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Hybrid Delivery of Environmental Engineering: Perception, Attitude, and Assessment

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Abstract

On-line or hybrid offering of courses is a time-demanding approach to web-based teaching and learning that is designed to engage students in investigations of authentic concepts/problems without coming to the pre-set class rooms two or three times a week. This paper presents perceptions and attitudes of students that have participated in a hybrid course in environmental engineering as well as an assessment of the hybrid approach on the quality of teaching and learning compared to face-to-face approach of the same course. The course, `Introduction to Environmental Engineering', was developed as an on-line course for Civil Engineering program students, but taught as a face-to-face course and as a hybrid course for several semesters. In the hybrid course set up, all of the quizzes and homeworks were on-line and only the midterms and final were in-class. At the very end of the semester, an on-line anonymous survey was conducted for only hybrid offerings with six questions to compare the students' learning environment in the environmental engineering course, with 50% in-class lecture and in-class midterms and final, with the traditional complete lecture-centric course. Students' perceptions and attitudes about hybrid approach compared to face-to-face approach appeared to be favorable and acceptable as a learning environment for future environmental engineering courses. Although it could not be proved by statistical data analysis that hybrid option improved the quality of teaching and learning, the assessment of the study indicates that hybrid approach did at least maintain the same quality.

Introduction

Web-based teaching and learning such as on-line or hybrid is becoming popular and time-demanding. The relatively recent advent of Learning Management Systems (LMS), such as blackboard, eCollege, Moodle, and WebCT, in the undergraduate setting in educational institutions has made it easy to provide on-line user education, that is, web-based augmentation to traditional (face-to-face) classroom instruction[1]. This 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]. Preliminary reports suggest that the hybrid approach holds significant benefits for students and instructors, regardless of their level of technological expertise[3,4] and regardless of whether the classroom is hard-wired for live Internet access[5]. Despite frequent use of an LMS for course administration purposes, the faculty do not appear to be harnessing the full pedagogical potential of web-based augmentation via LMSs such as blackboard. The possible potential of LMS tools to increase course administration efficiency and enhance learning in traditional settings is an important educational issue that must be fully explored from both faculty and student perspectives[6]. However, combining multiple modalities of on-line content with a *pot pouri* of in-class learning exercises that appeal to a number of learning styles may precipitate higher overall learning outcomes[7].

Although teaching hybrid or online courses may increase time demands and, in some cases, result in a loss of control, many faculty enjoy this approach because it allows for significant flexibility and benefits in instruction. A hybrid approach may improve the efficiency of

classroom management, especially for large classes[8], increase the degree of student-led learning[9], improve student morale and overall satisfaction of the learning experience[10], enhance information skills acquisition and student achievement[11], and may even reduce student withdrawals and absenteeism[12]. In light of such positive effects, not to mention the cost efficiency of a hybrid approach—an attractive feature for institutions faced with shrinking budgets and classroom space—Brown[13] posits that, in the future, institutions will design most courses by the 90–10 Rule Q (p. 22). In other words, a mix of face-to-face and online instruction (somewhere between 90% and 10% and 10% and 90%) will be superior to either 100% face-to-face or 100% online courses[6]. The findings of a study show that online learning can be as effective as face-to-face learning in many respects in spite of the fact that students in online programs may be less satisfied with their experience than students in more traditional learning environments[14]. In a study, participants who had more experience with the Internet indicated significantly higher perceptions toward the Web-based distance learning activities/assignments portion of the hybrid program[15]. This study focuses on the hybrid offerings of introductory environmental engineering course to understand the perceptions and attitudes of students as a learning environment for future environmental engineering courses.

Study Methodology

At the end of the semester, an on-line anonymous survey was conducted only for the hybrid offerings with six questions to compare the students' learning environment in the environmental engineering course, with 50% in-class lecture (hybrid) and in-class midterms and final exams, with the traditional complete lecture-centric and fully on-line course. The questions are presented in Figure 1. The data were collected for four semesters, Fall 2013, Fall 2014, Summer 2014, and Fall 2015. There are a total of 170 students enrolled in the course during these four semesters and 131 students participated in the survey. Thirty nine (39) students did not take the survey due to the fact that the survey was not mandatory and no incentive/point was given to take the survey. The analysis of survey data are illustrated in Figures 2 through 6. Please note that some of the responses to questions/options/choices, as seen in the Figures, might not sum up to 100% as a few students did not respond to all questions or options or choices.

