Student performance impacted from modifying a first-year/semester engineering core course during a global pandemic

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***Abstract*—This Research Full Paper considers the effects of abruptly migrating a first-semester engineering core course into a hybrid, partially online as a response to a global pandemic. This study combines both quantitative and qualitative methods to perform a retrospective analysis to identify and explain the effects of the sudden changes on students' performance in a course at a large research university in the southwestern continental United States. The qualitative portion of this study focuses on student performance as an important factor that directly impacts and concerns many students. The study first compares student performance on similar course materials provided in Fall of 2019 and 2020, pre- and post-pandemic respectively. The Fall 2020 course transitioned to a hybrid format, combining online content delivery with in-room class meetings synchronously, as part of precautions due to the pandemic. We utilize statistical analyses methods such as t-tests on existing student performance data. Preliminary results indicated that the Fall 2020 students performed worse on the first exam than those of their 2019 counterparts, leading to closer examinations of specific assignments that contribute to the exam performance. Using particular assignments we broke down which topics contributed most to the contrasting performance on each exam and what specific adjustments to make so that Fall 2020 students' performance became up to par with Fall 2019 students by the second exam.**

***Index Terms*—first-year, engineering, core, course, hybrid, pandemic**

I. Introduction

This Research Full Paper presents a study on data representative of Fall 2019 and 2020 student performance to help understand the effects of a pandemic. Given the unexpected emergence of the pandemic certain detailed characteristic demographic data on the students were not already planned for collection. However, both groups of students entering this first-year engineering (FYE) course are accepted into the university within a year time frame, with similar pre-requisites, and with similar distribution of demographic characteristics. The study focuses first and foremost on available data on the course and the students' performances in an attempt to retain the Fall 2019 course format for Fall 2020, leaving any further distinctions for later exploration.

A pandemic and 21^{st} century technology

The beginning of the Spring 2020 semester coincided with the emergence of a fatal disease due to a novel severe acute respiratory syndrome corona-virus (SARS-CoV-2). The illnesses began at the end of 2019 (hence the disease caused by the coronavirus is termed COVID-19) and by Spring Break 2020, a global pandemic was widely acknowledged. Global pandemics are not new [1]–[4]. One extremely significant and quintessential distinction in the internet era is the existence of said internet and its widespread use. The internet and associated technologies, helped make it possible for a course to transition to online at the time of the COVID-19 pandemic's acknowledgement as global. An important factor on student performance is how using the internet and associated technologies play a role in facilitating such a major transition. The works on courses that used internet technologies can have results relevant to this study and are therefore part of the literature survey for the framing of the study although the focus of the study is on student performance. Researchers studied internet use for distance learning [5], flipped or inverted classroom [6], mixed face-to-face with online or partially flipped courses [7]. Research findings indicate preferences for in-person or face-to-face (F2F) education [8]–[10] though Dutta [11] found students who appreciated the availability of internet technology. Downs [8] quotes students who preferred face-to-face interactions and getting feedback on course grading. Interestingly, Wladis et al. [10] found no significant differences in preferences by gender.

II. Review of Relevant Literature

Howcroft and Mercer [12] found students most concerned about health and safety [13], [14] then growth mindset (how well they are learning), student agency (coping, managing time) and other themes. Potts [14] found that FYE students felt that they handled the disruption better than their upper-class peers despite challenges ([15]. In particular, Gelles and Walker [16] found that FYE students had greater sense of belonging than upper-class peers. However the FYE students felt less connected to peers in general and the university [16],

[17]. Krishnakumar et al. [18] considered workplace thriving theory [19] that incorporates psychological elements of vitality and learning in an environment and apply this to students as adult learners working from home (WFH). Krishnakumar et al. [18] found some students more comfortable communicating online than in-person yet found professors less approachable; working on common goals helped team thrive (sense of vitality); problem-solving skills helped from exploring "different ways of doing stuff." The number of factors are numerous but this paper focuses on available data for the Fall 2019 and Fall 2020 implementation of the same course with respect to the change in the course modality. We contrast this study with the literature on COVID effects on engineering education. We discuss the factors understanding that we are focusing on retrospective analyses of available Fall 2019 and fall 2020 data on an unexpected study opportunity that was presented by the occurrence of a pandemic.

