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Opening the Classroom to the Civil Engineering Profession through Web-based Class Projects: Assessment of Student Learning

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Abstract

The purpose of this study was to assess whether exposing student course work to engineering practitioners and experts outside the classroom can motivate students to work harder and more enthusiastically and, as a consequence, improve their learning. A web-based platform for class projects has been implemented in two graduate-level civil engineering courses on Soil and Site Improvement and Geoenvironmental Engineering at the University of Michigan. The platform was used to replace a conventional class project, which typically comprises of a written report and a class presentation reviewed by the instructor only, and to promote virtual interaction between the students and professionals in the field. Student projects were made publically available online through the web-based platform. Practitioners and experts were invited to review the student reports and provide comments or ask questions. Students responded to review comments and addressed them in the final reports as part of the class deliverable. Final reports and presentation slides remain online as a resource for professionals. Student self-assessment surveys were developed and administered to assess the impact of the web-based projects on student learning. Self-reported survey results indicated that students preferred the web-based project to a conventional project and were more motivated to work harder and submit high-quality work. Students were also enthusiastic about receiving feedback from professionals in the field. An additional outcome of this initiative was the significant interest from professionals in reviewing class projects.

Introduction

This study was conducted to explore whether student learning, effort, and enthusiasm can be enhanced by exposing student projects to engineering practitioners and experts outside the classroom. Previous studies indicate that engineering students learn better when they perceive coursework as valuable to their future career, having impact on society, or relating closely to engineering practice[1,2,7]. Also, studies have shown that student learning improves when class projects are presented and reviewed by a much broader audience and that feedback from multiple sources improves overall academic performance[4,5]. In this study, these motivating factors are incorporated by augmenting "conventional" class projects into web-based projects using an online platform that makes them accessible to a wider technical audience.

Graduate-level civil engineering courses often have a project component. These "conventional" projects give students the opportunity to apply skills and knowledge acquired in the classroom, synthesize information, and independently study a specific topic in greater depth than could possibly be accommodated in the allotted contact hours. The deliverables of these projects, typically a written report and oral presentation, are evaluated by the course instructor and are often presented to student peers. Web-based projects, have been implemented in two graduate-level civil engineering courses at the University of Michigan. The concept of web-based projects is differentiated from conventional projects in that they engage professionals in the review

process and remain publically available. This opens the project to broader sources of feedback and adds benefits to the students' experience.

Description of Web-Based Projects

The hypothesis that is tested by replacing conventional class projects with online class projects is that student enthusiasm, commitment, and learning will be enhanced by working on projects that are directly viewed and critiqued by the professional engineering community. Specifically, does receiving professional feedback through online projects improve: (a) student motivation and enthusiasm, (b) student commitment, and (c) learning? Similar to conventional projects, web-based projects have two primary components: a written report that is made available online and an oral presentation in the classroom. Web-based projects were implemented in two courses at the University of Michigan, "Soil and Site Improvement" (CEE542) and "Geoenvironmental Engineering" (CEE549)[8], that were taught in the Winter 2014 and Winter 2013 semesters respectively. These were graduate-level civil engineering courses made up of primarily graduate as well as interested senior undergraduate students. The class rosters included 6 graduate and 5 undergraduate students in CEE542, and 13 graduate and 6 undergraduate students in CEE549. Students, in groups of two or three, selected a topic of their choice related to the course. These topics were beyond the content covered in the classroom, giving students an opportunity to expand the breadth of content covered in the course. In CEE549, students selected a topic from a list of options prepared by the instructor, whereas in CEE542, the selection of topics was completely free and subject to approval by the instructor.

