Online Synchronous Delivery of Environmental Engineering During COVID-19 Pandemic: A Case Study on Perception and Attitude

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Abstract

Online synchronous/asynchronous delivery of courses is a time-demanding approach to web-based teaching and learning systems that is designed to engage students in investigations of authentic concepts/problems without coming to the pre-set classrooms two or three times a week. This paper presents perceptions and attitudes of students that have participated in a hybrid course in environmental engineering then suddenly converted to an on-line synchronous delivery due to COVID-19 in Spring 2020. The course, `Introduction to Environmental Engineering', was developed as an on-line course for Civil and Environmental Engineering program students but taught as a face-to-face course and as a hybrid for several semesters. In the hybrid course set up, all the quizzes and homeworks were on-line while the midterm and final exams were in-class. However, for Spring 2020, the final exam was online, and for Summer and Fall 2020 both midterm and final exams were online due to COVID-19 adjustment. At the very end of the semesters, an on-line anonymous survey was conducted with five questions to understand the students' perceptions and attitudes towards exam taking options and learning environment. Students' perceptions and attitudes about online synchronous delivery approach compared to hybrid delivery approach appeared to be not favorable as a learning environment. Students preferred take-home exams over other options. Additionally, they learned less in online delivery than that of hybrid delivery.

Keywords

Environmental engineering, COVID-19 adjustment, Students' perception and attitude, online synchronous/asynchronous course delivery.

Introduction

Online and/or internet-based teaching and learning is becoming popular and was a dire need during pandemic. The relatively recent advancement of Learning Management Systems (LMS), such as blackboard, eCollege, Moodle, and WebCT, offer lectures via MS Teams, Zoom and other platforms in the undergraduate setting in educational institutions have made it easy to provide online user education, that is, web-based augmentation to traditional (face-to-face) classroom instruction[1]. This on-line, hybrid or mixed delivery approach lets instructors combine the advantages of online class learning with the benefits of face-to-face interaction with relatively

limited technological sophistication on their part[2]. The addition of a hybrid/on-line approach to the existing in-class lecture-centric environmental engineering course would not reduce the quality of teaching and learning as well as would be welcomed and well received by students[3,4]. Preliminary reports suggest that the hybrid approach holds significant benefits for students and instructors, regardless of their level of technological expertise[4,5] and regardless of whether the classroom is hard-wired for live Internet access[6]. Despite frequent use of an LMS for course administration purposes (content and lecture delivery), the faculty do not appear to be harnessing the full pedagogical potential of web-based augmentation via LMSs. The possible potential of LMS tools along with other on-line and mobile technology flatforms to increase course administration/lecture delivery efficiency and enhance learning in traditional settings is an important educational issue that must be fully explored from both faculty and student perspectives[7,8,9]. However, combining multiple modalities of on-line content with a *pot pouri* of in-class learning exercises that appeal to several learning styles may precipitate higher overall learning outcomes[10].

This study was designed mainly to answer a question: What are the students' perceptions and attitudes about the online synchronous course delivery along with online exam-taking option and online platform as a learning environment? To answer this question, an objective was formulated to understand the students' perceptions and attitudes about online synchronous course delivery along with online exam-taking options and online as a preferable learning environment for future environmental engineering courses. The objective was accomplished via an anonymous online survey and with statistical analyses of the collected data. Although teaching hybrid or online courses may increase time demands and, in some cases, result in a loss of control, many faculties enjoy this approach because it allows for significant flexibility and benefits in instruction. Due to COVID-19 in March 2020 the course delivery options had to change to on-line synchronous and all the exams had to administer on-line. The overall goal of this study was to understand the overall effect of COVID-19 pandemic on students' perceptions and attitude about an online synchronous course delivery option for an introductory environmental engineering course.

The terms Face-to-Face, Hybrid, HyFlex (Hybrid-flex), Online synchronous/asynchronous have been used throughout the manuscript. The following definitions of the terms are provided for clarification.