III. Purpose of the Study

The purpose of this research effort is to quantify the differences between a course held in a physical classroom building to the nearly identical course held partially inverted, where some students are on an online virtual classroom environment, due to a pandemic. The study focuses on student performance to help gauge how the transition to online impacts students. The grades are a very important indicator of performance to many students, as it will impact their entry to a major (ETAM). The grades are also important to students' parents, university faculty, staff, and administrators alike, as they are some of the stakeholders in what happens in the engineering education process. The grades are a factor that represent one specific example of the effects of the global pandemic locally materializing in student class and college life. This paper presents retrospective analyses of students' grades data during a semester when a course is partially online for the purpose of quantifying the effects of such pandemic-related changes. We compare data from the course experiencing the change to data from the pre-pandemic semester's offering of that same course a year earlier.

A. Research questions

The study poses the following research questions:

1) How does a major change in the format of course content delivery due to modifications for a pandemic affect students' performance in their grades?
2) How does students performance on course topics change during each semester for students who have been affected by the pandemic compared to students before it?

IV. Background

A. The course

First-year and first-semester courses form the introduction to the major disciplines that students get when they first enter college. First-year engineering (FYE) courses in particular focus on getting engineering students a closer experience to the engineering profession [20], [21]. The FYE courses engage students in engineering activities to help them better understand the engineering disciplines as intended by experiential learning theory (ELT) [22]–[24]. The university in this study redesigned their FYE courses from project-based [20], [21], [25] to a more subject-specific format [26], [27] in 2018 to improve retention.

The class was designed to be an engineering computation laboratory via an introduction to programming in python [26], [27]. The first-course in engineering for entering students became an introduction to programming where each week consists of one hour of lecture and three hours of in-class programming activities. The Computer Science faculty developed the course content. The course would provide sufficient proficiency in computer logic and good, structured, modular programming habits to be a foundation and base level of preparation for any additional languages that students may use when problem-solving in later courses of their major.

V. Methods

A. Setting

The Fall 2019 course employed an active learning environment as the designed format in an on-campus physical classroom. Fall 2020 combined the onsite physical classroom concurrently with a virtual classroom environment. The Fall 2019 and 2020 implementations of the courses are described each in this section with respect to the original intent of the class.

1) The typical class: The instructor lectures for an hour on a programming concept, then students apply the concept to engineering examples via laboratory activities for another hour. On a second day of the week, students return to continue working on the activities but they mainly finish outside of class to submit them online within approximately one week. Students work in teams of four during typical class laboratory activities where they apply the programming concepts to solving common engineering problems (e.g., interpolation; analyzing, arranging, controlling repetitive processes; pattern identification and matching). Many studies [22], [25], [28]–[30] emphasize the importance of such team problem-solving in building hard and soft skills (communication, networking, etc.) in engineering education. Students also get weekly individual homework and approximately weekly individual quizzes.

2) The physical classroom: The physical classroom contains the most up-to-date technology to make it a modern active learning environment. The physical classroom is state-of-the-art with tables for four students facing each other at two across. The tables had connections for their laptops, including the ability to connect to a large screen monitor at one end of each table. The classroom has several larger monitors mounted high on each of its perimeter walls, even though some walls are transparent glass or have large windows. The classroom had a podium that the instructor could use. The podium controls all other monitors.

A typical classroom holds 96 students with four per table. Another table would seat for four peer-teachers [31] who are

usually undergraduate students who would assist the instructor in walking around the classroom helping students. There would also be quizzes administered during 20-30 minutes of the laboratory hours, in the physical classroom but using the online learning management systems (LMS).

