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Investigating Students' Expectations of Instruction in Engineering Laboratory Courses During the COVID-19 Pandemic

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Introduction

The COVID-19 pandemic has enormously changed everyday operations, in particular the content delivery in higher education. At the first onset of the pandemic in Spring of 2020, and knowing where it was going, academic institutions fully transitioned to a remote instructional mode to sustain everyone's well-being. In this paper, we try to understand the critical differences in student expectations on the efficacy of instructional practices in two different courses: a computer-based lab course and a hands-on activity-based lab course. Over the past two years, both these courses were offered in different modalities- a face-to-face mode (Fall 2019), partially face-to-face, and partially asynchronous (Spring 2020), and a fully synchronous remote mode (Fall 2020). More specifically, we try to understand the impact of remote learning on both these courses in the abovementioned modalities using the Student Response to Instructional Practices (StRIP) survey [1-2]. The two sections of the instrument are- (1) Types of instruction: We first study the students' response to the types of instruction (interactive, constructive, active, passive); and (2) Students' response to instruction (or student engagement): To characterize a student's response to types of instruction, we try to link it to the forms of engagement following previous research [3-5]; cognitive engagement, affective-emotional and behavioral. That was done by employing four items (value, positivity, participation, distraction). The first part of the study aims to investigate the implementation of remote learning on the student responses to instruction for the two aforementioned courses, while the second part aims to understand the possible changes in students' expectations as a result of implementing different types of teaching modes for the hands-on lab course.

The Introduction to Computer-Aided Design (CAD) course at the Mechanical Engineering (ME) Department at New Jersey Institute of Technology (NJIT), a midsized STEM university is a three credits course (four contact hours) offered every semester to undergraduate Mechanical Engineering students. The course introduces students to 3D modeling, assembly, assembly drawings and orthographic engineering drawings. Students are also introduced to basic concepts of Finite Element Analysis (FEA) as applied to mechanical engineering design problems. In a typical class session (2 hours), the instructor assigns at least one exercise. He first shows a brief demonstration of the assigned exercise including pinch points. The rest of the session is dedicated to helping students complete the exercise by answering questions. Students are expected to finish at least one exercise by the end of each session. These concepts are taught using two software: Creo and SolidWorks. The grading policy is as follows: labs assignments worth 30%, a final project worth 20%, a midterm and a final exam worth 20% and 30% respectively of the total grade. Students can also earn 5% extra credit by submitting an ePortfolio. To complete this course, students are expected to have no more than 2 absences and submit at least 60% of the lab assignments. Besides that, students need to take both midterm and final exams and submit the final project.

The Hydraulics laboratory course is a hands-on activity lab, whose main goal is to provide students with knowledge of practical and real-life applications of the theoretical concepts taught in Fluid Mechanics, Water Resources, and Hydraulics Engineering courses. In this course, students test and validate the fundamental principles of Fluid Mechanics, investigate design principles of water resource facilities and network, and develop a deep understanding of hydraulic phenomena through carefully designed lab experiments. Hydraulic laboratory course is a one credit course (three contact hours). The course is traditionally taught in a face-to-face format. However, due to the COVID-19 pandemic, this course was converted to synchronous remote mode halfway through the Spring 2020 semester and subsequently for the entire Fall 2020 semester. For Fall 2020, experiments were pre-recorded, and students were given access to the recordings a week before their scheduled class time. During the synchronous remote class, instructors would play the recordings while providing supplementary comments and clarifications and answering any students' questions. The experiments' results, data, and reading materials are then shared with the students to perform the necessary calculations and complete the respective lab report or lab problem assignments. Typically, the labs for this course have a capacity of 24 students with four sections offered during both spring and fall semesters. However, since the course is offered in a synchronous remote mode, some sections allowed for a maximum of 30 students. Students are required to attend every lab session and submit an original lab assignment for each lab experiment. Some of the assignments consist of lab reports (individual or group reports), while other assignments consist of individual lab problems. Lab assignments account for 95% of the course grade, while attendance makes up the remaining 5% of the course grade.

The Institute of Teaching Excellence (ITE) at NJIT held multiple training workshops for faculty as well as teaching assistants to help them get familiarized with the sudden remote transition. This included workshops on using WebEx effectively, Canvas basics, online exam proctoring options, and how to engage students in a remote classroom. These workshops were optional to attend, but the instructors (co-authors of this paper) of the two courses part of this study attended all these workshops and believe that they were well trained in remote learning pedagogy.