Q.1. Did you take any hybrid or on-line class before? □ Yes □ No

Q.2. Are you male/female?

O Male O Female

Q.3. What is your class status?

O Senior O Junior O Sophomore

Q.4. Do you like the hybrid class with on-line quizzes and homeworks and in-class tests (5 being the highest)?

O 1 O 2 O 3 O 4 O 5

Q.5 Do you like this course to be offered as

- Face-to-face that is meeting 3 hours a week in-class with all the quizzes, homeworks, and tests are in-class?
- Hybrid that is meeting 1.5 hours once a week with all the quizzes and homeworks are on-line and all the tests are in-class (the way you are taking it now)?
- Completely on-line that is no meeting in-class with all the quizzes, homeworks, and tests are on-line?

Q.6 Please provide any comments/suggestions/concerns about hybrid/on-line/face-to-face course offerings that you may have.

Figure 1: Survey questionnaire for hybrid offerings of Environmental Engineering

Data Analysis, Results, and Discussion

About 77% of the students that were enrolled in the hybrid course participated in the survey. Based on the responses to Q.1, overall about 47% took either a hybrid or on-line course before, 47% did not take any kind of on-line or hybrid course, and 6% did not respond before they took the environmental engineering (Figure 2). The participants were well distributed with and without any exposure of on-line or hybrid learning. Overall it was almost the same for both the group with and without prior exposure to the on-line and hybrid courses although some semesters are showing a little difference. This could be due to the fact that everyone now-a-days are familiar with internet either through computer or smart phone. This observation is supported in a study by Koohangand Durante[15]. However, the study did not separate the effect of prior exposure to hybrid or on-line courses in the hybrid learning because the survey was anonymous and on-line using LMS where the responses from different group cannot be separated without additional questions.

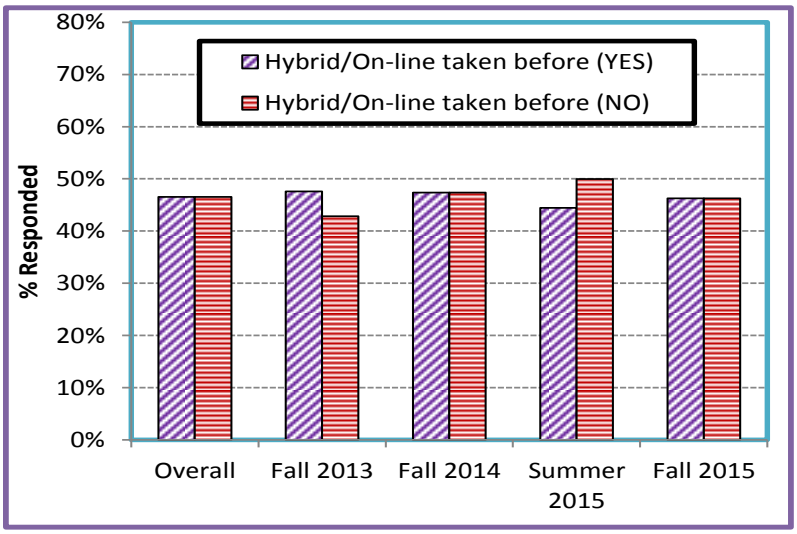

Figure 2: Distributions of responses for prior exposure to on-line or hybrid course

As shown in Figure 3, overall about 81% of the students participating in the survey were male, 15% were female, and 4% did not respond. This is the typical distribution of gender in the classes that the university has now-a-days. It appears that similar trends are observed every semester in terms of male and female distributions in the class as well as the overall. Please note that the study did not look into the effect of gender in the hybrid learning due to the same reasons mentioned earlier.