Student groups conducted literature reviews, researched their topic throughout the semester, and wrote a report that was submitted through a web-based platform. The web-based projects are hosted by Geoengineer.org, the international information center for geotechnical engineers[8]. Upon submission of the reports, the course instructor notified, via email, professionals in relevant fields affiliated with the American Society of Civil Engineers (ASCE), the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE), and geo-professionals who are members of the Geoengineer.org mailing list. The projects remained online for an approximately, two week "review" period. During this time, professionals viewed student projects, provided feedback, asked questions, or requested more information using a web-based commenting form. The number of views per project page during the review period are shown in Figures 1 and 2 for CEE549 and CEE542 respectively. As shown by this data, there was significant web traffic to the class projects during the review period. While only a small fraction of viewers leave review comments, the view counts indicate the sizable interest in student work by professionals. The final reports remain online and can be viewed at: http://www.geoengineer.org/education/web-based-class-projects

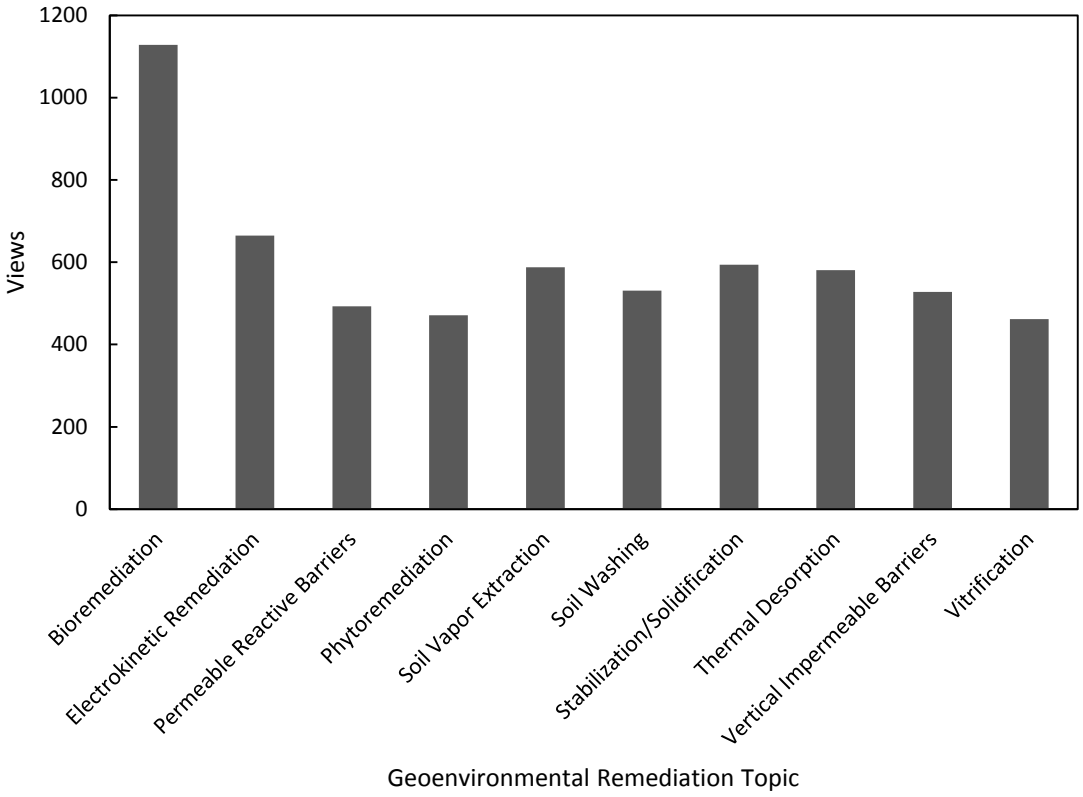

Figure 1. Number of views per project during review period in Geoenvironmental Engineering course.