Methodology

The first part of this study (Study I) uses survey data that was collected from 83 students from the two classes that were analyzed (47 students from the CAD course and 36 students from the Hydraulics course). This survey helped us to understand both the student expectations and engagement in class activities between a computer-based lab and a hands-on activity lab in a remote delivery mode. The second part of this study (Study II) uses survey data that was collected from a total of 74 students who took the Hydraulics course in different semesters: 36 students from Fall 2020, where COVID-19 measures were implemented with remotely offered lectures only; 20 students from Spring 2020 that started with regular in-person sessions but was converted to fully remote sessions in March due to COVID-19 measures, and 18 students from Fall 2019, who had regular in-person sessions. This survey helped us to understand both the student expectations and engagement for a hands-on activity lab based on the different modes of instruction. Table 1 Represents the demographic information of the study participants.

As previously stated, the instrument used in our study consists of two sections. The first section caters to the types of instructions students may experience and may respond to differently [1]. Particularly, the student response to instruction is classified into 4 subconstructs: interactive, constructive, active, and passive. The interactive-constructive-active-passive (ICAP) model provided by [2] was slightly modified to incorporate different types of instruction [6-7]. Similarly, in the second section, the instrument classifies the student's response to instruction into 4 subconstructs: value, positivity, participation, and distraction. These sub-constructs allow us to measure the student's response to instruction.

Table 1. Demographic Information of the Study Participants.

Demographic Classification	Study I	Study II
Gender		
Female	19.27%	27%
Male	82.72%	73%
Ethnicity		
Black/African/African American	3.61%	6.33%
Latin(x)/Hispanic	26.50%	24.05%
White/Caucasian	45.78%	48.10%
Hawaiian/Pacific Islander	1.20%	1.27%
American Indian/Native American	0%	1.27%
Asian/Asian-American	18.07%	15.19%
non-listed	2.40%	1.27%
declined to answer	2.40%	2.53%

The internal consistency of the items was assessed using Cronbach Alpha. For our research, the internal consistency is considered adequate when the value of Cronbach Alpha is above 0.6 for the combined items of each construct. The Cronbach Alpha is calculated as the ratio of true variance of the responses to the total variance. Table 2 presenting the constructs, description, Cronbach Alpha, and items shows that the students' responses are within adequate consistency. It is to note that the internal consistency for both Study I and Study II are combined, also all our analysis was done using SPSS (Statistical Package for the Social Sciences) software.

Table 2. Internal Consistency and Description for the Survey Items.

Construct	Description	Cronbach Alpha	Items
Interactive	Expresses the times when students performed group activities during the class in which they had to interact with their peers	0.836	Solve problems in a group during class
			Do hands-on group activities during class
			Discuss concepts with classmates during class
			Work in assigned groups to complete homework or other projects
			Be graded based on the performance of my group
			Study course content with classmates outside of class
Constructive	Involves students thinking and figuring out problems on their own, especially when brainstorming was needed to fill in the missing parts	0.806	Make and justify assumptions when not enough information is provided
			Find additional information not provided by the instructor to complete assignments
			Take initiative for identifying what I need to know
			Brainstorm different possible solutions to a given problem
			Assume responsibility for learning material on my own
			Solve problems that have more than one correct answer
Active	Includes the engagement of students with the course content in any individual activity. Examples include asking the instructor questions or answering questions posed by the instructor during class [1]	0.700	Make individual presentations to the class
			Be graded on my class participation
			Solve problems individually during class
			Answer questions posed by the instructor during class
			Ask the instructor questions during class
			Preview concepts before class by reading, watching videos, etc.
Passive	Reports the activity that didn't require a student's participation. Instead, those were the times when students fully relied on their instructor	0.771	Listen to the instructor lecture during class
			Watch the instructor demonstrate how to solve problems
			Get most of the information needed to solve the homework directly from the instructor
Value	Describes how much in-class activity is considered beneficial	0.884	I felt the time used for the activity was beneficial

	by the students. That item can be linked to cognitive engagement		I saw the value in the activity I felt the effort it took to do the activity was worthwhile
Positivity	Reflects the attitude of learners towards the in-class operation and the teacher and can be considered impactful on the affective-emotional aspect	0.720	I felt positively towards the instructor I felt the instructor had my best interests in mind I enjoyed the activity
Participation	Tests how students become active or resistant to in-class practice. The participation contains items that have been reversed coded to provide the interaction route and connected to the behavioral engagement	0.680	I participated actively (or attempted to) I tried my hardest to do a good job I pretended but did not actually participate* I rushed through the activity, giving minimal effort*
Distraction	Reports whether students were distracted during a class activity	0.596	I distracted my peers during the activity I talked with classmates about other topics besides the activity I surfed the internet, checked social media, or did something else instead of doing the activity

*Items are reverse coded.