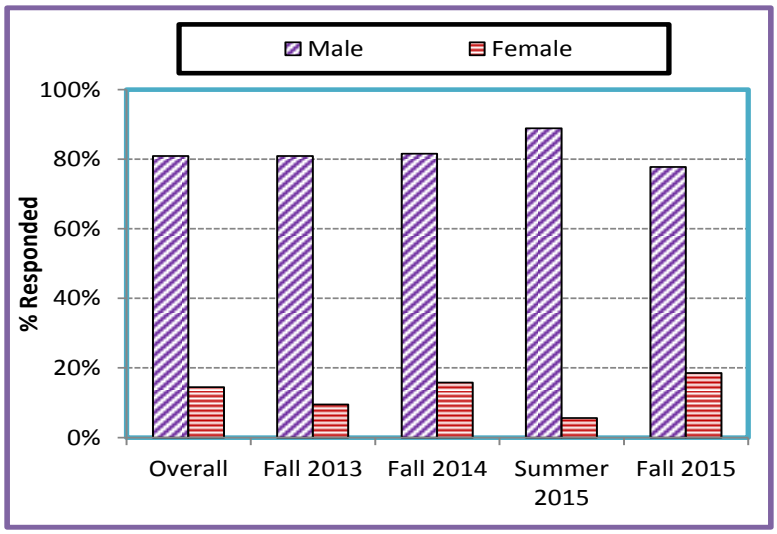

Figure 3: Distributions of male and female participants in the survey

Overall 51% were senior and 46% were junior with no sophomore (Figure 4) taking this course as they cannot not meet the prerequisite requirements at sophomore level. Since the fluid mechanics is the prerequisite for this course, most of the students earn enough credit to be designated either as junior or senior when it is time to take the first environmental engineering course in the civil engineering program. Similar to gender and prior exposure to on-line or hybrid courses, the study did not look into the effect of class status in the hybrid learning due to the same reasons mentioned earlier.

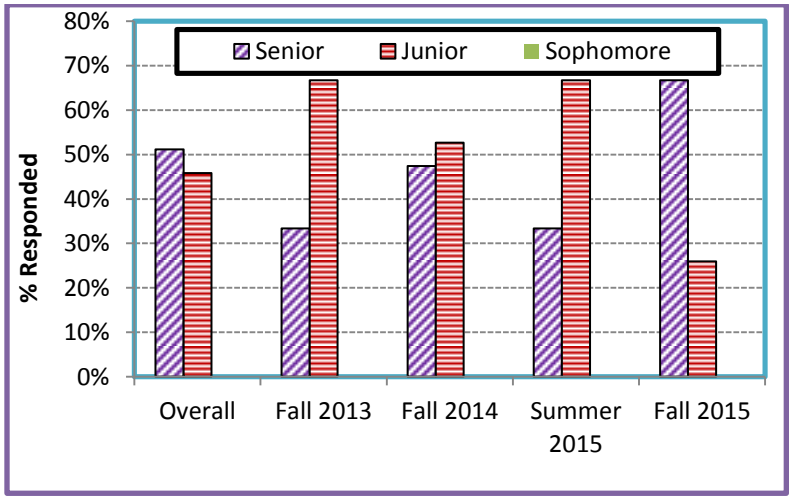

Figure 4: Distributions of class status for the survey participants

Based on the responses to Q.4 as to how the participants liked to take the course as hybrid, about 57% of the participants chose "5" scale, 28% chose "4" scale, 10% chose "3" scale, 4% chose "2" scale, and 2% chose "1" scale. No participants omitted this question. The weighted average of the choice was about 4.35 for overall, 4.52 for fall 2013, 4.63 for fall 2014, 4.72 for summer 2015, and 4.03 for fall 2015. It appears that hybrid course is a little bit popular in summer due to the fact that students do not need to attend the class 2 or 3 times in a week and can work outside. The distribution of Q.4 responses is presented in Figure 5. Based on the choice distributions in Figure 5, it is seen that majority of the participants would like to take the course as hybrid due to the underlying benefit.

