

A Case Study: Assessing Effectiveness of Online Instruction in an Upper Division Engineering Course

Dr. Rebeka Sultana, California State University, Long Beach

Rebeka Sultana received doctoral degree in civil engineering from the University of California, Irvine. She is a project engineer at the California Department of Transportation (Caltrans) and a lecturer at California State University, Long Beach (CSULB). At CSULB, she teaches courses in water resources engineering at the department of Civil Engineering and Construction Engineering Management (CECEM). Sultana's research focuses on water resources engineering and hydrology. Due to her passion in student learning and success, she is also involved in research in engineering education. She has published several peer-reviewed journals and conference proceedings in her research areas as well as in engineering education. In her teaching pursuits, Sultana integrates real world examples and research with the theoretical knowledge to prepare the future engineers. She has been involved with American Society of Engineering Education Pacific South West section for the past three years. In her current position, Relations with Industry, she collaborates with industry partners to bring their insight in engineering education. She is licensed Professional Engineer from the state of California.

A Case Study: Assessing Effectiveness of Online Instruction in an Upper Division Engineering Course

Introduction

With the invention of the World Wide Web in 1992, online education emerged and expanded at all levels of education. Ease of accessibility, interest in lifelong learning along with time and cost savings allowed many universities to embrace this new pedagogical model. Since then, online enrollment growth rate continues to rise. In a report of online education shows in 2013, number of students taking at least one online course increased by over 570,000 to a new total of 6.7 million¹.

Still, critics of online education finds the model to commercialize education and isolate students and faculties and may reduce standards or even devalue university degrees. Therefore, face-to-face (F2F) instruction continues to be the preferred mode of instructions where students, instructors can communicate and interact inside and outside the classroom. However, with COVID-19 pandemic in the year 2020 students were not left with any choice but to learn virtually. Many students and instructors who never had any online learning/teaching experience were forced to quickly adapt to virtual classroom in the middle of the semester. Pandemic also caused many students to lose jobs, eliminated/limited student's accessibility of technical support. Altogether, this unprecedented transition affected student's performance and their grades as well as students' ratings of instructors (from personal communication with colleagues within the college).

Soon universities took various initiatives to assist students with technical support and provide trainings to instructors. Students adjusted to virtual learning while instructors relearned how to teach their courses effectively in an online teaching mode. Instructors quickly identified three major conditions - instructional design, social matters, and students' personal factors contribute to the success in online learning². Instructional design factors such as flexible course structure, quick and frequent feedback, and effective visual layouts influence online interaction and learner satisfaction³. Social factors such as interpersonal interaction and social integration contributed to more than 60% of learner satisfaction⁴. Feeling of isolation due to lack of interaction with peers or faculty and lack of prompt feedback have been long been identified as difficulties of online learning. Students' personal factors, for example, prior knowledge of technology or the subject matter affected their learning online⁵. Considering these factors, the author of this study has made several changes in an upper-level engineering course offered in Fall 2020.

The objective of this study is to find if a 400-level engineering course, Engineering Hydraulics, can be taught as effectively as in F2F class. The class has been taught at XXX university only in F2F mode before the pandemic and synchronous online (SO) mode since the pandemic. To improve students' learning online, instructor has: (1) modified the class delivery by redesigning course interface including transparency in homework and adding quizzes to challenge students' understanding of the key concepts, (2) introduced various students' interaction tools, and (3) provided link or support for students' personal factors. The class performance was evaluated at the end of the semester and compared with previous semesters to evaluate effectiveness of

student learning in virtual learning environment. To determine students effective learning online, following two questions were posed:

- (1) Are the students effectively learning the modules and course objectives?
- (2) What is students' perception of virtual learning?

Methodology

The effectiveness of the students learning online is evaluated by comparing the class performance in the following three semesters:

- (1) Fall 2018 (18 students) - taught in traditional F2F mode.
- (2) Spring 2020 (28 students) - taught in traditional F2F mode and later transitioned into SO mode with onset of pandemic.
- (3) Fall 2020 (16 students) – taught in SO mode only.

