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Does student performance decline in online classroom setup? A study of students' performance in ECE controls class

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Abstract

With the strike of COVID-19, all schools transitioned to online learning. Studies conducted during the pandemic indicated that many instructors and students expressed that their experience has degraded compared to the regular face-to-face class meetings. During remote classes, students' attention spans were observed to be lower than ever before. Additionally, many students expressed that they are struggling with their learning and feel disconnected from the class and their classmates [1]. As a result, class attendance also dropped to unpreceded levels. Currently, although most of the schools returned to in-person instructions, thanks to the declined infection rate after the development of different vaccines, online and hybrid class meetings are still an option for conducting a class, especially for those students who might contract COVID during the semester. In this work, we study the students' performance in a linear control course across three different cohorts: pre, during, and after the pandemic. Statistical analysis of students' exam scores is used to infer whether the online experience significantly affected the students learning or not. We use data from the course offering in fall 2019, fall 2020, and fall 2021, where the taught modules and final exams were kept the same. In addition, while the homework assignments were not identical, they were of the same level of difficulty and coverage, so we extend the study to include the students' performance using the homework assignments too. To study how the same student cohort reacts to different class meeting modes of the same subject, we study the students' perception of the change in teaching mode, from in-person to online, during the offering of a feedback control course in the summer of 2022. In that semester, with the same body of enrolled students, we taught the first half of the semester in-person and the second half online. We fixed the class activities and teaching pedagogy throughout the semester. We compared students' scores, participation rate, and attendance rate in the in-person modules vs their scores in the online modules. The statistical analysis of student scores in the two courses showed that students' performance in remote setup is significantly higher than, or at least the same as, student performance in in-person offerings of these two courses. Finally, we used an anonymous student survey to capture students' perceptions of the change in the teaching mode during the semester. Students indicated that the transition to remote learning made it hard to stay engaged in class. However, class activities and class recordings helped to mitigate these shortfalls.

1. Introduction

The traditional in-person learning experience has been a staple of education for centuries. Despite the emergence of online learning, many students still prefer the traditional in-person learning experience. The primary advantage of traditional in-person learning is the ability to interact with teachers and peers in real-time. This allows for more effective communication and collaboration, which can lead to a deeper understanding of the material. While there are means for communication in online classrooms, previous research has shown that class interactivity tends to drop in online classes during the pandemic [1]–[3]. Additionally, in-person learning allows for more personalized instruction, as teachers can tailor their lessons to the individual needs of their students. Finally, in-person learning can provide a more engaging learning environment, as

students can participate in activities such as group discussions and hands-on activities. On the other hand, the primary disadvantage of traditional in-person learning is the lack of flexibility. Students must attend classes at specific times and locations, which can be difficult for those with busy schedules or who live far away from the school. Additionally, in-person learning can be disruptive, as their peers or the environment may distract students. However, the traditional in-person learning experience can have a positive impact on student learning and engagement. Previous studies have shown that students who participate in in-person learning are more likely to retain information and develop a deeper understanding of the material [4].

The COVID-19 pandemic has affected education in various aspects. Several studies reported the challenges with online teaching before and during the pandemic [1]–[3], [5], [6]. Many students reported that they experienced feelings of isolation and lack of motivation due to the lack of face-to-face interaction. Additionally, students might struggle with the technical aspects of online learning, such as navigating the learning platform or understanding the course material. Many instructors and students expressed that their experience has degraded compared to the regular face-to-face class meetings [1]–[3]. However, previous research on the student experience in online classrooms reveals that students often find online learning to be more convenient and flexible than traditional classroom learning [1].

The performance of students in an in-person classroom and an online classroom can vary significantly [7], [8]. In an in-person classroom, students can interact with their peers and the instructor in real-time, which can help them to better understand the material and stay engaged. Additionally, in-person classrooms often provide more opportunities for hands-on learning and collaboration. A recent study surveyed electrical and computer engineering (ECE) students about their preference for teaching methodology during the pandemic, The majority of the responses were in favor of having in-person class meetings [9], [10]. On the other hand, online classrooms can be more convenient and allow students to work at their own pace. However, online classrooms can also be more isolating and lack the same level of engagement as an in-person classroom. Furthermore, the current generation of students is typically more accustomed to traditional in-person learning, and a shift to online learning may disrupt their preferred methods of learning and studying. Ultimately, the performance of students in an in-person classroom and an online classroom will depend on the individual student and the type of learning environment they prefer. However, the literature lacks on quantitative assessment of remote learning on students' performance. This motivated the author to conduct a quantitative study on the impact of online remote learning on student performance in online class setups and as they transition from in-person to online instruction. In this study, we focus on Linear and feedback control courses offered at the ECE department of the University of Pittsburgh.