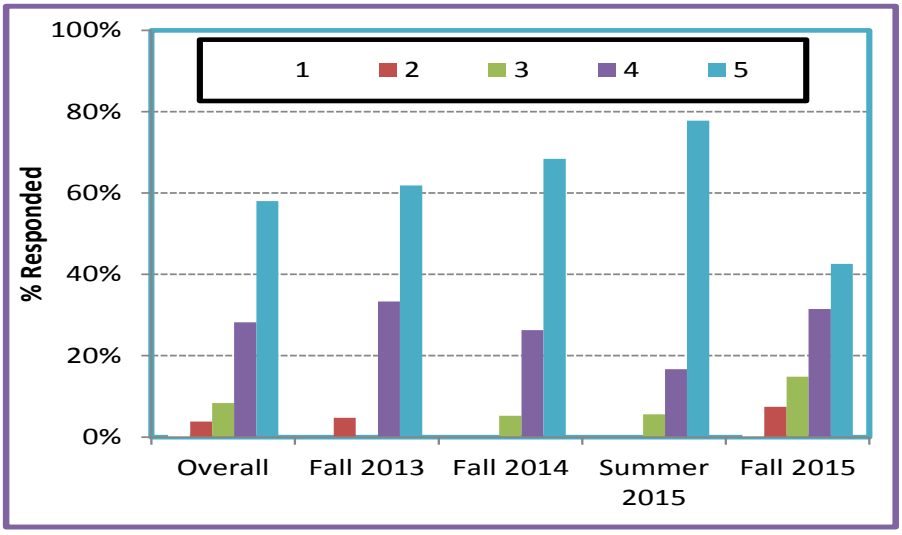

Figure 5: Distributions of choices of the participants who took the hybrid course

Based on the responses to Q.5 as to see the distribution of participants' choices to take the course as face-to-face, hybrid, or fully on-line, overall 77% of the participants chose "hybrid", 13% chose "face-to-face", and only 10% chose "fully on-line". Similar to Q.4, no participants omitted this question. The distribution of Q.5 responses is presented in Figure 6 and it is obvious from this Figure that hybrid option for environmental engineering is more appealing compared to fully on-line or face-face-face option. Similar to Q.4, 76% of the participants were in favor of hybrid in fall 2013, 87% in fall 2014, 78% in summer 2015, and 70% in fall 2015. To see the variations of face-to-face, hybrid, and fully on-line options for fall 2013, fall 204, and fall 2015 (summer 2015 was not included as it is not a regular semester), a chi-square goodness of fit test was performed to validate or reject the null hypothesis "no differences among semester to semester and face-to-face, hybrid, and fully on-line options". The chi-square test data are shown in Table 1(a). From the chi-square test, a p-value of ***0.4057*** was obtained which is NOT less than both 0.05 (α = 5%) and 0.01 (α = 1%). A χ^2-value of ***4.0023*** was also obtained. For a degree of freedom of 4, the critical values for χ^2 are 9.49 (for α = 5%) and 13.3 (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 conclude that that "no significant differences in the year to year and among face-to-face, hybrid, and fully on-line options". That means, similar trends are observed in the semester to semester and for all three course delivery options. However, it is obvious from the data that hybrid received more responses than the other two options. In order to

verify it more, a single factor ANOVA was performed and the data are presented in Table 1(b). Since $F > F_{critical}$ (in this is the case, 8.611 > 5.143), therefore, the null hypothesis is rejected. The means of the three delivery options populations are not all equal. At least one of the means is different. However, the ANOVA does not tell us exactly where the difference lies. We may need a t-Test to test each pair of means. However, no t-Test was performed as it is clear that the mean for hybrid option is more than that of other two means.

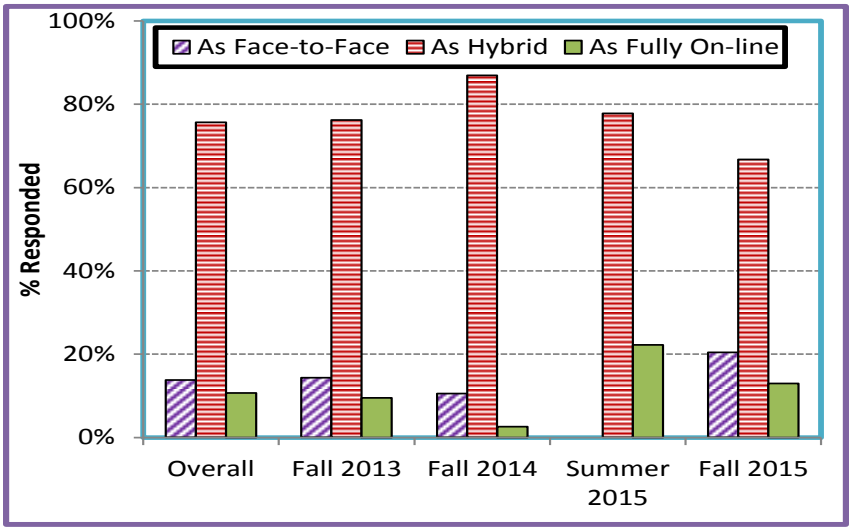

Figure 6: Distributions of responses of the participants for different delivery options