Demography of the students were not collected for any of the semesters. Curriculum and course content of the class were the same for all the semesters. The class' grading rubric were also same in the three semesters except minor change in Fall 2020. Students' performances were evaluated on homework, midterms, and final exam in Fall 2018 and Spring 2020. In Fall 2020, new item - quizzes, was added to the grading rubric which replaced the homework grades in the previous semester. Students were still assigned homework, but they were not graded. Instead, students took quizzes based on homework. Quizzes were added to improve the students' module learning objectives as well as to familiarize students with the online testing system. In Spring 2020, when classes transitioned to SO mode, the students initially struggled to understand how to efficiently take exams online. During the F2F instruction mode, the students submitted their homework in person and exams were in class. For SO mode, homework was not collected, and all the quizzes and exams were taken online. The quizzes were asynchronous but time restricted and each quiz was opened for a week so that the students can take the quiz at their convenience. Midterms and finals were synchronous and proctored via Desire to Learn (D2L) learning management system.

Several changes were made in the course design while the traditional course lectures were delivered via Zoom video conferencing software using PowerPoint and the Microsoft OneNote as the main teaching tools. PowerPoints slides which were developed in previous semesters, were more animated in Fall 2020 to increase dynamics of students learning. Instructor used Microsoft OneNote to write down class examples and the lectures was recorded. The class examples, lecture materials in PowerPoint, and lecture videos were uploaded in the class website. This increased course accessibility and allowed students to focus more on course material/examples rather than students hurrying to write down lecture notes. In Fall 2020, transparency was added in the homework assignment. Transparent assignment design allows students to link the assignment to the module learning objectives by explicitly stating the purpose of the assignment, tasks that are required to complete the assignment successfully and criteria for successful completion. Studies found transparency in assignment design when taught virtually can promote students success⁶. Each of the module's objectives was also stated and linked with the course learning objectives.

Students experience of virtual learning environment and instructional design were evaluated by conducting a survey at the end of the Fall 2020 semester. Survey was posted on the class website and its purpose was clarified at the beginning of the survey question as well as in email before inviting students to participate in the survey. Students were given extra credit for their participation in the survey. There were 5 questions in the survey to determine students general view on learning online. These questions were:

1. Have you ever taken online class(s) before classes becoming virtual in COVID-19 pandemic?
If “YES”, did you like online classes?
2. What do you like about online classes?
3. What do you DON'T like about online classes?
4. What do you miss about F2F classes?
5. Do you think your grades (in general) have been impacted by online classes?

Questions 1, and 5 had fixed response choices and for questions 2 to 4, students could have open responses. They were also encouraged to add additional response/comments.

Survey also included 10 questions specific to this course and instructional design. These questions were:

6. Did you buy the textbook for this class?
7. What materials you have used to prepare for this class?
8. What helped you most to understand the topic better?
9. Have you ever watched the lecture videos that were uploaded after each class?
10. Was transparency in homework helpful to understand the purpose of the homework?
11. Do you think quizzes challenged you enough to understand the study material better?
12. In terms of getting a good grade (70% or better), what was the most challenging part in this class?
13. Have you interacted with anyone of your fellow classmates via chat or emails? (This question is just to see if the students have interacted with other students in a virtual classroom)
14. The Discussion questions/answers posted at the beginning of the semester was intended to know each other. Do you think it helped you to connect with your classmates?
15. Any suggestions that may help to improve this class for the future students?

The purpose of questions 6 to 9 is to evaluate what resources students found helpful to learn the course material. Responses to questions 7 to 12 are used to assess the student's perception on the instructional design and questions 13 and 14 are used to determine social factors in the course.

Results and discussion

The research questions are addressed individually.

Are the students effective in understanding the modules and class objectives?