3) The partially virtual classroom: The university was transitioning the learning management systems (LMS) from 2019 to 2020 (from BlackBoard™ to Canvas™). The university-wide licensing of the remote virtual conferencing systems switched by 2019 (from Cisco WebEx™ to Zoom™). The university had switched to completely virtual classrooms (with options for synchronous and asynchronous content delivery) after Spring Break 2020 with the world acknowledging a global COVID-19 pandemic. The university faculty and student groups' surveys found that many disliked the completely virtual classroom of the second half of the spring 2020 semester. Many students did not feel connected to their peers and the college classroom experience as found in research on COVID effects [12]–[14], [16]–[18], [32], importance of peer interactions in FYE education [20], [21], and teaming [22], [25], [28]–[30]. Therefore, the university decided to have onsite classes with a virtual option for students who were not comfortable attending class in-person or face-to-face, in other words, a Hybrid-Flexible or "HyFlex" format that combined virtual and onsite class meetings (again with synchronous and asynchronous content delivery options). A student may choose to attend online or in-person as desired, or according to their sense of safety, or following university protocol to self-isolate if positive for SARS-CoV-2 or awaiting test results.

For the hybrid classroom to maintain social distancing, the typical physical classroom population was reduced by a factor of three. This enabled only one student per table, where there were four before the pandemic. Each table had a one-inch circular adhesive color-coded tab at each of the four places to sit at the table to dictate when students would sit at that location. For example, the first class to use a classroom would only have masked students sit according to the color on a chart at the entrance to the building. The next class to use that classroom would sit students according to the next color on the chart, and so forth. The classrooms were to be cleaned in-between classes or as needed. Students were to wait outside the classroom (socially distanced) and enter the classroom when the instructor entered to start class. Everyone was to enter a classroom through doors designated for entry only and leave through doors designated for exit only.

The contact hours were changed to the instructor in the physical classroom holding the one-hour in-person lecture for the third of the class expected to attend in-person while other students attended virtually for synchronous content delivery. The remaining contact hours were completely virtual and dedicated to the in-class laboratory activities as per the design of the course. To lecture, the instructor came in and set up the classroom technology and the virtual connection to enable students that chose not to attend in-person to join the in-person group, to have as close to the typical experience as possible. However, due to occasional technical issues, the instructor elected to modify some "rules of online etiquette" allowing some students to not turn on video, if internet-challenged, but still be prepared to participate in classroom discussions or to answer questions. This was intended to engage the remote students the same as the in-person ones but then became an unintended check on students who were not necessarily paying attention or as attentive as the zoom window would suggest. The peer teachers did not need to attend class in-person and most attended virtually. This arrangement minimized the number of persons in the classroom and enabled the peer teachers to answer questions in the chat box of the virtual meeting software.

The laboratory activities were primarily handled by the peer teachers completely virtually. Since there was less control over who could attend virtually depending on student health or any reason beyond instructor control, the arrangements of teams of students to work on laboratory activities dictated a lot of flexibility due to the course taking place in the midst of a pandemic. Students were able to join virtual breakout rooms to continue their teamwork on team laboratory activities. The team laboratory activities were to continue outside of class and students could then choose to work virtually or in-person if possible. Other coursework were to be conducted individually. Quizzes would be administered completely online but still using the LMS.

4) The classwork: The lecture part of class introduces a programming concept then quickly goes into using that concept in engineering problem-solving examples similar to what would show up in later courses. For example, upon introducing the order of operations on variables in the programming language, students would then have laboratory activities where they write interpolation codes to see how it applies to say, tabulated data. Subsequent classes would show why you need loops to use interpolation on large data sets after introducing conditional logic, loops, lists, etc. then introducing functions to show why the interpolation needs to be coded as a function for re-use. The instructor and peer teachers would walk around to help students as needed or upon requests but this was highly discouraged during a pandemic.

The instructor (the first author) has a Socratic teaching style that is interactive lecturing, an approach that centers the student-teacher relationships around discussions of the course subject matter: engineering (e.g., Parker Palmer's [33] "subject-centered" teaching, 2021 Wakonse conference). The interaction enables quick small checks to see if students are involved and getting the material. Hence, the instructor asks and encourages many questions (Freire's [34] "dialogic teaching"), and furthermore, question every design and more. The instructor in fact, would frequently leave the slide presentation to work examples with students on the integrated development environment (IDE) as a form of the intended engagement of ELT [22]–[24]. However, walking around the classroom to see how students were implementing their own examples or to help them was discouraged during a pandemic. The coursework of students of other instructors (e.g., the second author) are excluded due mainly to variations in key assignments (e.g.,

TABLE I
FALL 2019 COURSE TOPICS BY WEEK (DATES MAY BE CHANGED DUE TO EXIGENT CIRCUMSTANCES)