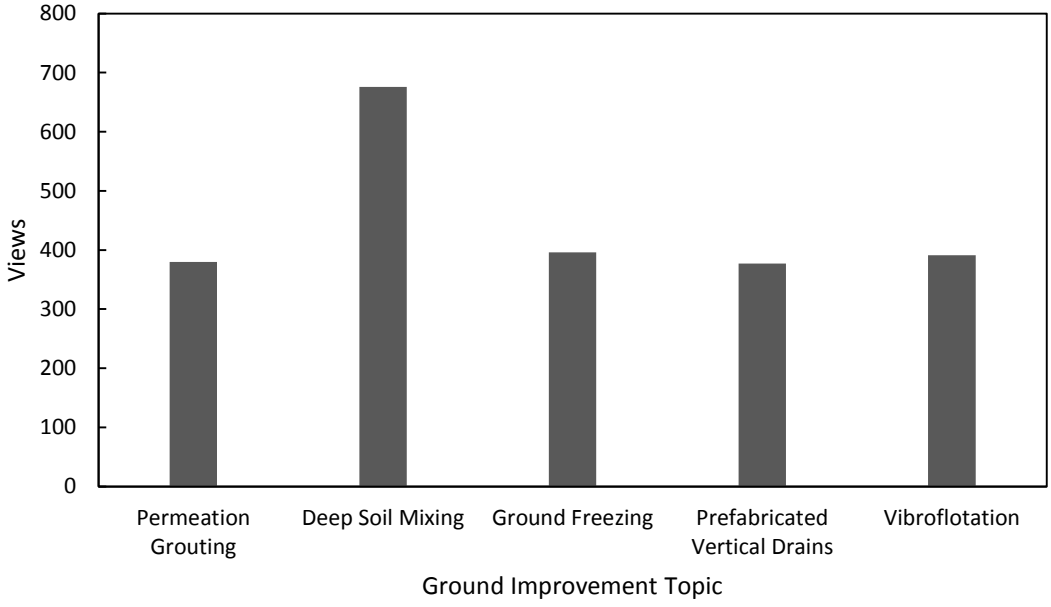

Figure 2. Number of views per project during review period in Soil and Site Improvement course.

Feedback was provided primarily as public comments, however, some reviewers contacted the instructor directly, through e-mail, with the request to forward their feedback to students. Projects received as many as five public comments of varying depth, depending on the topic, from more than ten independent commenters. After the two week review period, students were required to respond to the review comments. Responding to constructive criticism or technical questions from professionals is not an experience that is incorporated in conventional projects. This aspect of the web-based projects gives students an opportunity to develop a useful skill for their careers. The course instructor provided corrections separately offline. Reviewer comments and course instructor corrections were implemented, as necessary, by the students into the revised reports. Reviewed (final) reports and class presentation slides were uploaded to the website and remain online as a resource for professionals or students. The post-review website statistics indicate that the student projects are not only beneficial to the student, but also professionals. Thus, students recognize that their project outcome will have an impact in professional practice that extends beyond the classroom, which is another motivating factor for students [6].

Student Response

All students participated in an anonymous exit survey upon completing the course. The survey aimed to assess the impact of web-based projects on the individual student's learning experience. Survey questions targeted student's self-reported learning, motivation, preferences, and overall experience. In addition to the investigative questions posed previously, the survey aimed to assess potential strategies for improvements to the project and the course. Open-ended written feedback was also solicited from the students. As part of the analysis, means (μ) and standard deviations were calculated for the responses to each survey question. The mean response value and coefficient of variation (COV), the ratio of one standard deviation to the mean, are provided here. It should be noted that the survey (included in the appendix) contains more questions than are presented in this paper. The responses to the most pertinent questions are reported and discussed. Questions 1-3 asked students to score from 1 to 7 (7 extremely high, 4 neutral, 1 not at all), to what degree the various class components contributed to understanding the breadth of ground improvement or geoenvironmental remediation technologies (Question 1), understanding a certain aspect of ground improvement or geoenvironmental remediation in depth (Question 2), and working collaboratively (Question 3). Questions 1 and 2 measure the influence of class components on specific course objectives. One goal of the CEE549 and CEE542 courses was to expose students to a broad array of techniques used in the fields of ground improvement or geoenvironmental remediation, giving them some familiarity with many techniques. The scores for Question 1 are shown in Table 1. Students indicated that classroom lecture was the most important component for understanding the breadth of the course subject. In both classes, the online project was rated as the second most important component for understanding the breadth of these fields. While exploring the breadth of topics was not an established goal of the online projects, it seems to contribute significantly. One objective of the class projects was to allow students to explore a topic in much greater depth than is possible through the course lectures. Question 2 gauges how effective, relative to other class components, the online project was at achieving this explicit goal. The scores for Question 2 are shown in Table 2. The results of Question 2 indicate that students considered the online projects to be the most important course component contributing to an in-depth understanding of the course material. In response to

Question 3, shown in Table 3, students strongly indicated that the online project was the primary course component promoting collaborative work, ranking the project even higher than joint studying.