Face-to-Face - A traditional higher education **course** that occurs with the learner and the instructor physically located in the same place at the same time[1]. A **course** in which zero to 29% of the content and instruction is delivered online[2]. A **course** which delivers at least 80% of its content in person[3].
Hybrid - A hybrid approach to course delivery combines face-to-face classroom instruction with online activities. This approach reduces the amount of seat time in a traditional face-to-face course

[1] Learn more in: Promoting Digital Teaching and Learning: Faculty Development Options for Distance Learning Instructors
[2] Learn more in: The Relationship between Individual Student Attributes and Online Course Completion
[3] Learn more in: Doctoral Student Experiences in an Online Degree Program: A Review of the Distance Education Literature and an Exploration of Their Perspectives

and moves more of the course delivery online. During classroom instruction time, students can be engaged in authentic, collaborative learning experiences. The online components can include multimedia-enhanced content and channels for ongoing discussion. The best practices and resources on this site will primarily focus on hybrid courses that utilize classroom sessions with or without a video conferencing component[4].

HyFlex - Short for "hybrid flexible", HyFlex learning is a variation of the hybrid programs we have come to know. It includes in-person, synchronous online *and* asynchronous online options for every course. According to Dave Lungren, vice president of content solutions at College Education, universities have an opportunity to evolve into the University of Tomorrow through the flexibility offered by this modality[5].

Online synchronous/asynchronous - Both are **primarily delivered online, accessible via online course modules** from your own computer or laptop. Both could be completed from anywhere. Both are flexible options, designed to help all kinds of different students earn their degrees on their own terms. Both synchronous and asynchronous learning options, in some cases, might even be offered by the same program. However, beyond that, they can be a little different. Synchronous learning is when classes **occur on set schedules and time frames**. Students and instructors are online at the same time in synchronous classes since lectures, discussions, and presentations take place at specific hours. All students must be online at that exact time in order to participate in the class. Asynchronous classes let students **complete their work on their own time**. Students are given a timeframe – it is usually a one-week window – during which they need to connect to their class at least once or twice. The good news is that in asynchronous courses, you could hit the books no matter what hour of day (or night)[6].

It is the author's reflection and opinion that depending on the type of course, project-based or problem-based learning (PBL) option with alternative evaluations processes[11] may be introduced and implemented in a situation during COVID-19 or in the future semesters to maintain the levels of teaching and learning same as before COVID-19 era. Studies conducted by several researchers[12,13,14,15,16,17,18,19,20] elaborated the optimum group forming strategy, content design, effectiveness measurement, implementation framework, and other procedures for optimum learning that were acceptable to students and instructors. To maintain the quality of teaching and learning same as before COVID-19 era appropriate courses have to be designed by closely following procedure and guidance available in the literature and offered accordingly.

Study Methodology

The instrument used to conduct this study was an online survey. To understand the effect of COVID-19 pandemic on the perceptions and attitudes of students an on-line anonymous survey was conducted at the end of the semester with five questions to compare the students' learning environment in the environmental engineering course, with 50% in-class lecture (hybrid) with 100% online synchronous offering along with online midterm and final exams. The survey questions are presented in Figure 1. The first two questions were asked to understand the students'

[4] https://sites.psu.edu/hybridlearning/what-is-hybrid/

[5] https://collegiseducation.com/news/online-learning/hyflex-course-model/

[6] https://www.elearners.com/education-resources/degrees-and-programs/synchronous-vs-asynchronous-classes/

perceptions and attitudes about the course content and alignment delivered with online synchronous approach although no changes were made in the course content and other alignment. The third question was asked to introduce an alternative assessment process using technologies and to understand the students' perceptions and attitudes about the challenges of conducting online closed book exam using of lockdown browser and webcam as most of the traditional students were not familiar with these technologies. The fourth and fifth questions were asked to understand the students' perceptions and attitudes about several test taking options (alternative assessments) and levels of learning.

Q.1. Did tests reflect material covered in the class? □ Yes □ No

Q.2. Is there a good agreement between the course outline and the course content?
□ Yes □ No

Q.3. Do you like the On-line Midterm and Final Exam Through D2L using Lockdown Browser and Webcam (5 being the highest)?
O 1 O 2 O 3 O 4 O 5

Q.4. Do you want the Midterm and Final Exam be as?

- **Option 1**: Get the questions from D2L, print it, take it, scan, and submit it in Submission Folder without proctoring
- **Option 2:** Take home exam for a day or two
- **Option 3:** 100% online with Multiple Choice Questions like a quiz
- **Option 4:** 100% online and get the questions in D2L like a quiz, take the exam like quiz and do the detail work in papers proctoring with webcam, scan the papers in pdf and submit the papers in submission folder

Q.5 What kind of learning perception you have due to the change of the course from face-to-face to on-line due to COVID-19?