Week	Class Topics
1 (8/26-8/30)	Introduction to Course, Engineering, Programming
2 (9/2-9/6)	Sequential Steps, Variables, Assignment, Data Types
3 (9/9-9/13)	Input/Output and Modules and Calling Functions
4 (9/16-9/20)	Conditionals and Boolean Expressions
5 (9/23-9/27)	Loops and Iteration
6 (9/30-10/4)	Creating and Testing Programs; Basic Debugging
7 (10/7-10/11)	Arrays and Lists of Data (last topic on Midterm)
8 (10/14-10/18)	Top-Down Design of Programs
9 (10/21-10/25)	File Input and Output
10 (10/28-11/1)	Using Engineering Modules in Python
11 (11/4-11/8)	Writing Functions, Scope
12 (11/11-11/15)	Functions and use in top-down/bottom-up design
13 (11/18-11/22)	Systematic Debugging
14 (11/25-11/26)	Exam 2
15 (12/2-12/4)	Topic TBD
14 Finals Week	NO FINAL

different quizzes).

The syllabus topics for Fall 2019 did not change significantly from the original design of the course [26], [27]. A minor rearrangement of topics introduced simple functions earlier for more utility throughout the semester. The Fall 2019 course topics are in table I.

Exam 1 was held during the second class of week 8. Exam was held during week 14. However, for Fall 2020 all exams were held virtually on the teleconferencing software and the LMS.

The syllabus topics for Fall 2020 did not change significantly from 2020 to try to give students as much of an equivalent experience to their pre-pandemic peers as possible. The schedule was moved up, however, because the university started the semester earlier in order to end it by Thanksgiving.

The one-hour-lecture and three-hours-laboratory structure of the course was retained for Fall 2020. However, the students were to watch video lectures for asynchronous content delivery before class. The video lectures were recorded by two other instructors prior to the start of the Fall 2020 semester. The in-class lecture was more of a complement to the video lectures for synchronous content delivery to the in-room and remote students. The one-hour in-person time was used to, say, quickly summarize lecture videos as needed and answer any questions on them, but mostly to work examples and apply the concepts within the limited in-person interaction contact time available.

B. Students

There are normally up to 384 students in the four sections of this first-year engineering class taught by the instructor. However, there were 340 students by the end of the Fall 2019 semester. The Fall 2020 decomposition of the usual four sections into 10-12 smaller sections led to 293 students by the end of the semester. Other further details on the demographic data are not considered in the retrospective analyses of strictly performance via grades data. Consideration of demographic data is left for other research that go deeper into the students and course topic [35], [36] than just on their available performance data.

C. Measures

Grades are considered in the analyses because they are of so much importance to the students and likely to be most directly and indirectly impacted by the pandemic. The final letter grade may be of greatest importance to many students, as it will impact their entry to a major (ETAM), but this study focuses on the two major exams that contribute more than half the points for the final letter grades. It is likely that the pandemic would influence the team laboratory activities, the homework, the quizzes, and exams, and therefore, the pandemic could directly or indirectly affect much coursework and final grades. Exams are valued as partly indicative of course performance [8]. The exams are not the only items analyzed but other coursework (laboratory activities, homework, quizzes) are also examined within the context of their later bearing on the exams. We can analyze the exams by questions but such data was only collected for 2019 due to disruptions in the instructor's normal interactions and communications with the less easily accessible Fall 2020 graders. The exam topics are the same and arranged in similar order for Fall 2019 and Fall 2020 though the problem statements or questions varied.

The first three weeks cover mostly introductory level material to acclimate students to computer representation of data and proper steps for calculations as well as receiving and displaying data (table I). The fourth week of class begins to use more sophisticated computer logic leading to the most difficult topics in the first exam: "Conditionals and Boolean Expressions," "Loops and Iteration," and "Arrays and Lists of Data" building on understanding conditional expressions to access data or data slices. Therefore, coursework related to these topics are more closely scrutinized. For brevity, these difficult topics are cited as conditionals (abbreviated as cond.), loops, and lists.

The second exam is not intended to be cumulative but builds on topics covered in the first exam. The most difficult topics in the second exam are file input/output wherein more sophisticated logic and list manipulations are needed to process data files and functions representing code segments. Therefore, coursework related to these topics are also more closely scrutinized.