The survey also included questions specifically about the web-based projects. Zekkos and Tsantilas (2014) previously reported the responses to questions 4 – 17 for CEE549[8]. It was found that students were more motivated to submit quality projects and were enthusiastic about receiving feedback from professionals in the field[8]. The responses to these questions, on a scale from 1 to 5 (1 strong agreement, 3 neutral, 5 strong disagreement), for both CEE549 and CEE542 are shown in Table 4. In general, the results from CEE549 and CEE542 are in agreement; students reacted positively to the incorporation of online projects. Students also greatly preferred the project rather than a final exam (Question 4) and felt that they learned more from having an online project instead of a final exam (Question 5) despite spending about the same amount of time studying (Question 6). Students indicated that they preferred the web-based project to a conventional project (Question 7) and were motivated to work harder and present better-quality work (Question 8-9). Students also responded positively to interacting with the professional engineering community. They found this type of interaction professionally fulfilling and, overall, a valuable experience (Question 13-14).

Overall, CEE549 class scores were slightly more positive about the online projects than in CEE542. Students in both classes found the online projects to be more stressful than a conventional project, especially in CEE542 (Question 11). The greatest difference between the two classes was that CEE549 students were more excited about their projects remaining online as a resource to others (Question 15). The reasons for this difference are not known. The overall positive results in both courses are encouraging evidence for the value of the online project platform to engineering courses.

Table 1. Response to question #1: To what degree do you think that the following class components contributed in terms of providing you with the opportunity to understand the breadth of *ground improvement / remediation* techniques (7 extremely high, 4 neutral, 1 not at all)?

Component	Ground improvement (CEE542) μ (COV)	Geoenvironmental remediation (CEE549) μ (COV)
Classroom Lecture	6.73 (0.07)	6.47 (0.09)
Textbook	1.27 (0.71)	4.47 (0.27)
Problem sets	5.18 (0.27)	5.11 (0.25)
Literature papers	5.36 (0.17)	4.47 (0.31)
Online project	5.73 (0.18)	5.37 (0.27)
Studying alone	4.64 (0.26)	4.68 (0.19)
Studying with others	4.27 (0.15)	4.58 (0.26)

Table 2. Response to question #2: To what degree do you think that the following class components contributed in terms of providing you the opportunity to understand in more depth a certain aspect of *ground improvement / remediation* practice (7 extremely high, 4 neutral, 1 not at all)?

Component	Ground improvement (CEE542) μ (COV)	Geoenvironmental remediation (CEE549) μ (COV)
Classroom Lecture	6.09 (0.17)	6.00 (0.18)
Textbook	1.27 (0.71)	4.84 (0.35)
Problem sets	5.27 (0.28)	5.47 (0.21)
Literature papers	5.73 (0.11)	5.53 (0.24)
Online project	6.45 (0.16)	6.42 (0.15)
Studying alone	4.64 (0.24)	4.79 (0.25)
Studying with others	4.36 (0.19)	4.26 (0.23)

Table 3. Response to question #3: To what degree do you think each of the following class components contributed to working collaboratively (7 extremely high, 4 neutral, 1 not at all)?

Component	CEE542 μ (COV)	CEE549 μ (COV)
Classroom Lecture	4.64 (0.28)	3.53 (0.39)
Textbook	1.27 (0.71)	2.05(0.57)
Problem sets	4.64 (0.28)	4.95 (0.26)
Literature papers	2.82 (0.65)	2.53 (0.55)
Online project	6.64 (0.10)	6.47 (0.19)
Studying alone	2.36 (0.85)	1.94 (0.65)
Studying with others	5.36 (0.29)	5.53 (0.27)

Table 4. Student responses to survey questions (1 strong agreement, 3 neutral, 5 strong disagreement).