To examine the differences between the study groups, we performed two types of statistical tests. Particularly, we used the independent samples t-test to compare between two independent groups (CAD course and Hydraulics course) for Study I, and one-way ANOVA to compare between the mode instructions of the three groups for Study II (all of them being from the Hydraulics course).

To perform an independent sample t-test, one must meet the following assumptions: (1) Continuous dependent variable: In our work, the score for the dependent variable ranges from 1 to 5, which satisfies the first requirement. (2) Independent variables have two categorical groups: Our study focused on the comparison between two categorical groups, CAD course, and Hydraulics. (3) Independence of observations: There was no relationship between the observations in the two groups. (4) No significant outliers should exist in the two groups: Outliers were investigated using boxplots and were removed from our data set. (5) Dependent variables should be approximately normally distributed for each of the two groups: The normality was checked using the Shapiro-Wilk test of normality (see Table 3). This assumption did not hold for all our dependent variables (because of the nature of some questions in specific items, i.e., the distraction item for example measured the level of distraction in the two classes, most students reported a low level of distraction which skewed our data); however, a visual representation helped us to ensure that our dependent variables can be assumed to be close to normal distribution. (6) Homogeneity of the variances: The homogeneity of variances was checked using Levine's equality test (see Table 3). This assumption was held for all the cases except for the participation item. Appropriate measures were undertaken for that case when we performed the t-test.

Similarly, certain conditions need to be met for one-way ANOVA to provide valid results. (1) The dependent variable must be a continuous random variable: students recorded their responses on a scale from one to five; and to form continuous variables, the average value for each response construct of instructional practices and students' perception from each student observation is calculated. (2) The independent variable must consist of three or more categorical groups: This study considered three semesters with each having a different level of implementation of COVID-19 measures as categorical groups. (3) Observations must be independent: Students responded to this survey anonymously without any influence from their peers and without any relationship between the students in different categorical groups. (4) The data is normally distributed with minimal or no correlations or outliers: normality is evaluated using the Shapiro-Wilk test in SPSS as shown in Table 3. Shapiro-Wilk test shows that normality is violated in five of the constructs. However, by visually inspecting Normal Q-Q plots, we notice that the deviations from the normal line are not severe. Additionally, boxplots are visually examined to identify possible outliers. Based on the boxplots, few outliers are identified; however, outliers were not removed since they did not appear to be significant and because of the small size of the sample. (5) Categorical groups must have homogeneous variances: Levene's test was conducted to test the homogeneity of the variance as shown in Table 3. The test results show that all constructs, except for participation, have homogeneous variance with a p-value over (0.05).

Table 3. Shapiro-Wilk Test of Normality and Levene's Test of Homogeneity.

Construct		Study I		Study II	
		Normality	Homogeneity	Normality	Homogeneity
		Significance			
Interactive	CAD	0.021*	0.694	0.000*	0.415
	Hydraulics	0.549			
Constructive	CAD	0.577	0.967	0.060	0.491
	Hydraulics	0.055			
Active	CAD	0.062	0.985	0.245	0.306
	Hydraulics	0.341			
Passive	CAD	0.000*	0.179	0.112	0.156
	Hydraulics	0.002*			
Value	CAD	0.000*	0.456	0.000*	0.817
	Hydraulics	0.245			
Positivity	CAD	0.001*	0.117	0.000*	0.992
	Hydraulics	0.002*			
Participation	CAD	0.000*	0.002**	0.000*	0.002**
	Hydraulics	0.078			
Distraction	CAD	0.000*	0.167	0.000*	0.842
	Hydraulics	0.000*			

*Significant value ($p<0.05$), Normality is violated.
**Significant value ($p<0.05$), Homogeneity is violated.

Results and Discussion

For Study I, the descriptive statistics shown in both Table 4 and Figure 1 help us compare the mean and standard deviation for each item between the two classes, giving us a better understanding of how the mode of delivery affected the learning experience. However, since the two classes do not have the same number of students nor the same standard deviation, further statistical tests were needed in order to form a conclusion.

41 students from the CAD course and 31 students from the Hydraulics course participated in this study. An independent t-test was conducted to determine if there were differences in the types of instructions (interactive, constructive, active, passive) and the student response to instruction (value, positivity, participation, distraction). Also, another important statistical measure to look at is the effect size, which provides a quantitative measure of magnitude of the difference effect between examined cases.