For each module, students completed the homework and submitted their completed work during F2F class session, i.e., in Fall 2018 and Spring 2020. In SO mode (Fall 2020), students did not submit the homework but took a quiz online after they completed the respective homework. Each quiz had 2 or 3 questions like the questions in the homework. The students' performance is evaluated on their grades received from the quizzes. Figure 1 shows the grades received by students (in percentage) for the six-homework/ quizzes during the three studied semesters. Depending on the topic of the module, grades varied among the homework/quizzes as well as in the semesters. Although no specific trend is observed, class average for homework/quizzes in Fall 2020 is 72.4%, lower than that of the class average in Spring 2020 and Fall 2020 (80.3% and 82.7%, respectively). However, this difference in class average is not significant when compared in an unpaired t-test between Fall 2018 and Spring 2020 or Fall 2018 and Fall 2020 ($p > 0.05$).

Range of this homework/quiz data varied in the semesters (not shown). In Fall 2018 and Spring 2020, ranges are comparable (28.76 and 30.65, respectively) but, in Fall 2020, the range is 44.73, higher than both the previous semesters. Few conditions may have caused this difference in the class performance. Homework, when graded, was open book with known answer keys and students were assigned a week to complete and submit their work. On the contrary, quizzes are open book but time restricted with no answer keys or hint options. Quizzes also did not have retake option for the wrong answers.

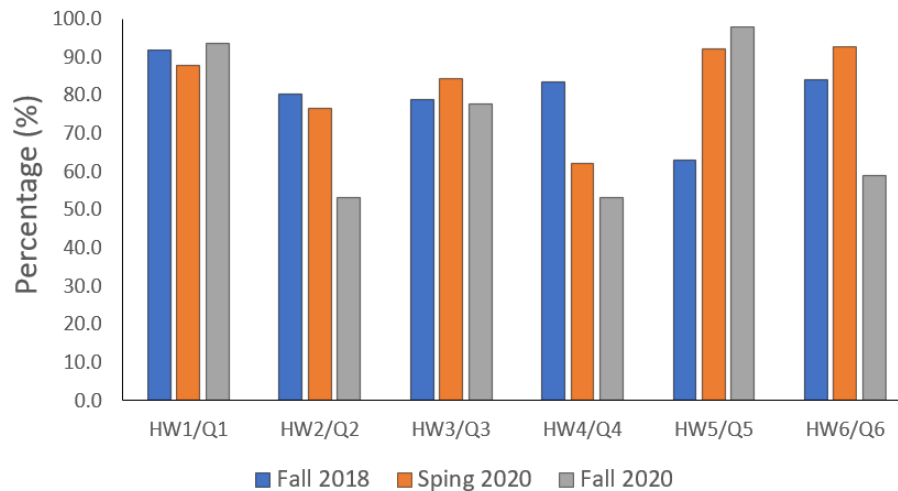


Figure 1. Comparison of points in percentage in homework/quizzes.

The midterms and final exams results are used to evaluate students' performances in the course learning objectives. Their performance was similar in Fall 2018 and Fall 2020, pre and during pandemic semesters, respectively as shown in Figure 2. In comparison to the Fall 2018 and 2020 performance, the students performed poorly in Spring 2020 when pandemic started (Figure 2). However, these overall lower grades in Spring 2020 cannot be attributed to students' study challenges of pandemic alone. Before the pandemic started, the average grade received in Midterm-1 is below than the grades received in Midterm-1 in the other two semesters, Fall 2018 and 2020 (Figure 2a). Similarly, in Spring 2020, the class performance continued to be lower in the Midterm-II and Final exams (Figures 2b, c). To understand the difference in Spring 2020

performance, student factors such as their overall readiness for this course, i.e., knowledge on course' prerequisite also need to be considered. However, this is not within the scope of this study. Comparison of students' performance in Fall 2020 with that of the previous semesters suggest this course can be taught effectively in both F2F and SO mode to meet module and class objectives.