Q#	Question Description	CEE549 μ (COV)	CEE542 μ (COV)
4	Having an online project instead of a final exam was overall an excellent decision	1.53 (0.72)	1.82 (0.41)
5	Having an online project instead of a final exam helped me learn more	2.16 (0.51)	2.00 (0.59)
6	Having an online project instead of a final exam forced me to study more	3.00 (0.43)	2.91 (0.42)
7	I overall prefer the experience of a web-based project compared to a conventional class project	1.58 (0.44)	2.09 (0.40)
8	The web-based project motivated me to do a better quality job overall than a conventional class project	1.74 (0.52)	2.00 (0.55)
9	The web-based project motivated me to work harder than a conventional class project	1.63 (0.49)	1.91 (0.55)
10	I like the idea of having professionals/online visitors reviewing my project, as opposed to just the instructor	1.53 (0.52)	1.64 (0.41)
11	Preparing the web-based project was more stressful than a conventional project	2.68 (0.41)	2.09 (0.50)
12	Working on a web-based project forced me to work more closely with my teammate(s) than I would have for a conventional project	2.47 (0.40)	2.18 (0.45)
13	Receiving feedback from the online visitors was professionally fulfilling	1.79 (0.39)	1.91 (0.44)
14	Responding to visitor's review comments was a valuable experience	2.21 (0.50)	2.09 (0.40)
15	I am excited about the fact that the web-based project will remain online and will be used as reference/resource by other professionals, students, or faculty	1.53 (0.46)	2.45 (0.33)
16	Do you recommend incorporating a final exam in the class in the future, in addition to a web-based class project	3.63 (0.28)	4.00 (0.27)
17	Do you recommend incorporating a final exam in the class in the future, instead of a web-based class project	4.26 (0.21)	4.09 (0.23)

Impact on the Profession

As previously discussed, it was found that students reported being more motivated to submit high-quality projects. Increased motivation, and a preference for this type of project, resulted in improved work quality from students and a more valuable online report. Projects generally contain an overview of the selected topic and a list of important technical references. Some projects may focus on specific case histories or a fundamental overview of a topic. Such online resources contain valuable content.

Practitioners, researchers, and students, may use these new resources online. A knowledge database with the compilation of student projects has the potential to be used as a quality resource when learning about a new subject or to find quality references. This may partially explain the continuous increase in traffic in the class project pages even after the review period. Project view counts have shown significant increase over time. The number of project views at the end of the review period (April 23rd 2014) and as of January 30, 2015 for CEE542 are shown in Table 5. The number of project views at several dates for CEE549 are shown in Table 6. As of January 30, 2015, projects from CEE542 had between 7,618 – 10,676 views and projects from CEE549 had between 13,495 – 30,613 views depending on the topic. This high volume of traffic may be attributed partially to the popularity of Geoengineer.org website as a technical resource, and the favorable ranking of Geoengineer.org in Google's web search engine results.

The high volume of traffic for projects posted for less than one or two years shows that they are extremely visible to the professional engineering community. The consolidation of this information, with the provided feedback, into a single resource, acts as a form of professional crowdsourcing. Other web-based knowledge crowd-sourcing methods have been successful[3]. The depth and breadth of professional crowdsourcing is expected to grow as more projects are completed across additional topics. Professional interest in this knowledge base is also expected to increase as more topics are explored, attracting more users.

Table 5. Project Views for CEE542 according to the server's statistics.

Project Topic	4/23/2014	1/30/2015
Permeation Grouting	380	8872
Deep Soil Mixing	676	8155
Ground Freezing	396	7618
Prefabricated Vertical Drains	377	10676
Vibroflotation	391	10026

Table 6. Project Views for CEE549 according to the server's statistics.