D. Data analyses

The first analysis was of a graphical representation of the performance of the classes on similar coursework to observe any obvious visual distinctions. Then came using paired t-tests and ANOVA of the unequal samples of 340 of Fall 2019 coursework to 293 of Fall 2020 coursework.

VI. RESULTS

A. Performance on Exams

Figure 1 shows the changes from exam 1 to exam 2 for Fall 2019 and Fall 2020, respectively. The difference between exam means for the first exam between Fall 2019 and Fall

2020 is 7.26. The difference between exam means for the second exam between Fall 2019 and Fall 2020 is -5.79. These differences also show in the t-tests. For exam 1, the t-test(T_1^{F19}, T_1^{F20}) : $t_{statistic} = 5.97, p_{value} = 3.87 \times 10^{-9}$. For exam 2, the t-test$(T_2^{F19}, T_2^{F20})$: $t_{statistic} = -4.41, p_{value} = 3.87 \times 10^{-9}$. The differences in exam means also show in the ANOVA. For exam 1, the one-way ANOVA(T_1^{F19}, T_1^{F20}) : $F_{statistic} = 35.7, p_{value} = 3.87 \times 10^{-9}$. For exam 2, the one-way ANOVA(T_2^{F19}, T_2^{F20}) : $F_{statistic} = 19.4 =, p_{value} = 1.24 \times 10^{-5}$. Fall 2020 students' performance on exams started off poorer than Fall 2019 but that is reversed for exam 2 albeit a much smaller difference in mean of 0.321.

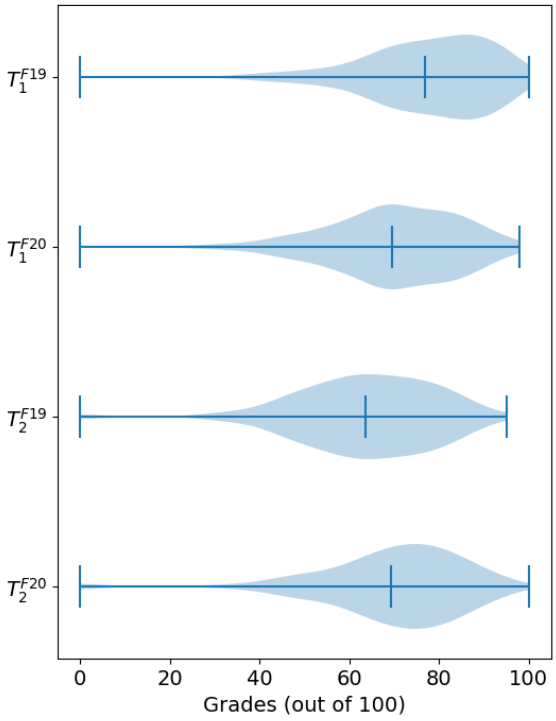

Fig. 1. Differences between Fall 2019 and Fall 2020 exam 1 and exam 2.