Before we start with the discussion, we note that the results listed in the following paragraph are represented in Tables 4 and 5. With regards to the types of instruction, the interactive instructions were lower in CAD students (2.11 ± 0.81) than in Hydraulics students (3.04 ± 0.86), a statistically significant difference of -0.93 (95% CI, -1.33 to -0.54), $t(70) = -4.7000$, $p = 0.000$ with a large effect ($d = 0.83$). This item tells us about students' expectation to perform a group activity in-class in which they had to interact with their peers. The Hydraulics course scored a statistically higher value in this item with a large effect size, meaning that students in the Hydraulics course expected to interact more with their peers. This can be explained by unpacking the way this course is implemented. Particularly, students are expected to complete experiments in a group and sometimes submit group work rather than completing individual tasks on their computer. The constructive instructions can be similarly reported where the scores were lower in CAD students (3.21 ± 0.83) than in Hydraulics students (3.42 ± 0.84) but there was not any statistically significant difference, meaning that the means can be assumed to be statistically equal. This finding tells us how often students were expected to think and figure out problems independently. Our results show no significant differences between the two classes. This was expected because the two classes require students to critically think in order to figure out the solutions to specific problems.

As per the active construct the CAD scored a lower score (2.54 ± 0.76) than in Hydraulics students (2.91 ± 0.72), a statistically significant difference of -0.38 (95% CI, -0.73 to -0.02), $t(70) = -2.134$, $p = 0.036$ with a medium effect ($d = 0.74$). This item represents students' engagement with the course content in any individual activity, such as asking the instructor questions or answering questions that were asked by the instructor. The Hydraulics course scored a statistically higher value with a medium effect size in this item, implying that the students expected to address more questions to the instructor. One reason could be the availability of CAD tutorials across the internet, where students can clear any doubts they have on their own, at any time they wish, rather than asking the instructor. And lastly, the scores in the passive construct were higher in the CAD course (4.70 ± 0.45) than in Hydraulics lab students (4.44 ± 0.55), a statistically significant difference of 0.27 (95% CI, 0.03 to 0.50), $t(70) = 2.271$, $p = 0.04$ with a medium effect ($d = 0.49$). This item reports the activity where students relied heavily on the instructor. The CAD course scored a statistically higher score in this item, while the Hydraulics course score was also high approximately (medium effect size). That can be explained by the fact that the instructor starts by giving a demonstration, making the students rely more on the instructor to do the job, and it will look easy until they try to do it independently. As for the Hydraulics course, that has to do with the fact that students do not have to make any effort to complete their experiments anymore; the data was automatically provided to them. One way to reduce that problem is to employ some of the active learning techniques such as peer review, where students are asked to evaluate their peer's work and assign additional grades based on that review. That would create a vibrant and interactive environment in class, which can reduce that passive mode.

Similar analysis can be done for the student response to instruction; the value score was higher in CAD students (4.33 ± 0.65) than in Hydraulics students (3.82 ± 0.77), a statistically significant difference of 0.52 (95% CI, 0.18 to 0.85), t (70) = 3.073, p = 0.003 with a medium effect (d = 0.70). This item describes how much the students considered the in-class activity to be beneficial. The Hydraulics course scored a statistically significant lower value (large effect size). This can be explained due to many reasons. One way to look at it is that students pre-judged the course because that course relies heavily on hands-on activities. Another way to look at it is the disappointment of students. This was one of the few opportunities where students had the chance to link their theoretical background to real-life engineering problems. However, that did not happen because of the pandemic, making students lose interest in the lab. Also, this item is related to cognitive engagement, where students are willing to learn tasks on their own once they classify the activity as worthwhile [1]. Further investigation is needed for this item to better understand what was causing that disappointment in students. Moreover, the positivity score was higher in CAD students (4.45 ± 0.44) than in Hydraulics students (4.17 ± 0.0.65), a statistically significant difference of 0.27 (95% CI, 0.02 to 0.53), t (70) = 2.145, p = 0.035 with a medium effect (d = 0.54). This item reflects the attitude of the students towards the in-class operation and the teacher. The CAD course scored a statistically significantly higher value (medium effect size) and this item favorably impacts the student's affective-emotional aspect, which is very important to the student's success. This item needs to be studied more thoroughly to understand why a difference between the two classes was there since this item describes more the student-instructor interaction rather than any technical content.