Project Topic	4/2/2013	10/16/2013	1/16/2014	1/30/2015
Bioremediation	1128	7862	10336	30613
Electrokinetic Remediation	665	2590	3591	19200
Permeable Reactive Barriers	493	2468	3664	18962
Phytoremediation	471	1806	2458	13495
Soil Vapor Extraction	588	2132	2899	17944
Soil Washing	531	4088	5774	18262
Stabilization/Solidification	594	2712	3961	21674
Thermal Desorption	581	2387	3376	17147
Vertical Impermeable Barriers	528	2230	3517	18314
Vitrification	462	1812	2653	14659

Conclusions

"Conventional" class projects were replaced by web-based projects in two graduate-level engineering courses at the University of Michigan. The online accessibility of these projects allowed professionals to virtually interact with students and contribute to the project review process. Survey results indicate that students' self-reported learning and motivation are enhanced when working on a web-based project compared to a conventional project. The significant level of interest shown by professionals in student coursework was also very encouraging. The large number of online visitors of student class projects during the review process, but especially post-review, is an indication of the potential value of these online resources for practitioners, researchers, and other students. Beyond academics, students engaged in the web-based projects, drew satisfaction from creating a lasting resource for the profession and their work attracted the interest of potential employers. The online platform is freely available through Geoengineer.org for use by educators.

Future work

The implementation of these projects and virtual professional engagement is planned to be expanded to additional courses and universities with the assistance of other course instructors. Currently, online projects are planned to be implemented in another civil engineering course, Rock Mechanics, and expanded to subjects beyond geotechnical engineering. Feedback received from students through the survey is used to devise improved strategies for the student experience. Additional student feedback is being planned through formal interviews of online project participants.

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Appendix A. Survey Instrument

Note: This is the survey used for the CEE542 course. Note that the question numbers do not match those used in the main text of the paper.

CEE 542 WEB-BASED CLASS PROJECT EVALUATION FORM

Winter 2014

1. GRADUATE STUDENT (Circle one) YES NO

2. A main learning goal for CEE 542 was to give the expose students to the broad field of Ground Improvement. To what degree do you think that each of the following contributed to this main learning goal?

	extremely		significantly	neutral	not significantly		not at all
(a) classroom lecture	7	6	5	4	3	2	1
(b) textbook	7	6	5	4	3	2	1
(c) problem sets	7	6	5	4	3	2	1
(d) literature papers	7	6	5	4	3	2	1
(e) online project	7	6	5	4	3	2	1
(f) studying alone	7	6	5	4	3	2	1
(g) studying with others	7	6	5	4	3	2	1

3A. *To what degree* do you think that the following class components contributed in terms of providing you the opportunity to understand the breadth of ground improvement techniques.

	extremely		significantly	neutral	not significantly		not at all
(a) classroom lecture	7	6	5	4	3	2	1
(b) textbook	7	6	5	4	3	2	1
(c) problem sets	7	6	5	4	3	2	1
(d) literature papers	7	6	5	4	3	2	1
(e) online project	7	6	5	4	3	2	1
(f) studying alone	7	6	5	4	3	2	1
(g) studying with others	7	6	5	4	3	2	1

3B. Now, *rank* these seven according to their significance in getting you to understand the breadth of ground improvement techniques.

RANK (1 = most significant; 7 = least significant; no ties allowed!)

(a) classroom lecture	1	2	3	4	5	6	7
(b) textbook	1	2	3	4	5	6	7
(c) problem sets	1	2	3	4	5	6	7
(d) literature papers	1	2	3	4	5	6	7
(e) online project	1	2	3	4	5	6	7
(f) studying alone	1	2	3	4	5	6	7
(g) studying with others	1	2	3	4	5	6	7

4A. *To what degree* do you think that the following class components contributed in terms of providing you the opportunity to understand in more depth a certain aspect of ground improvement practice.

	extremely		significantly	neutral	not significantly		not at all
(a) classroom lecture	7	6	5	4	3	2	1
(b) textbook	7	6	5	4	3	2	1
(c) problem sets	7	6	5	4	3	2	1
(d) literature papers	7	6	5	4	3	2	1
(e) online project	7	6	5	4	3	2	1
(f) studying alone	7	6	5	4	3	2	1
(g) studying with others	7	6	5	4	3	2	1

4B. Now, *rank* these seven according to their significance in getting you to understand in more depth a certain aspect of ground improvement practice.