- **Option 1:** Learned same as hybrid/face-to-face
- **Option 2:** Learned more in on-line than hybrid/face-to-face
- **Option 3:** Learned less in on-line than hybrid/face-to-face

Figure 1: Survey questionnaire for online offerings of Environmental Engineering

The data collected through the online survey was analyzed to understand students' perceptions and attitudes about the course content and alignment, online exams using technologies, the exam-taking alternatives, and the degree of learning. The data was collected for Spring, Summer, and Fall 2020 semesters that represent the data during COVID-19 pandemic (online delivery option)

and compared it with Spring, Summer, and Fall 2019 semesters that represent the data for hybrid delivery option only for first two questions. The last four questions were not included in the survey for Spring, Summer, and Fall 2019 semesters. There was a total of 37 students enrolled in Spring 2019, 34 in Summer 2019, 35 in Fall 2019, 48 in Spring 2020 (2 sections), 33 in Summer 2020, and 27 in Fall 2020 semesters. Out of 214 enrolled students overall, only 123 (about 57%) students participated in the survey for all 6 semesters. Twenty-four students (about 65%) participated in the survey for Spring 2019, 9 (about 26%) for Summer 2019, 15 (about 43%) in Fall 2019, 29 (about 60%) in Spring 2020, 23 (about 70%) in Summer 2020, and 15 (about 56%) in Fall 2020. HyFlex delivery mode was followed in Fall 2020. Overall, 91 students (about 43%) did not participated in the survey because the survey was not mandatory, and no incentive/grade points was given to participate in the survey. The analysis of data was performed with simple statics and with excel for Goodness-of-fit tests such as ANOVA, χ^2-tests, student *t*-Tests, and *F*-Tests, as necessary. The results of the data analysis are illustrated in the following section and in the Figure 2 through Figure 6. Please note that some of the responses to questions/options/choices, as seen in the Figures, might not sum up to 100% as few students did not respond to all questions or selected all options or choices.

Results and Discussions

Overall, about 91% of the participants agreed with Q.1 that is the test materials reflected what was covered in the class and about 9% did not agree on that (Figure 2). The participants were well represented by the fact the before and during COVID-19 situation. Among the individual semester about 96% agreed that tests materials reflected what was covered in the class in Summer 2020, followed by Spring 2020 (93%), Spring 2019 (92%), Summer 2019 (89%), and both Fall 2019 and Fall 2020 (87%).