Also, the participation score were higher in CAD students (4.63 ± 0.38) than in Hydraulics students (4.10 ± 0.67), a statistically significant difference of 0.52 (95% CI, 0.25 to 0.79), t(44.243) = 3.885, p = 0.000 with a medium effect (d = 0.53). This item tests how students become active or resistant to in-class practice (high score reflects a high participation). The CAD course scored a statistically significant higher score, perhaps because of the nature of the course. Students are expected to complete at least one assigned exercise by the end of the session, leading to more participation to do the job on time. However, when it comes to the Hydraulics lab, students are provided with the experimental data, requiring them to write a report. And for that reason, students can work on their report, later, leading to a drop in participation during class. And finally, the distraction score was lower in CAD students (1.23 ± 0.27) than in Hydraulics students. (1.41 ± 0.44), a statistically significant difference of - 0.18 (95% CI, -0.35 to – 0.01), t (70) = -2.130, p = 0.093 with a medium (d = 0.35). This item reflects how often the students got distracted during the class. The means are both low, but the Hydraulics course scored a statistically significant higher score, which takes us back to the fact that in the CAD course, students were expected to deliver at least one exercise by the end of the class; however, for the Hydraulics course, students were provided with the data.

Table 4. Descriptive statistics for the two classes (mean and standard deviation).

	Mean		Standard deviation	
	CAD	Hydraulics	CAD	Hydraulics
Interactive	2.1057	3.0376	0.81373	0.85820
Constructive	3.2114	3.4194	0.82834	0.83983
Active	2.5366	2.9140	0.75967	0.71992
Passive	4.7073	4.4409	0.44842	0.54696
Value	4.3333	3.8172	0.64979	0.77383
Positivity	4.4472	4.1720	0.43849	0.64905
Participation	4.6280	4.1048	0.37965	0.67322
Distraction	1.2276	1.4086	0.27324	0.44480

*Response options for each item were: 1 = Almost never (<10% of the times), 2 = Seldom (~30% of the time), 3 = Sometimes (~50% of the time), 4 = Often (~70% of the time), 5 = Very often (>90% of the time). The scores shown in this table are the items averaged values for each construct.

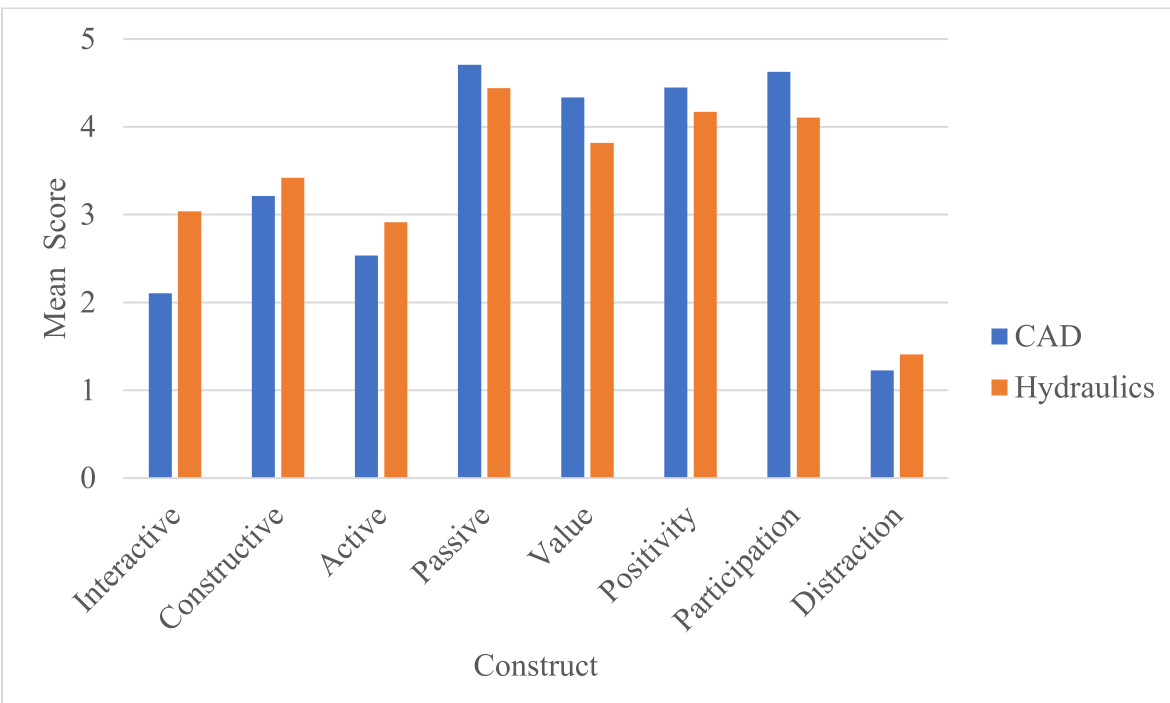

Figure 1. Bar chart showing the mean score for the two classes.