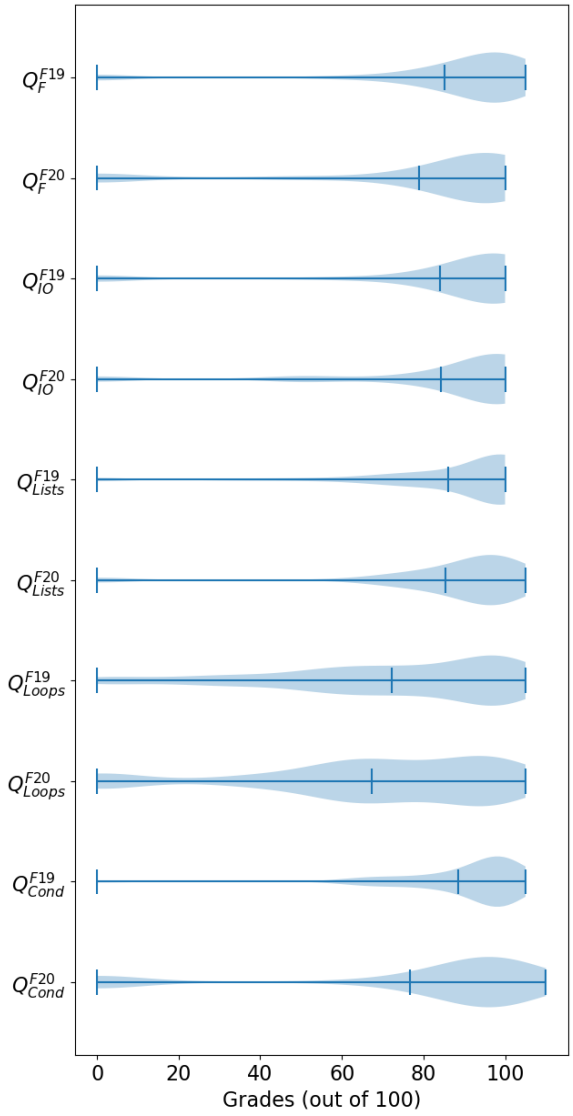

Fig. 2. Quizzes on the more difficult exam topics, Fall 2019 and Fall 2020.

B. Performance on Assignments That Contribute to Exams

The time-constrained in-class quizzes are more closely examined for indicators of any bearing on the exams. Figure 2 shows the results. The team laboratory activities and individual homework are not as restricted as the exams (timed, proctored, etc.) and are not closely examined.

The average on the conditionals quizzes, the biggest topic of exam 1, for the Fall 2019 students was 11.7 points higher than for the Fall 2020 students. The average on the loops quizzes for the Fall 2019 students was 4.78 points higher than for the Fall 2020 students. The average on the lists quizzes for the Fall 2019 students was 1.99 points lower than for the Fall 2020 students. This indicates that conditionals and loops were the major factors for the lower performance of Fall 2020 students on exam 1 than for the Fall 2019 students. The difference between averages on the file input/output quiz for Fall 2019 and Fall 2020 is -0.304 indicating hardly any change in how both groups did on that topic. The difference between averages on the functions quiz for Fall 2019 and Fall 2020 is 6.35 indicating that this is the main contributor to the difference in the performance of Fall 2019 students to that of Fall 2020 students on exam 2.

TABLE II
PAIRED t-TEST OF QUIZZES ON QUINTESSENTIAL COURSE MATERIAL, FALL 2019 TO FALL 2020

t-tests	t-statistic	p-value
Cond.: $t-test_{ind}(Q^{F19}_{Cond}, Q^{F20}_{Cond})$	5.172	3.117×10^{-7}
Loops: $t-test_{ind}(Q^{F19}_{Loops}, Q^{F20}_{Loops})$	2.0324	0.04253
Lists: $t-test_{ind}(Q^{F19}_{Lists}, Q^{F20}_{Lists})$	-0.9619	0.3365
File I/O: $t-test_{ind}(Q^{F19}_{Loops}, Q^{F20}_{Loops})$	-0.1351	0.8926
Functions: $t-test_{ind}(Q^{F19}_{Lists}, Q^{F20}_{Lists})$	2.703	0.007063

TABLE III
ANOVA OF QUIZZES ON QUINTESSENTIAL COURSE MATERIAL, FALL 2019 TO FALL 2020

1-way ANOVA	F-statistic	p-value
Cond.: ANOVA($Q^{F19}_{Cond}, Q^{F20}_{Cond}$)	26.75	3.117×10^{-7}
Loops: ANOVA($Q^{F19}_{Loops}, Q^{F20}_{Loops}$)	4.131	0.04253
Lists: ANOVA($Q^{F19}_{Lists}, Q^{F20}_{Lists}$)	0.1123	0.7377
File I/O: ANOVA($Q^{F19}_{Loops}, Q^{F20}_{Loops}$)	0.01826	0.8926
Functions: ANOVA($Q^{F19}_{Lists}, Q^{F20}_{Lists}$)	7.305	0.007063

Table II shows the t-test results. The higher the t-stat, the further away 1 class is from the other. Table III shows the ANOVA results to see the trends. The results show that conditionals were the most difficult course topics for both groups, but even worse for Fall 2020 than for Fall 2019 students. Loops were the next worse topics. The concept of lists builds on understanding conditionals and loops and benefited from more adjustments on them after the results of the prior quizzes. Further adjustments also helped on file input/output which requires loops and lists to manipulate data files. Functions introduce a different way to organize code and a drop in performance recurred with Fall 2020 students (during the pandemic) performing even worse than the Fall 2019 students.