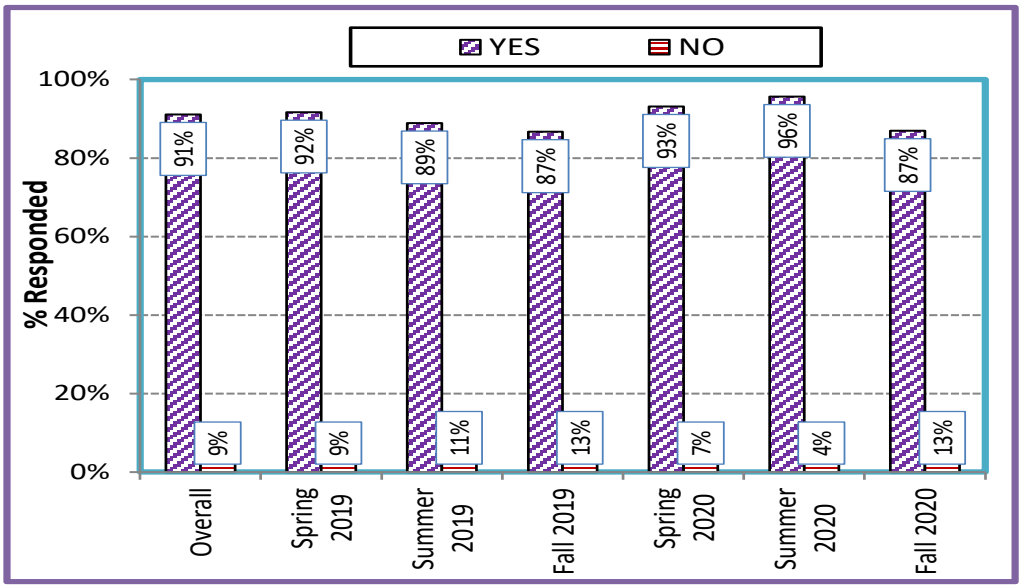

Figure 2: Distributions of responses for Q.1

As shown in Figure 3, overall, about 94% of the students, participating in the survey, agreed with Q.2 that is there is a good agreement between the course outline and the course content. Among the individual semester 100% participants agreed that there was a good agreement between the course outline and the course content both in Spring and Summer 2019, followed by both Fall 2019 and Spring 2020 (93%), and both Summer and Fall 2020 (91%). It appeared that very similar trends were observed every semester as well as the combined for all semesters (overall). In Fall 2020, the course offered as HyFlex (hybrid-flexible) that is 50% students were in-class face-to-face and 50% students were online synchronous. The HyFlex option was adopted to maintain the 6 ft social distancing due to COVID-19 restrictions. Therefore, students' perception and attitude about the course content and the alignment were consistent and similar to some extent for hybrid and online deliveries.

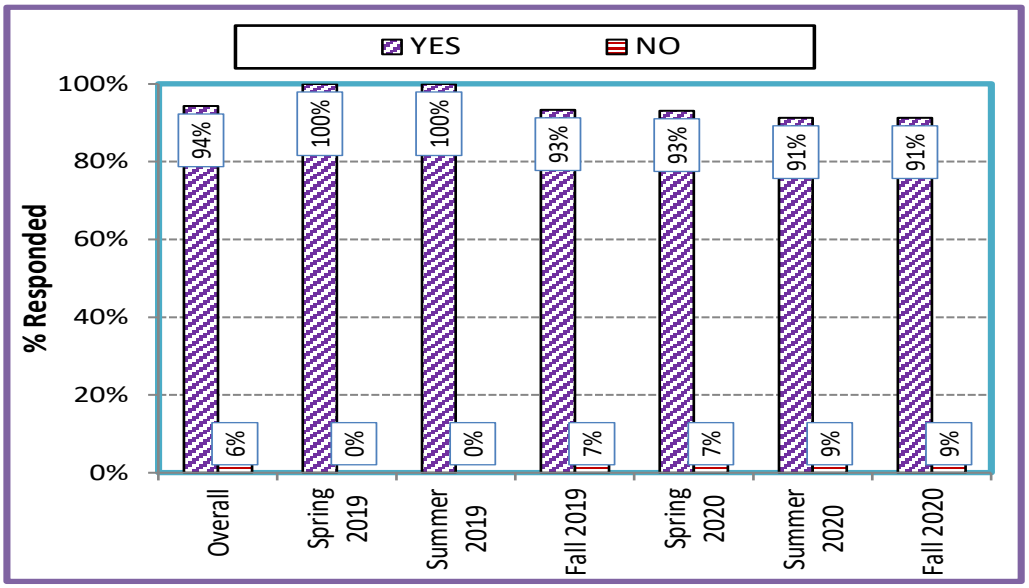

Figure 3: Distributions of responses for Q.2

Based on the responses to Q.3 as to how the participants liked taking online midterm and final exams through D2L using Respondus Lockdown Browser and Webcam, overall, about 12% of the participants chose "5" scale, 16% chose "4" scale, 33% chose "3", 9% chose "2" scales, and 23% chose "1" scale. About 7% of the participants omitted this question. The weighted average of the choice was about 2.83 for overall, no values for Spring, Summer, and Fall 2019 (as this question was not part of these semesters), 3.00 for Spring 2020, 2.58 for Summer 2020, and 2.86 for Fall 2020. It appeared that online exams with lockdown browser and webcam was not that popular and acceptable option as the lockdown browser and webcam issues could be cumbersome to make them work in computer based on the individual knowledge of computer operations and software knowledge. The distribution of Q.3 responses is presented in Figure 4. Based on the choice distributions, it was seen that majority of the participants would not like taking online exams due to the underlying issues of lockdown browser and webcam. Although, the participants were well

represented before COVID-19 and during COVID-19 situations in Q.1 and Q2 (Figure 2 and Figure 3), the distribution of choices for this question were completely different.