*Response options for each item were: 1 = Almost never (<10% of the times), 2 = Seldom (~30% of the time), 3 = Sometimes (~50% of the time), 4 = Often (~70% of the time), 5 = Very often (>90% of the time). The scores shown in this table are the items averaged values for each construct.

Table 5. Mean comparison using the independent sample t-test.

	t	df	p-value	Mean Difference	Cohen's d	95% Confidence Interval of the difference	
						Lower	Upper
Interactive	-4.700	70	0.000	-0.93914	0.83308	-1.32740	-0.53649
Constructive	-1.049	70	0.298*	-0.20797	0.83328	-0.60353	0.18758
Active	-2.134	70	0.036	-0.37739	0.74289	-0.73004	-0.02475
Passive	2.271	70	0.026	0.26646	0.49307	0.03240	0.50051
Value	3.073	70	0.003	0.51613	0.70562	0.18118	0.85108
Positivity	2.145	70	0.035	0.27511	0.53890	0.01930	0.53092
Participation	4.180	44.243	0.000	0.52321	0.52593	0.25185	0.79457
Distraction	-2.130	70	0.037	-0.18096	0.35701	-0.35043	-0.01149

*Means are assumed not to have a statistical difference only when the significance is more than 0.05 ($p > 0.05$)

For Study II, the mean scores for students' responses for the three teaching modes (remote, mixed, and in-person) are calculated for each construct of the Hydraulic Laboratory course as shown in both Table 6 and Figure 2. When comparing the average scores, in-person mode received the highest mean scores for each of the constructs. Additionally, the remote mode scored the lowest means for interactive, passive, value, positivity, and participation; while the mixed mode has the smallest mean scores for constructive, active, and distraction. These observations tend to suggest that students in in-person classes for this type of laboratory course anticipate having received higher levels of classroom interactions and engagements, critical thinking, beneficial information, and positive knowledge while also having higher levels of distractions in the in-person classes as compared with mixed or remote classes. On the other hand, these initial findings aim to show the possible differences without considering the statistical significance. One-way ANOVA is used for this part of the study. Based on ANOVA, significant differences in students' responses to interactive learning and perception of participation is found. SPSS results for one-way ANOVA are shown in Table 7.

Table 6. Descriptive Statistics of Students' Responses for Different Modes of Instructions.

Instruction Mode	**Remote**		**Mixed In-person & Remote**		**In- Person**	
Sample Size	36		20		18	
Construct	**Mean**	**Variance**	**Mean**	**Variance**	**Mean**	**Variance**
Interactive	3.1157	0.7426	3.6417	0.7903	4.0463	0.4242
Constructive	3.4028	0.6260	3.1917	0.8663	3.4907	0.7205

Active	2.9676	0.4918	2.9250	0.3523	3.2407	0.8406
Passive	4.3148	0.4250	4.7000	0.1743	4.5370	0.3286
Value	3.7685	0.5766	4.2167	0.7284	4.2037	0.6816
Positivity	4.0833	0.4532	4.3333	0.4094	4.4815	0.4343
Participation	3.9722	0.5135	4.5375	0.2123	4.5556	0.1438
Distraction	1.6759	0.6507	1.6500	0.4734	1.8148	0.3951

*Response options for each item were: 1 = Almost never (<10% of the times), 2 = Seldom (~30% of the time), 3 = Sometimes (~50% of the time), 4 = Often (~70% of the time), 5 = Very often (>90% of the time). The scores shown in this table are the items averaged values for each construct.

