotally, the articles that scored lowest were also those that had the highest number of unclear items as noted by the student summaries.

Table 2: Student evaluations of contemporary articles on civil engineering (1 = Poor, 2 = Fair, 3 = Good, 4 = Very Good 5 = Excellent), n = 18.

Article	Average Score (± 1 standard deviation)
Rebuilding America's Infrastructure[11]	4.16 ± 0.78
Cliff-Hanger[6]	3.27 ± 0.67
Damage Report Seattle[7]	3.88 ± 0.76
The California Experience[8]	3.44 ± 1.04
Replacement Strategy[9]	3.44 ± 0.74
Out of the Way[10]	3.72 ± 0.83

Students were also asked how well these articles increased their awareness of contemporary civil engineering issues. The average survey result of 3.94 indicated that the use of these articles significantly increased their awareness.

Computer Applications

Students begin college with varying degrees of computer skills. Since these skills have become a necessity for effective communication, one objective of the course was to ensure that every student was able to 1) use basic spreadsheet functions 2) prepare PowerPoint presentations and 3) produce a web page. Spreadsheet exercises ranged from simple comparisons of example data (e.g. percent differences) to the use of built-in statistical functions (e.g. descriptive statistics, F-tests for sample means, t-tests). Students typed their summaries of the contemporary journal articles, made 5-10 slide PowerPoint presentations of the summary then transferred the presentation to the Internet so that it could be accessed from their web page. As a result, PowerPoint and web page production skills were developed, however word processing skills did not significantly improve according to the self-assessment. The results of the pre-course and post-course student surveys related to computer applications are shown in Table 3. Wilcoxon rank-sum tests of this ordinal data revealed that the scores for the student self-assessments significantly increased by the end of the course for spreadsheet, PowerPoint and web page production skills.

Table 3: Pre-course and post course student survey results showed significant differences when student's rated their computer skills on a scale from 1 (low) to 5. (Results are averages ± 1 standard deviation; p-values are based on the two-tailed, Wilcoxon rank-sum test)

Application	**Pre-Course Survey** (n = 18)	**Post-Course Survey** (n = 18)	**p-value**
Spreadsheet	3.11 ± 0.94	3.83 ± 0.55	0.0034
Word Processing	4.22 ± 0.94	4.78 ± 0.55	0.064*
PowerPoint	2.83 ± 1.50	4.39 ± 0.61	0.0023
Web Page Production	1.83 ± 1.38	3.83 ± 0.76	4.6×10^{-5}

*denotes an insignificant change

Student Retention

The primary reason for implementing CEEGR 100 was to increase student retention. In both the pre-course and post-course surveys, students were asked to rate their interest in civil engineering. As Table 4 indicates, the course did not significantly change the average response (p = 0.13). However, the raw data showed that at least two students realized that perhaps civil engineering was not for them. Although not an ideal result, such an outcome is also desirable in the sense that a course such as this can help guide vocational decisions at a relatively early academic stage.

Table 4: Pre-course and post course student survey results showed no significant differences when student's rated their interest in civil engineering on a scale from 1 (low) to 5. (Results are averages ± 1 standard deviation; p-values are based on the two-tailed, Wilcoxon rank-sum test)

Question	Pre-Course Survey (n = 18)	Post-Course Survey (n = 18)	p-value
Rate Your Interest in Civil Engineering	4.44 ± 0.70	4.05 ± 0.97	0.13

Conclusions

CEEGR 100 was designed to illustrate to students what civil and environmental engineers do and to stimulate excitement for the field with the ultimate objective being increased student matriculation. The course was also designed to meet ABET 2000 requirements and was the first freshman course to implement the program assessment tool developed by TIDEE. A comparison of pre-course and post-course surveys indicated that the students developed a clear understanding of the profession. The active learning activities were generally a success, however time constraints during the 50-minute class period were evident and will likely lead to a change in the course structure from two, 50-minute periods per week to one, 50-minute and one 2-3 hour period. By having the students read and write about civil engineering projects, they were able to develop their technical writing skills and their knowledge of technical terms. This course was also successful at significantly developing spreadsheet, PowerPoint and web page production skills.

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