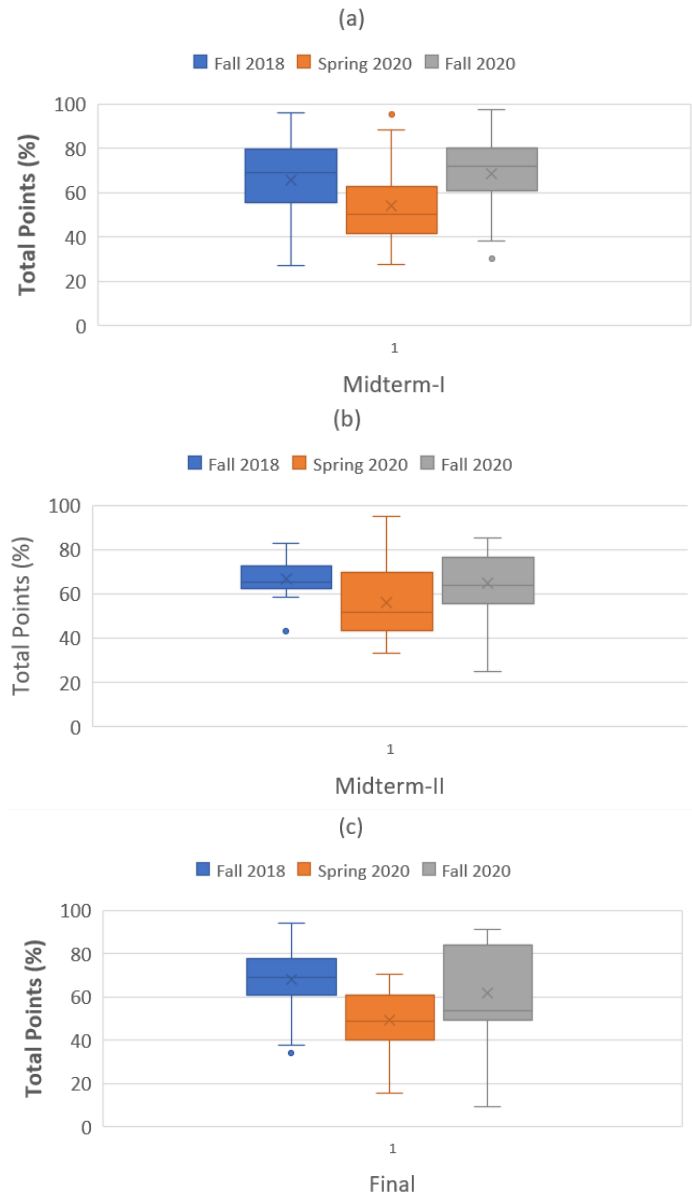


Figure 2. Comparison of students' performance in the exams

What is students' perception of virtual learning?

To understand students' perspective on online learning, survey questions 1 through 5 stated in the methodology section is analyzed. Students were given extra credit to participate in the survey

but 11 students from total of 16 students have responded to the survey. Results show that 64% of the respondents have taken online courses before pandemic but 71% of them liked their virtual classes. Regardless of the students who enjoyed online classes or not, all responded to question 2 (see Methodology section) stating what they like about virtual learning. Top reason for liking online classes is reduction of commute time and savings in fuel cost. No need to get dressed is also another reason to like online classes. Top reasons for not liking learning online is to be in front of the computer for longer time and missing friends. Students also expressed they feel less motivated to study and miss the academic environment when learning online. One student also noted that the lectures are less engaging in online environment.

Survey questions 6 to 15 were analyzed to learn students' perception specific to the course. Results show although 36% of students bought the textbook, 91% students primarily relied on lecture notes and instructor's video recordings to prepare/understand for the class. Self-study with instructor's notes helped them to understand the topic better. When asked if transparency in homework were helpful, 91% students responded positively. Most of the students (73%) found quizzes to be challenging enough to understand the concept. Although quizzes were only 10% of the total grade, 82% of the students considered quiz grades were the key factor affecting their grades. Few students suggested to add solutions and retake options for the quizzes will improve their learning and grades.