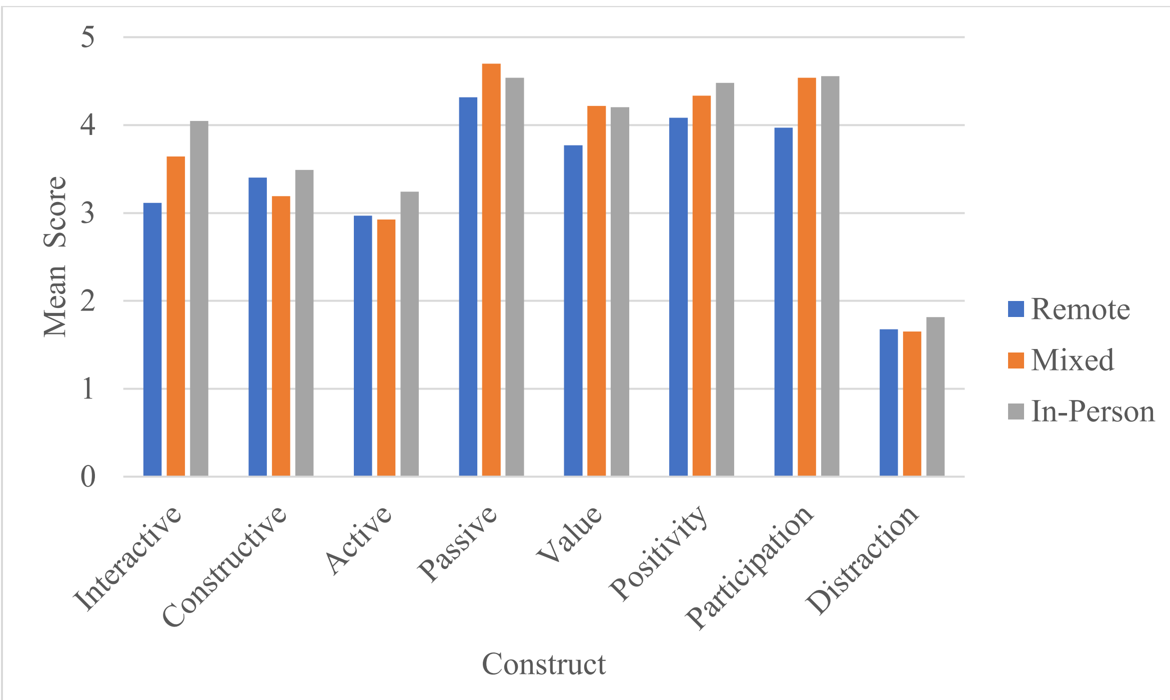

Figure 2. Bar chart showing the mean score for different modes of instruction.

*Response options for each item were: 1 = Almost never (<10% of the times), 2 = Seldom (~30% of the time), 3 = Sometimes (~50% of the time), 4 = Often (~70% of the time), 5 = Very often (>90% of the time). The scores shown in this table are the items averaged values for each construct.

The ANOVA analysis indicated significant differences in student's responses with regards to two constructs between the three semesters with different modes of teachings (remote, mixed, and in-person) with low p-values (0.001) and (0.000) respectively as shown in Table 7. The significant constructs are: (1) interactive learning, and (2) participation. On the other hand, the differences in other constructs appear to be insignificant with p-values of ($p > 0.05$). Additionally, the effect size is determined by calculating Eta-squared (η^2) values using SPSS for each construct (shown in Table 7). the effect size value for interactive is found to be ($\eta^2 = 0.187$) and for participation to be ($\eta^2 = 0.199$). Since Eta-squared values are Above (0.14), the effect size of the differences across different teaching modes on the students' response to interactive learning and participation is high.

Nevertheless, ANOVA analysis suggests that the differences in the students' response to constructive, active, and passive learnings, in addition to the anticipated levels of value, positivity, and distraction are not significant with reasonable p-values higher than the critical value ($p > 0.05$). This suggests that different teaching modes do not have a significant impact on the students' response to these constructs.

Table 7. One-Way ANOVA for The Differences in Students' Response Due to Different Modes of Instructional for Three Semesters.

Construct		SS	df	MS	F	p-value	Effect Size (η^2)
Interactive	Between	11.070	2	5.535	8.151	0.001*	0.187
	Within	48.217	71	0.679			
	Total	59.287	73				
Constructive	Between	0.937	2	0.468	0.657	0.522	0.018
	Within	50.618	71	0.713			
	Total	51.554	73				
Active	Between	1.156	2	0.578	1.074	0.347	0.029
	Within	38.195	71	0.538			
	Total	39.351	73				
Passive	Between	2.005	2	1.003	2.994	0.056	0.078
	Within	23.774	71	0.335			
	Total	25.779	73				
Value	Between	3.613	2	1.807	2.813	0.067	0.073
	Within	45.607	71	0.642			
	Total	49.221	73				
Positivity	Between	2.103	2	1.052	2.407	0.097	0.063
	Within	31.022	71	0.437			
	Total	33.125	73				
Participation	Between	6.090	2	3.045	8.842	0.000*	0.199
	Within	24.451	71	0.344			
	Total	39.351	73				
Distraction	Between	2.005	2	1.003	2.994	0.056	0.008
	Within	23.774	71	0.335			
	Total	25.779	73				

*Significant value ($p<0.05$).