VII. DISCUSSION

The Fall 2020 semester began with the best attempts to the students the same experience as the Fall 2019 semester students. However, Exam 1 results mandated further accommodating student needs that kept increasing during the semester. Accommodations included allowing more late homework than was usual. This became more and more necessary during the Fall 2020 semester with more and more students testing positive for COVID or awaiting test results. This section presents a closer look at the results with some useful student comments from the evaluations.

A. RQ1. How does a major change in the format of course content delivery due to modifications for a pandemic affect students' performance in their grades?

Laboratory activities conducted in teams are intended to help students get immediate support from teammates, thereby helping them do well in a large class [28], [30]. Team dysfunction arose more frequently during Fall 2020 and that probably influenced the performance in exam 1 as it was worse for Fall 2020 students than Fall 2019 students, undoubtedly due to the pandemic-mandated changes. Typically students rarely change teams during the semester. However, for Fall 2020, students had difficulty forming or finding teams in a hybrid class structure and switched teams more often than for Fall 2019. The sense of vitality to help teams thrive [18] found initial difficulties in getting established. A more formal team formation process [25], [29] was difficult to follow with the many modifications for Fall 2020. Some students teamed with people they knew from outside of class. Some students would gravitate to teaming with whoever is there with them in the physical classroom. There was no teaming with a lesser-known person in a virtual environment, especially if remote students preferred video off when virtually attending class [32]. Indeed, some students took advantage of the instructor relaxing the "video-on rule" of "online etiquette," meant to accommodate students with internet issues, and often kept video off. Nonetheless, a few virtually-attending students expressed that they found it advantageous to have a teammate who could be physically present who then could supplement anything that might be missed. What were not found to be problems were communication [18] and technology [11] for options available (e.g., Google Groups™, Slacker™, Microsoft Teams™, GroupMe™) despite occasional internet issues. The more favorable team interactions in some inverted or flipped classrooms noted in previous studies on such classrooms [6] were not always observed in this study. However, any class that takes place during a pandemic is likely experiencing more tensions than normal.

Students readily and heavily used the technology available to them [11], despite occasional technical issues (a few students suggested that they might design new or redesign some of the technology in a future job). Some of the students who attended class in-person would watch one or both of the pre-recorded lectures and the recording of the in-class lectures, after attending class in-person, availing themselves both the synchronous and asynchronous content. Many teams supplemented the virtual meeting software used in class with other internet collaboration software. Another lesson of this study on modifying this course for a pandemic would be to plan for how to team for optimal beneficial use of reliable technology under difficult circumstances to avoid low grades, especially at the start of the semester.

B. RQ2. How does students performance on course topics change during each semester for students who have been affected by the pandemic compared to students before it?

With respect to the course topics, conditionals and loops emerged as needing more resources and support for ensuring student understanding and performance, especially for the pandemic-affected Fall 2020 students. The average on the conditionals quiz for the Fall 2020 students is 11.7 points lower than Fall 2019 students. Despite more Fall 2020 students' bonus points on the conditionals quiz, some other Fall 2020 students did worse on that quiz. Understanding conditionals helps with controlling loops and that explains the further decrease from the conditionals quizzes to the loops quizzes for

both Fall 2019 and fall 2020 groups of students. The topics of conditionals and loops may simply need more time.

The pandemic restrictions and the hybrid format would require adjustments by the students in many aspects including seeking help. Students came to identify preferred resources (PT, TA, Supplemental Instruction (SI) [31] sessions, office hours, etc.) but finding in-person help was no doubt more cumbersome for Fall 2020's students than for Fall 2019's.