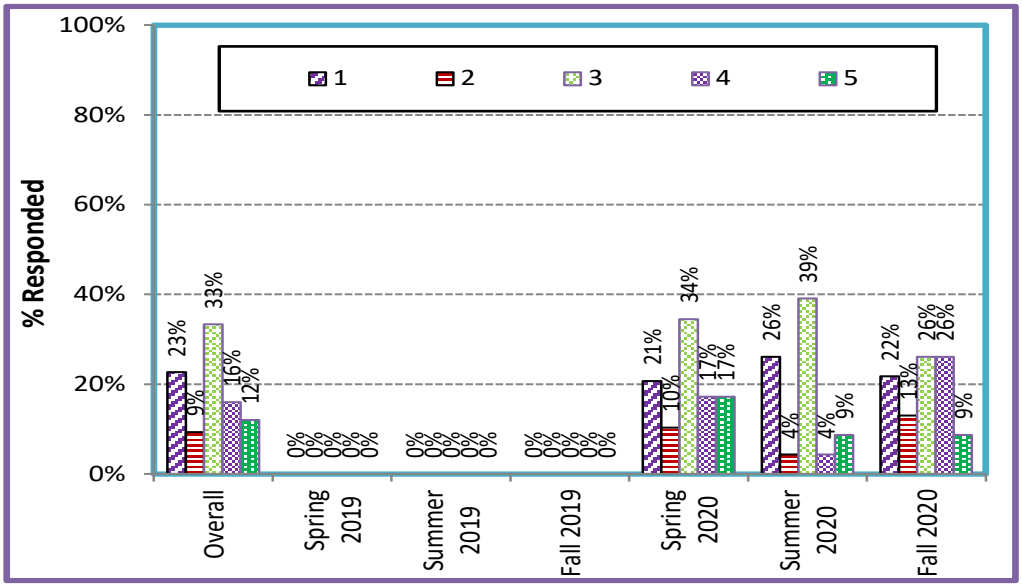

Figure 4: Distributions of choices of the participants for Q.3

In response to Q.4 as to see the distribution of participants' choices to take the midterm and final exams as per the four choices, overall 23% of the participants chose "Option 1: Get the questions from D2L, print it, take it, scan and submit it in submission folder without proctoring", 37% chose "Option 2: Take-home exam for a day or two", 12% chose "Option 3: 100% online with Multiple Choice Questions like a quiz", and 23% chose "Option 4: 100% online that is get the questions in D2L like a quiz, take the exam like quiz and do the detail work in papers proctored using webcam, scan the papers in pdf and submit the papers in submission folder". About 5% of the participants omitted this question. The distribution of Q.4 responses is presented in Figure 5 and it is clear from this Figure that option 2 (take-home exam) seemed to be preferable compared to other 3 options. The choice distributions for individual semester were similar and somewhat agreed with the overall distributions.

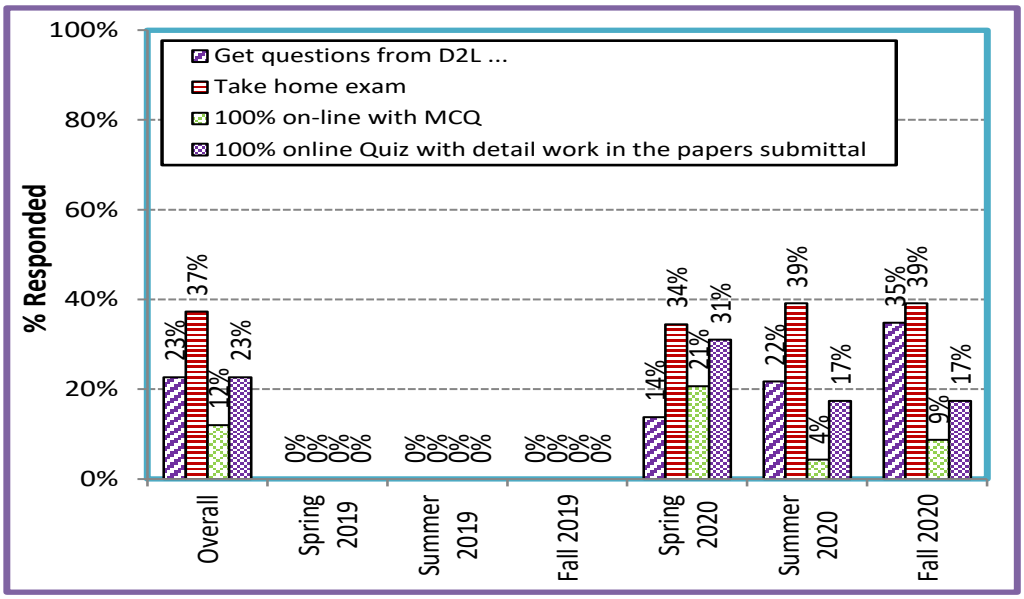

Figure 5: Distributions of responses of the participants for exam delivery options (Q.4)