RANK (1 = most significant; 7 = least significant; no ties allowed!)

(a) classroom lecture	1	2	3	4	5	6	7
(b) textbook	1	2	3	4	5	6	7
(c) problem sets	1	2	3	4	5	6	7
(d) literature papers	1	2	3	4	5	6	7
(e) online project	1	2	3	4	5	6	7
(f) studying alone	1	2	3	4	5	6	7
(g) studying with others	1	2	3	4	5	6	7

5A. To *what degree* you think each of the following class components contributed to working collaboratively?

	extremely		significantly	neutral	not significantly		not at all
(a) classroom lecture	7	6	5	4	3	2	1
(b) textbook	7	6	5	4	3	2	1
(c) problem sets	7	6	5	4	3	2	1
(d) literature papers	7	6	5	4	3	2	1
(e) online project	7	6	5	4	3	2	1
(f) studying alone	7	6	5	4	3	2	1
(g) studying with others	7	6	5	4	3	2	1

5B. Now, *rank* these seven according to their significance in getting you to work collaboratively.

RANK (1 = most significant; 7 = least significant; no ties allowed!)

(a) classroom lecture	1	2	3	4	5	6	7
(b) textbook	1	2	3	4	5	6	7
(c) problem sets	1	2	3	4	5	6	7
(d) literature papers	1	2	3	4	5	6	7
(e) online project	1	2	3	4	5	6	7
(f) studying alone	1	2	3	4	5	6	7
(g) studying with others	1	2	3	4	5	6	7

7. To accommodate the significant requirements of the web-based class project, this course had no final exam. Please provide an opinion on the following questions using the following Grading scheme (1-5): 1 Strongly Agree / 3 Neutral / 5 Strongly Disagree

A. Having an online project instead of a final exam was overall an excellent decision

1 2 3 4 5

B. Having an online project instead of a final exam helped me learn more

1 2 3 4 5

C. Having an online project instead of a final exam forced me to study more

1 2 3 4 5

8. Instead of a web-based class project, we could have had a "conventional" class project, i.e., a paper project submittal to the instructor and a presentation to the class. Please rate according to the following grading scheme (1-5): 1 Strongly Agree / 3 Neutral / 5 Strongly Disagree

A. I overall prefer the experience of a web-based project compared to a conventional class project

1 2 3 4 5

B. The web-based project motivated me to do a better quality job overall than a conventional class project

1 2 3 4 5

C. The web-based project motivated me work harder than a conventional class project

1 2 3 4 5

D. I liked the idea of having professionals/online visitors reviewing my project, as opposed to just the instructor

1 2 3 4 5

E. Preparing the web-based project was more stressful than a conventional project

1 2 3 4 5

F. Working on a web-based project forced me to work more closely with my teammate than I would have for a conventional project

1 2 3 4 5

G. Receiving feedback from the online visitors was professionally fulfilling

1 2 3 4 5

H. Responding to visitor's review comments was a valuable experience

1 2 3 4 5

I. I am excited about the fact that the web-based project will remain online and will be used as reference/resource by other professionals, students or Faculty

1 2 3 4 5

9A. Do you recommend incorporating a final in the class in the future, <u>in addition to</u> a web-based class project. Grading scheme (1-5) as follows: 1 Strongly Agree / 3 Neutral / 5 Strongly Disagree

1 2 3 4 5

9B. Do you recommend incorporating a final in the class in the future, <u>instead of</u> a web-based class project. Grading scheme (1-5) as follows: 1 Strongly Agree / 3 Neutral / 5 Strongly Disagree

1 2 3 4 5

OPEN-ENDED QUESTIONS

A. Based on your experience, what could be done to improve the web-based project?

B. Based on your experience, what could be done to improve the course?