To encourage student's interaction, Discussion in the D2L platform was introduced and assignment on "introduce yourself to the class" was assigned. They received grades on completion of the assignment and additional credit was assigned for further participation through Discussion posts. However, students did not use the platform and communicated with students through emails and/or chats. Personal communication with students revealed that students were not used to the Discussion posts and felt lack of guidance on benefits of participation in Discussion posts other than assigned credit. However, they have expressed that the assignment "introduce yourself to the class" made them feel "who was who in the class" and they "like the idea" of student introduction. One student expressed such introduction is merely knowing a person and does not allow quality time with the peers like in F2F classes. To engage students in the class, Zooms' Breakroom feature which is widely used in virtual classrooms was also used during the first couple of lectures. However, the tool was not used often later in the semester due to time limit to complete the course content.

Conclusion

The results indicate that students in virtual classroom does not vary than the F2F classroom. However, incorporating the following can enhance online teaching and learning among students.

- In case of SO mode, to increase students' interaction, some class time should be dedicated for problem solving in Zoom's Breakrooms. To accommodate this dedicated time for students' interactions and completion of the course syllabus, some lectures can be recorded and taught in asynchronous mode. The asynchronous online lectures also can be incorporated when teaching F2F. This will allow traditional classes to be converted to flipped classroom model and increase classroom engagements.

- In SO mode, students' interactions and active participation in class can be increased by assigning separate points for class participation.
- Adding quizzes in addition to homework challenges students with the key concepts discussed in each module. Thus, online quizzes can be continued in both F2F and SO classes without sacrificing any class time for quizzes. However, allowing students to retake the quizzes can improve their grades. This will also help them better understand the concepts. For immediate feedback on quizzes, students should get quiz solution.
- The students primarily rely on lecture notes to prepare for the course in both F2F and SO mode. Although lecture notes and lecture videos are available to the students, students do not have access to numerous problems from the back of the chapters as many do not buy/collect the textbook or reference books. By increasing the homework problems will provide students opportunity to practice more. This will equally improve their performance in quizzes and exams.
- Online exams can reduce grading time for the instructors. But depending on the course, instructor may need to check the students work and provide partial credit and feedback for individual work.

There are many benefits of virtual learning. Therefore, inclusion of some online learning or testing features can also complement F2F teaching and learning among students. Past pandemic, these pedagogical methods can be implemented in F2F classes and enhance students learning outcomes. Finally, finding an instructional and course design that maximizes the effectiveness in students learning in either of the instruction mode for a specific course takes years of experience and inclusion of students' feedback.

References

1. Allen, I. E., & Seaman, J. (2013). *Changing Course: Ten years of tracking online education in the United States, 2013*. Retrieved from http://www.sloanc.org/publications/survey/pdf/changing_course.pdf
2. Jung, I., & Rha, I. (2000). Effectiveness and Cost-Effectiveness of Online Education: A Review of the Literature. *Educational Technology*, 40(4).
3. McLoughlin, C. (1999). Culturally responsive technology use: Developing an online community of learners. *British Journal of Educational Technology*, 30(3), 231-244.
4. Gunawardena, C. N., & Zittle, F. J. (1997). Social presence as a predictor of satisfaction within a computer-mediated conferencing environment. *American Journal of Distance Education*, 7 7(3), 8-26
5. Hill, J. R., & Hannafin, M. (1997). Cognitive strategies and learning from the World Wide Web. *Educational Technology Research and Development*, 45(4), 3
6. Winkelmes, M., Bernacki, M., Butler, J., Zochowski, M., Golanics, J., & Weavil, K.H. (2016). A teaching intervention that increases underserved college students' success. *Peer Review*, 8(1/2), 31-36.