To see the variations of the four options for spring 2020, summer 2020, and fall 2020 (spring 2019, summer 2019, and fall 2019 were not included as they were not a part of the remote offering semester), a chi-square goodness of fit test was performed to validate or reject the null hypothesis "no differences among semester to semester and among four exam delivery options". The chi-square test data is shown in Table 1. From the chi-square test, a *p*-value of ***0.4446*** was obtained which is greater than both 0.05 (α = 5%) and 0.01 (α = 1%). A χ^2-value of ***5.8119*** was also obtained. For a degree of freedom of 6, the critical values for χ^2 are 12.6 (for α = 5%) and 16.8 (for α = 1%). The chi-square (χ^2) value is less than the critical values of both the significance levels. So, the null hypothesis cannot be rejected and concluded that "no significant differences in the semester to semester and among the four options exams". This means, similar trends are observed in the semester to semester and for all four exam taking options. It is clear from the response data that option 2: take-home exam received more responses than the other three options; however, statistically it is not different from the other three options.

Table 1: Chi-square Goodness-of-fit test for Q.4 data

Semester	**Observed Values**					**Expected Values**				
	Option 1	**Option 2**	**Option 3**	**Option 4**	**Total**	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Total**
Spring 2020	4	10	6	9	**29**	5.438	11.479	4.229	7.854	**29**
Summer 2020	5	9	1	4	**19**	3.563	7.521	2.771	5.146	**19**
Fall 2020	5	9	1	4	**19**	3.970	7.940	2.269	4.821	**19**
Total	**14**	**28**	**8**	**17**	**67**	**14**	**28**	**8**	**17**	**67**
p-value = 0.4446; χ^2-value = 5.8119; DF = 6, χ^2-critical = 12.6 (for α = 5%) and 16.8 (for α = 1%)										

To verify it more, a single factor ANOVA was performed, and the data is presented in Table 2. Since $F < F_{critical}$ (in this case, 4.0611 < 4.062), therefore, the null hypothesis cannot be rejected and concluded that "no significant differences in the semester to semester and among the four options exams". The means of the four exam taking option populations are all statistically equal. Therefore, we may not need a *t*-Test to compare the means of each pair.

Table 2: ANOVA analysis for Q.4 data

Group	Sum	Count	Average	Variance	*Source*	*SS*	*DF*	*MS*	*F*	*p-value*	*F-crit*
Option 1	17	3	5.67	4.33	*Between group*	*61*	*3*	*20*	*4.061*	*0.0501*	*4.062*
Option 2	28	3	9.33	0.33	*Within group*	*40*	*8*	*5.0*	---	---	---
Option 3	9	3	3.00	7.0	*Total*	*101*	*11*	---	---	---	---
Option 4	17	3	5.67	8.33							

Based on the responses to Q.5 as to see the distribution of participants' choices of learning the materials as per the three choices, overall, 35% of the participants chose "Option 1: Learned same as hybrid/face-to-face", 15% chose "Option 2: Learned more on-line than hybrid/face-to-face", and 45% chose "Option 3: Learned less on-line than hybrid/face-to-face". About 5% participants omitted this question. The distribution of Q.5 responses is presented in Figure 6 and it is obvious from this figure that option 3 that is learned less on-line than hybrid/face-to-face seemed to be prominent compared to other 2 options. The choice distributions for individual semester were similar and somewhat agreed with the overall distributions.