Students' statements in the course evaluations indicated that those who attended class in-person preferred the face-to-face time spent with peer teachers or teaching assistants than during virtual office hours. Virtual office hours with the instructor increased and was preferred by some students [18]. Fall 2020 students appeared to generally value office hours more than their Fall 2019 peers. Students appeared to relish the one-on-one time spent with the instructor or PT's more than usual, even if it was virtual. However, there was no anecdotal observation of an increase in the request for office hours over previous semesters. Stopping by the podium to discuss anything with the instructor after class occurred much less for Fall 2020 than for Fall 2019, which is to be expected given the social distancing requirements. Thus in-person opportunities to request help decreased for Fall 2020, despite being preferred. Using office hours generally increase during a semester when students get to know instructor and PT, or realize they need more help, but Fall 2020 included virtual office hours. Teleconferencing improved office hours because screen-sharing enabled walking students through properly coding an assigned problem's solution instead of looking over a student's shoulder or typing on the student's laptop. As office hours increased, expressions of frustrations decreased, and that partly helped improve performance after the first exam.

VIII. Limitations of the Study and Suggestions for Future Research

The opportunity for a comparative study arose from the unexpected declaration of a pandemic that caused a difference between the implementation of the same course over two subsequent semesters, one before and one during the pandemic. As such, the study was therefore not pre-planned, it had to be conducted quantitatively and retrospectively on existing comparable data. An obvious limitation then is that there were no immediately available other corresponding data characteristic of the students in the courses to enable a broader perspective correlated with qualitative research. For example, student observations were not readily available for the pre-pandemic semester that would correspond that well to impressions of students during the pandemic. Focus group interviews could be conducted with the caveat that pre-pandemic students would be trying to retrospectively reflect with a possible bias: everyone now knows of the pandemic. Demographic data was difficult to gather but could be considered to broaden the context of the results. Specific roles of specific technologies should be studied for not just the impact on students but if even suitable or viable for the students accounting for their human needs. Studying other sections by other faculty would be helpful but the coursework has to be very similar yet minimize the risk of cheating. A study of faculty teaching the courses could also help incorporate their viewpoints. Assembling this study with those of other institutions FYE experience would also help broaden and deepen the understanding, and also the scope of the study, of the broader effects of a global pandemic.

IX. Significance of the Study

The findings of this study have several implications for the design of university courses to be prepared in case of not just a pandemic but any natural disaster or other unexpected major societal disruption. It does not suffice to just have the technology readily available (the internet already existed, LMS and virtual meeting software were already licensed, etc.) but now the specific role of the technology must be properly planned just in case. Specific to the FYE core course is the need to consider the technology that has to be amalgamated appropriately with the human needs (e.g., student health (not just physical but mental, etc.), teaming, staying connected). Indeed online office hours should remain an option post-pandemic and even post-endemic as some students preferred it and thrived with it because the instructor could connect one-on-one with a student. Even one-on-team could be done with fewer distractions online than at a table in the physical classroom. Of course, there is the ability to walk a student through coding a problem's solution when screen-sharing. Also, with respect to the course subject matter, conditionals and loops emerged as topics that need more resources and support for ensuring student understanding and performance.

X. Conclusions

We conducted a quantitative and retrospective study to note how student performance is influenced by changing a first-year engineering computation course from completely face-to-face for Fall 2019 to partially online for Fall 2020 in response to a global pandemic. The pandemic adversely impacted the teaming in a course where each week consists of one-hour lecture and three-hours in-class team activities: difficulties arose in team formation, interactions; more teams than usual needed re-structuring throughout the semester. Two in-class exams and major in-class quizzes on key topics on those exams are closely examined as they contribute about 2/3 of the points toward the final letter grade that most concern the students as primary course stakeholders. The first exam averaged 7.26 points lower for Fall 2020 students than Fall 2019 while that reversed by -5.79 in the second exam with more pandemic-related adjustments made (e.g., more accepting of late work, thus allowing more time toward mastery; students' increasing use of online office hours; getting support, e.g., a peer teacher, in-person or not). The lowest quiz grades were on conditionals and loops, which explained the first exams being worse than the second. These quizzes were bad for both groups, indicating that these topics need more resources (e.g., time), especially during a pandemic when these grades were even worse. The findings suggest that courses have sufficient fluidity for a pandemic, natural disasters, or other unexpected major

societal disruptions, to have reliable technologies available (the internet, virtual meeting software, etc.) and plan their specific role for human needs (e.g., student health (including mental, etc.), teaming, staying connected, online office hours).

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