Table 1(a): Chi-square Goodness-of-fit test for Q.5 data

Semester	Observed Values				Expected Values			
	Face-to-Face	Hybrid	Fully On-line	Total	Face-to-Face	Hybrid	Fully On-line	Total
Fall 2013	3	16	2	**21**	3.244	16.049	1.707	**21**
Fall 2014	4	33	1	**38**	5.870	29.041	3.089	**38**
Fall 2015	12	45	7	**64**	9.886	48.910	5.204	**64**
Total	**19**	**94**	**10**	**123**	**19**	**94**	**10**	**123**
	p-value = 0.4057; χ^2-value = 4.0023							

Table 1(b): ANOVA for Q.5 data

Group	Sum	Count	Average	Variance	*Source*	*SS*	*DF*	*MS*	*F*	*p-value*	*F-crit*
Face-to-face	19	3	6.33	24.33	*Between group*	*1418*	*2*	*709*	*8.611*	*0.0172*	*5.143*
Hybrid	94	3	31.22	212.22	*Within group*	*494*	*6*	*82.3*	---	---	---
Fully on-line	10	3	3.33	10.33	*Total*	*1912*	*8*	---	---	---	---

An assessment was performed based on the final grades for face-to-face and hybrid semesters and the data is presented in Table 2. F-grade is not included in the assessment as the students got F when they stopped coming to the class or dropped after the deadline. From the chi-square test, a p-value of ***0.5918*** was obtained which is NOT less than both 0.05 (α = 5%) and 0.01 (α = 1%).

A χ^2-value of ***13.14*** was also obtained. For a degree of freedom (DF) of 15, the critical values for χ^2 are 24.996 (for α = 5%) and 30.6 (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 conclude that that "no significant differences in the semester to semester and between face-to-face and hybrid options". That means similar trends are observed in the semester to semester and for both face-to-face and hybrid delivery options.

Table 2: Assessment based on final grades using Chi-square Goodness-of-fit test

Offering Option	Semester	Observed Grades					Expected Grades				
		A	**B**	**C**	**D**	**Total**	**A**	**B**	**C**	**D**	**Total**
Face-to-face	Spring 2012	8	13	10	2	**33**	8.88	13.96	8.41	1.75	**33**
	Fall 2012	7	5	2	2	**16**	4.31	6.77	4.08	0.85	**16**
	Spring 2013	6	7	2	0	**15**	4.04	6.35	3.82	0.79	**15**
Hybrid	Fall 2013	10	10	9	1	**30**	8.08	12.69	7.64	1.59	**30**
	Fall 2014	12	22	16	4	**54**	14.54	22.85	13.76	2.86	**54**
	Fall 2015	13	31	14	2	**60**	16.15	25.38	15.29	3.17	**60**
	Total	**56**	**88**	**53**	**11**	**208**	**56**	**88**	**53**	**11**	**208**
		p-value = 0.5918; χ^2-value = 13.14									

Another assessment was performed based on the weighted average GPA for face-to-face and hybrid semesters and the data is presented in Table 3. From the chi-square test, a p-value of ***0.99997*** was obtained which is NOT less than both 0.05 (α = 5%) and 0.01 (α = 1%). A χ^2-value of ***0.0537*** was also obtained. For a degree of freedom of 5, the critical values for χ^2 are 11.1 (for α = 5%) and 15.1 (for α = 1%). The chi-square (χ^2) value is less than the critical values of both 11.1 (α = 5%) and 15.1 (α = 1%). Therefore, from both the χ^2-value and p-value point of view, the null hypothesis cannot be rejected and conclude that that "no significant differences in the semester to semester and between face-to-face and hybrid delivery options". That means similar trends are observed in the semester to semester for both face-to-face and hybrid delivery options. The t-Test and F-Test performed for this parameter (Table 5) also confirmed that the observed difference between the sample means as well as the population variances is not convincing enough to say that the average GPA and the variances between Face-to-face and hybrid differ significantly.