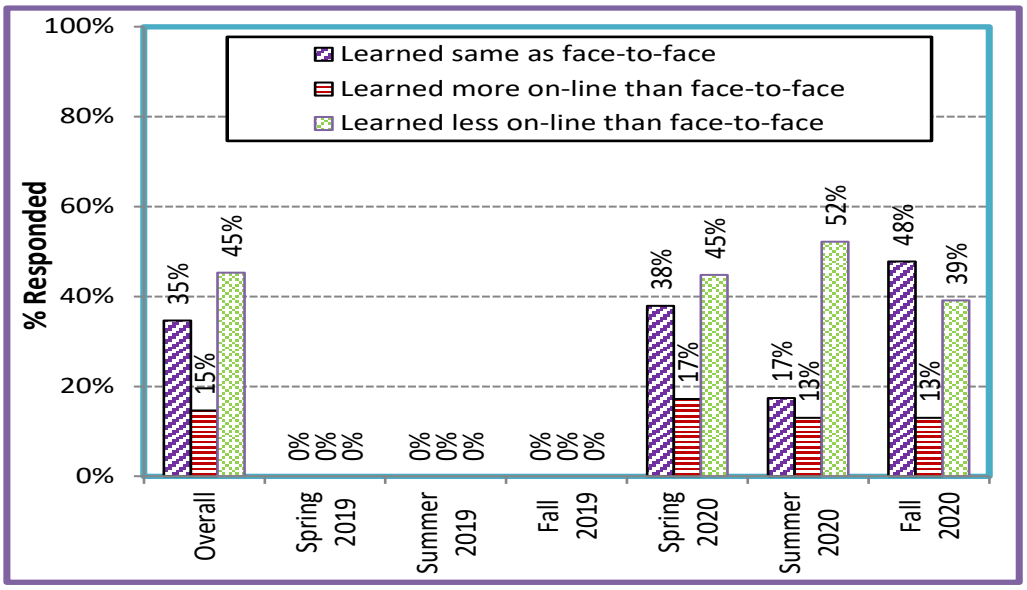

Figure 6: Distributions of responses of the participants for learning materials options (Q.5)

To see the variations of the three learning options for Spring, Summer, and Fall 2020 (Spring, Summer, and Fall 2019 were not included as these semesters were not a part of the online synchronous or HyFlex delivery), a chi-square goodness of fit test was performed to validate or reject the null hypothesis "no differences among semester to semester and among three learning options". The chi-square test data are shown in Table 3. From the chi-square test, a *p*-value (0.4692) is greater than that of both significance levels and the χ^2-value (3.5573) is less than the critical values of both the significance levels. So, the null hypothesis cannot be rejected and concluded that "no significant differences in the semester to semester and among the three learning options". That means, similar trends were observed in the semester to semester and for all three learning options. However, it is obvious from the data that option 3: learned less online than hybrid/face-to-face received more responses than the other two options.

Table 3: Chi-square Goodness-of-fit test for Q.5 data

Semester	**Observed Values**				**Expected Values**			
	Option 1	**Option 2**	**Option 3**	**Total**	**Option 1**	**Option 2**	**Option 3**	**Total**
Spring 2020	11	5	13	**29**	10.620	4.493	13.887	**29**
Summer 2020	4	3	12	**19**	6.958	2.944	9.099	**19**
Fall 2020	11	3	9	**23**	8.423	3.563	11.014	**23**
Total	**26**	**11**	**34**	**71**	**26**	**11**	**34**	**71**
p-value = 0.4692; χ^2***-value = 3.5573; DF = 4,*** χ^2***-critical*** = 9.49 (for α = 5%) and 13.3 (for α = 1%)								

To verify this scenario further, a single factor ANOVA was performed, and the data is presented in Table 4. Since $F > F_{critical}$ (in this case, 6.197 > 5.143), therefore, the null hypothesis is rejected. Therefore, the populations of the three learning options are NOT statistically equal. Since χ^2-test and ANOVA did not agree, a *t*-Test was run to compare each pair of means for further verification. From the two-tail *t*-Test, there was no significant differences in between Option 1 and Option 2 as well as Option 1 and Option 3. However, there seemed to be a significant difference in between Option 2 and Option 3 that means none to very few students learned more in online than hybrid/face-to-face.

Table 4: ANOVA analysis for Q.5 data

Group	**Sum**	**Count**	**Average**	**Variance**	***Source***	***SS***	***DF***	***MS***	***F***	***p-value***	***F-crit***
Option 1	26	3	8.67	16.33	*Between group*	*91*	*2*	*45.4*	*6.197*	*0.0347*	*5.143*
Option 2	11	3	3.67	1.33	*Within group*	*44*	*6*	*7.33*	---	---	---
Option 3	34	3	1.33	4.3	*Total*	*135*	*8*	---	---	---	---

The summary of the goodness-of-fit test analyses is listed in Table 5 for four different types of data. Based on the goodness-of-fit tests and ANOVA it was apparent that students' perception and attitude about the four different exam-taking options did not differ significantly although direct responses showed differently. However, ANOVA analysis showed that three different options of

learning statistically differed significantly although direct responses showed differently. Based on the t-Tests, there seemed to be a significant difference in between Option 2 and Option 3 that means none to very few students learned more in online than hybrid. Therefore, the three learning option means are NOT statistically equal.