Although ANOVA found significant differences in students' responses for Interactive construct and Participation construct, this significance does not necessarily suggest that all students' responses differ amongst all three teaching modes. Nevertheless, significant differences may sometimes exist between one or two pairs. Thus, post-hoc analysis (Tukey) is used to determine which pair(s) cause this significance, shown in Table 8. Tukey's analysis are performed only on the two significant constructs from the ANOVA analysis, and the results indicate that the students' response to the interactive construct differ significantly between a semester with fully implemented remote teaching and one with in-person labs with a p-value of ($p = 0.001$), a mean difference of (-0.930), and a standard error of (0.238); this difference indicates that students in in-person sessions anticipated to receive more interactive learning instructions than those in remote sessions. Similarly, significant differences are found in the participation construct between remote and mixed modes with a p-value of ($p = 0.003$), a mean difference of (-0.565), and a standard error of (0.164); and between remote and in-person modes with p-value ($p = 0.003$), mean difference of (-0.583), and standard error of (0.169); such difference indicates that students in remote session expect to participate less often than those in mixed and in-person sessions. On the other hand, Tukey's analysis indicates that no significant differences are present between the in-person and mixed mode for the interactive and participation constructs and between the remote and mixed mode for the interactive construct with reasonable p-values ($p > 0.05$).

Table 8. Post-Hoc Analysis (Tukey).

Construct	Mode of Instruction (Semester)		Mean Difference	Std. Error	p-value
Interactive	Remote	Mixed	-0.52593	0.22982	0.064
	Remote	In-Person	-0.93056	0.23789	0.001*
	Mixed	In-Person	-0.40463	0.26774	0.292
Participation	Remote	Mixed	-0.56528	0.16366	0.003*
	Remote	In-Person	-0.58333	0.16941	0.003*
	Mixed	In-Person	-0.01806	0.19066	0.995

*Significant value ($p<0.05$).

Conclusion

If we look closer at the results from Study I, particularly at the types of instructions, we notice that both the interactive and active constructs were higher in the Hydraulics course compared to the CAD course. Whereas the passive construct was higher in the CAD course. That really tells us that students in the CAD course need to be more engaged in remote learning activities during the classroom session. Similarly, if we look at the students' response to the instructions, we notice that all of the value, positivity, and participation constructs scored higher in the CAD course, meaning that students found it beneficial to attend and participate in the class. Also, the distraction construct scored higher in the Hydraulics lab course, which can confirm our point. In these two cases, those problems can be avoided by having a more interactive classroom environment, where students feel their importance in participating in-class activities. In other words, student-centered instruction should be applied instead. That can happen by implementing the active learning style, which was shown to promote student learning and highly depends on the students' engagement [9-11].

Remote and mixed teaching modes for hands-on activity-based laboratory courses can pose new challenges; many students may be hesitant or confused with how this new teaching mode can be utilized to achieve the promised learning objectives. Study II showed that remote teaching mode for this type of laboratory course can compromise the interactive learning and the participation constructs of the instructional practices and students' expectations. Instructors need to utilize various active learning techniques alongside cognitive and constructive learning theories to help keep the students engaged with class and bridge the gap between traditional and remote modes. Also, students can benefit from the use of interactive videos to provide them with the opportunity to become active participants in the class; Thus, by increasing the engagement level, students' perceptions of remotely offered laboratories should improve.

In conclusion, this work played a role in identifying some aspects that need to be revisited, especially in laboratory courses offered in a remote mode. While it seems quite easy to conduct a computer-based class remote, this study shows students were also facing some difficulties in such classes. This study is valid for those two courses and should also be considered in all the courses offered remotely for the first time. As the current situation seems to be drifting to the worse, it might be beneficial to the instructors to adapt to their students' needs and meet the course outcomes as expected. One way of doing that is to visit the items and rethink the way those courses were delivered. While adjusting courses, instructors should be highly encouraged to know more about their students. One way to do that is to send a survey in the very first lecture that can give the instructor a rough estimation about what type of learners is enrolled in the class (Auditory, Visual, Kinesthetic, etc.). Another aspect that the instructor should be aware of is the importance of learning theories (Behaviorist, Cognitivist, Constructivist). While the behaviorist theory that relies more on an instruction-based (stimulus-response) seems to be more convenient to be applied in a remote class, instructors should also try to include both the cognitivist and constructivist, which are very similar in a sense and require some interaction between students, where they can learn from each other's experience. That can be done by using active learning techniques that were proven to be very efficient in learning. All together with using active learning, instructors must also consider the 'Student Resistance to Active Learning' which remains a new area of interest for engineering education research [12]. 'Student Resistance to Active Learning' may be reduced by employing the strategies proposed in literature such as varying the teaching methods used throughout the course and making and using a public grading rubric for students to avoid perception of grading unfairness, just to mention few [13-14]. Although, this paper focused on the differences in student expectations on the efficacy of instructional practices, the impact of those changes on the learning outcomes is yet to be determined and is the focus of our future work.

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