Table 3: Assessment based on weighted average GPA using Chi-square Goodness-of-fit test

Offering Option	Semester	Observed Values	Expected Values	
Face-to-face	Spring 2012	2.8182	2.9681	***p-value = 0.99997*** ***χ^2 value = 0.0537***
	Fall 2012	3.0625	2.9681	
	Spring 2013	3.2667	2.9681	
Hybrid	Fall 2013	2.9667	2.9681	
	Fall 2014	2.7778	2.9681	
	Fall 2015	2.9167	2.9681	
	Total	**17.8085**	**17.8085**	

The last and final assessment was done based on the course learning outcomes (CLO) for both the face-to-face and hybrid semesters and the data is presented in Table 4. There were 6 CLOs for face-to-face option and 10 for hybrid option. CLOs for hybrid offering were revised to align with the course content/module for hybrid offering. CLO 1 was on the environmental regulations for both the offerings, CLO 2 for face-to-face was on the water chemistry and water treatment principles and design which aligns with CLO 4 of the hybrid offering, CLO 3 for face-to-face was on the wastewater treatment principles and design which aligns with CLO 6 of the hybrid offering, CLO 4 for face-to-face was on the air pollution which aligns with CLO 7 of the hybrid offering, CLO 5 for face-to-face was a combined on solid waste (SW) and hazardous waste (HW) management which aligns with CLO 9 (SW) and CLO 10 (HW) of the hybrid offering, and CLO 6 for face-to-face was on the global contemporary issues which aligns with CLO 8 of the hybrid offering. CLOs 2 (mass balance equation), 3 (water supply system), 5 (water pollution), and 7 (air pollution) for the hybrid offering were included during the revision of the course for fall 2014. Therefore, the assessment was done based on only the six common/ similar CLOs.

Multiple exam and quiz questions were used to assess the CLOs. Average of the average points obtained in percentage by the students in different questions for a particular CLO is shown in Table 4. Seventy percent was considered as "meet the target" and no further action is necessary. From the chi-square test (Table 4), a p-value of ***0.4011*** was obtained which is NOT less than both 0.05 (α = 5%) and 0.01 (α = 1%). A χ^2-value of ***26.12*** was also obtained. For a degree of freedom of 25, the critical values for χ^2 are 37.65 (for α = 5%) and 44.31 (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 conclude that that "no significant differences in the semester to semester and between face-to-face and hybrid delivery options". The t-Test and F-Test performed for this parameter (Table 5) also confirmed that the observed sample means as well as the population variances between face-to-face and hybrid are equal.

Table 4: Assessment based on the CLOs using Chi-square Goodness-of-fit test

Delivery Option	Semester	Observed Value							Expected Value						
		CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6	Total	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6	Total
Face-to-face	Spring 2012	86	87	94	90	94	67	518	81	84	89	88	94	81	518
	Fall 2012	94	57	88	81	87	75	482	75	78	83	82	88	76	482
	Spring 2013	60	75	78	84	87	73	457	72	74	79	78	83	72	457
Hybrid	Fall 2013	60	75	78	84	86	73	456	71	74	79	78	83	72	456
	Fall 2014	72	84	73	61	77	79	446	70	72	77	76	81	70	446
	Fall 2015	65	74	70	75	78	71	433	68	70	75	74	79	68	433
	Total	**437**	**452**	**481**	**475**	**509**	**438**	**2792**	**437**	**452**	**481**	**475**	**509**	**438**	**2792**
		p-value = 0.4011; χ^2-value =26.12													

The summary of the goodness-of-fit test analysis is listed in Table 5 for four different types of data. Based on the goodness-of-fit test analysis it is apparent that hybrid option is more appealing compared to other two options and the other seven tests showed similar outcomes in the semester to semester observations for both face-to-face and hybrid delivery options. Therefore, the addition of a hybrid approach to the existing in-class lecture-centric environmental engineering courses would be welcomed by students and would not reduce the quality of teaching and learning although it could not be proved that hybrid approach improved it.