Table 5: Summary of Goodness-of-fit test analysis

Data Type: χ^2-Test	***p-value***	***χ^2-value***	***DF***	***Critical Value***		**χ^2-Test Comment**
				0.05	***0.01***	
Students' choices for four exam options (Survey Q.4 –Table 1)	0.4446	5.8119	6	12.6	16.8	The *p*-values are greater than both 0.05 (α = 5%) and 0.01 (α = 1%) and χ^2-values are less than the corresponding critical values. Therefore, null hypothesis cannot be rejected and concluded that "no significant differences in the semester to semester and among four exam taking options and three learning options."
Students' choices for three learning options (Survey Q.5 – Table 3)	0.6622	2.4024	4	9.49	13.3	
Data Type: *t-Test*	***p-value***	***t-value***	***DF***	***$t_{Critical}$ (two tail)***		***t*-Test Comment**
Q.5 Learning Options: Option 1 vs. Option 2 Option 2 vs. Option 3 Option 1 vs. Option 3	 0.0542 0.0050 0.3670	 0.1080 -5.578 -1.016	 4 4 4	 2.7764 2.7764 2.7764		Based on the *t*-Test data, there was no significant differences in between Option 1 and Option 2 as well as Option 1 and Option 3. However, there seemed to be a significant difference in between Option 2 and Option 3 that means none to very few students learned more in online than hybrid. Therefore, the three learning option means are NOT statistically equal.
Data Type: *ANOVA*	***p-value***	***F-value***	***DF***	***$F_{critical}$***		***ANOVA* Comment**
Students' choices for four exam options (Survey – Q.4 – Table 2)	0.0501	2.1538	3	6.5914		Since $F < F_{critical}$ (in this is the case, 2.1538 < 6.5914), therefore, the null hypothesis cannot be rejected. The means of the four exam taking option populations are all statistically equal.
Students' choices for three learning options (Survey – Q.5 – Table 4)	0.0347	6.1970	2	5.1432		Since $F > F_{critical}$ (in this case, 6.1970 > 5.1432), therefore, the null hypothesis is rejected. The means of the three learning option populations are NOT statistically equal that coincided with the corresponding *t*-Test findings.

Study Limitations

The main source of bias for this study could be the fact that the author was the only person who designed this study, conducted the survey, collected the semester end data, and analyze the data. The evident conflict of interests and potential unconscious bias could genuinely affect the validity of this study. The other limitations could be the missing part of question 4 for an oral assessment (another acceptable alternative evaluation) option and the number of subjects used to test the concept and hypothesis Several other subjects in engineering field along with other faculty collaboration could make the study more reliable and conclusive.

Summary and Conclusions

In this paper, an effort was made to assess the perceptions and attitudes of students, which influence the learning environment as well as the quality of teaching and learning in environmental engineering for the changes in the course offerings due to COVID-19 pandemic at the middle of Spring 2020. The course, `Intro to Environmental Engineering', was developed and approved as a fully on-line and taught as a hybrid and face-to-face for several semesters. In the hybrid delivery option, all of the quizzes and homeworks were on-line and only the midterm and final exams were in-class. At the middle of Spring 2020, the course delivery was changed to an online synchronous due to COVID-19 situation. For the same reason, the course was offered online synchronous in Summer 2020 and HyFlex (hybrid-flexible to maintain social distancing) in Fall 2020. In spring 2020, the final exam and in Summer and Fall 2020 both the midterm and final exams were conducted online using Respondus lockdown browser and webcam. At the very end of the semester, an online anonymous survey was conducted with five questions to assess the effectives of online synchronous delivery option and to understand the students' perception and attitude about online exams and content learning. Although students agreed with the course content and alignment, their perception and attitude about taking online exam using technologies (respondus lockdown browser and webcam) and learning in online environment appeared to be not favorable. Students' obvious choice was take-home exam and they expressed that they learned less in online delivery than that of hybrid delivery. It is the author's opinion and reflection that PBL delivery with alternate evaluation processes such as take-home exam option, as preferred by the students in this study, along with other alternative evaluation processes such as oral evaluation, can be adopted to maximize and augment the students learning that may improve the levels of students' performance for the future semesters.

Disclaimer

The partial data and results, especially up to Summer 2020 has been submitted in a journal that is under review at this time.

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