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 face-to-face, hybrid, and on-line delivery options (Survey)	0.4057	4.0023	4	9.49	13.3	Null hypothesis cannot be rejected and conclude that that "no significant differences in the semester to semester and between face-to-face and hybrid options."
Final grades	0.5918	13.14	15	24.99	30.6	
Weighted average GPA	0.99997	0.0537	5	11.1	15.1	
Course learning outcomes	0.4011	26.12	25	37.65	44.31	
Data Type: *t-Test*	***p-value***	***t-value***	***DF***	***$t_{Critical}$ (two tail)***		***t*-Test Comment**
Weighted average GPA	0.3348	1.146	3	3.182		Since *t-value* is within $-t_{critical}$ and $+t_{critical}$, the null hypothesis cannot be rejected. The observed difference between the sample means is not convincing enough to say that the average GPA and LOs between face-to-face and hybrid options differ significantly.
Course learning outcomes	0.1207	2.149	3	3.182		
Data Type: *F-Test*	***p-value***	***F-value***	***DF***	***$F_{Critical}$ (one tail)***		***F*-Test Comment**
Weighted average GPA	0.1596	5.264	2	19.000		Since *F-value* is < $F_{critical}$, the null hypothesis cannot be rejected. Therefore, variances of the two populations, face-to-face and hybrid options are equal.
Course learning outcomes	0.1239	7.070	2	19.000		
Data Type: *ANOVA*	***p-value***	***F-value***	***DF***	***$F_{critical}$***		***ANOVA* Comment**
Students' choices for face-to-face, hybrid, and on-line delivery options (Survey)	0.0172	8.611	2	5.143		Since $F > F_{critical}$ (in this is the case, 8.611 > 5.143), therefore, the null hypothesis is rejected. The means of the three delivery options populations are not all equal.

The typical comments received for Q.6 are quoted below. Most of the participants responded to these questions. However, only a few pertinent comments and one of the similar responses are quoted below for each question.

"Please don't go full online for this course. (for the sake of future students). Making this class hybrid was an incredible idea, it would get tedious learning everything in the class. I appreciate meeting to discuss examples and important concepts, then being able to look at it on my own later. Making it full online would be extremely overwhelming. There's a lot of material for this class, and without the direct guidance I feel that I would be lost in a sea of slides."

"Face to face offers more teacher/student interaction as well as student/student interaction. It commits you to showing up, facing the professor, and being prepared for class. The hybrid classes have both advantages and disadvantages. Hybrid offers the student a little more versatility schedule wise and time management wise. It is more interactive with technology which can be helpful or hurtful at times. Purely on-line classes offer little to no student/teacher interaction, grades based purely on right or wrong answers with no partial work looked at, hold student less accountable therefore allowing the student to slack more and typically not put as much work or effort into the course and learning less. I do not prefer classes based solely online and would not recommend them, there only benefit is less time constraints."

"Hybrid classes require a lot of outside study time."

"Hybrid/on-line classes can work for introduction level classes such as economics or political science, but I don't think they work as well for more difficult classes."

"Hybrid courses are good, because when we meet the professor, we are able to ask questions we don't understand. I like the way the professor explain the entire subject when we meet, really helpful, I like it."

"I prefer the hybrid class because I learn better when working problems on my own. The lecture is good for introducing the material, and then the quizzes and homeworks outside of class help cement in the concepts."

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 through the hybrid delivery approach compared to face-to-face approach. 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 midterms and final were in-class. At the very end of the semester, an on-line anonymous survey was conducted only for hybrid delivery option with six questions to compare the students' learning environment in the environmental engineering course, with 50% in-class lecture and in-class midterms and final, with the traditional complete in-class lecture-centric course. Students' perceptions and attitudes of hybrid approach appeared to be favorable and acceptable as a learning environment for future environmental engineering courses. Based on the data analysis, goodness-of-fit test, and specific students' comments, the lesson learned is that the addition of a hybrid 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.

Disclaimer

The partial results, especially the perception and attitude of hybrid, on-line, and face-to-face delivery of Environmental Engineering was presented in ASEE SE Annual Conference held at the University of Alabama, Tuscaloosa on March 13-15, 2016.

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