We depend on two courses in our study. In the first course, we consider three different cohorts to study whether remote instruction significantly affects students' performance compared to in-person instruction. In the second course, we study how the same student cohort reacts to different class meeting modes of the same subject throughout the semester. We used students' scores in homework assignments and exams for the quantitative assessment of the online instruction's

impact on student performance. We also used student surveys to capture their perception of changing the class' meeting mode during the semester.

The Methods section of this paper introduces and references the research questions, class description, and data analysis methods used, including statistical and qualitative analysis methods. The Results section presents and discusses the quantitative analysis of students' scores in online vs. in-person teaching, as well as content analyses of student perspectives on switching to a remote setup during the semester. Finally, the paper concludes in section 4.

2. Methods

In this work, we study the impact of online remote learning on student performance in two control classes at the ECE department, University of Pittsburgh. In our analysis, we investigate an answer to the following questions:

1. Does students' performance decline in an online classroom setup compared to an in-person setup for the same subject?
2. How do students react to changing the class' meeting mode in the middle of the semester?

To address the first question, we studied the students' performance in Linear Systems Theory (Course 1) across three different cohorts; pre, during, and after the pandemic. Statistical analysis of students' exam scores was used to infer whether the online experience significantly affected the students learning or not. We used data from the course offering in fall 2019, fall 2020, and fall 2021, where the taught modules and final exams were kept the same. In addition, while the homework assignments were not identical, they were of the same level of difficulty and coverage, so we extend the study to include the students' performance using the homework assignments too.

To study how the same student cohort reacts to different class meeting modes of the same subject, we study the students' perception of the change in teaching mode, from in-person to online, during the offing of the Feedback Control course (Course 2) in summer 2022 (12-week). In this semester, with the same body of enrolled students, we taught the first half of the semester in-person and the second half online. We fixed the class activities and teaching pedagogy throughout the semester. We compare students' scores, participation rate, and attendance rate in the in-person modules vs their scores in the online modules. In addition, we used an anonymous student survey to capture students' perceptions of the change in the teaching mode during the semester. The results of the student survey from Course 2 not only shed light on the COVID-19 phase but also can assist instructors who are interested in offering online modules to design them more effectively. The decision to adopt online teaching can arise from a variety of factors, including emergency response, pedagogical considerations, and personal needs. That was the motivator to change the class-meeting mode for the second course mid-semester in the summer of 2022.

2.1. Courses and Classroom Instructional Activities

This study considered two ECE control courses: 1) linear systems theory and 2) feedback control. Both courses were taught synchronously with active learning activities included, regardless of the class's meeting mode (i.e., in-person or online). The linear systems theory course (Course 1) is offered as an elective to first-year master's students and senior undergraduate students. Whereas

feedback control (Course 2) is offered to junior and senior undergraduate students as a required course towards the completion of the electrical engineering program in the ECE department hosting this study. During the online offering of both courses, class meetings were held synchronously over Zoom, and class recordings were posted on the course website (Canvas) after each class meeting.

In Course 1, students learn the system's state-space representation, linearization, controllability, observability, state-feedback, and design of state-observer and state-feedback controller. In Course 2, the students learn the basics of system modeling, system analysis and characteristics, and different controller designs, e.g., proportional, integral, phase-lead, phase-lag, and PID. In both courses, the lectures cover mathematical definitions and theories, analytical problems, and design problems that students can attempt to demonstrate their knowledge of the different control approaches. In both courses and regardless of the meeting mode, the instructor used simple active learning exercises, like think-pair-share (TPS) and class discussions. In the online offering, activities like TPS were held using the breakout rooms feature of Zoom.

In Course 1, we address the first research question and we considered three cohorts; fall 2019, fall 2020, and fall 2021. Cohort 1 (fall 2019) and Cohort 3 (fall 2021) were offered in-person, while Cohort 2 (fall 2020) was offered online. The average enrollment over the three cohorts was 36.

On the other hand, to study how the same student cohort reacts to different class meeting modes of the same subject, we considered the summer 2022 cohort from Course 2, with an enrollment of 15 students. In Course 2, the first half of the semester was taught in-person, while the second half of the semester was taught remotely. Thus, besides addressing the first research question, Course 2 is also addressing the second research question.

To diversify the text, we use the course names and their respective IDs (i.e., Course 1 and Course 2) interchangeably throughout this paper. For reference, Table 1 summarizes the two courses, the semesters in which they were offered, and the research questions they address.

2.2. Direct assessment of student performance

We used students' scores in homework assignments and exams to directly assess the student performance with changes in meeting modes (i.e., in-person vs. online) in both courses. In all offerings of Course 1, the taught modules and final exams were the same. Since we used the same final exam, the exam questions were only accessible during the exam time for all cohorts. In Course 2, since it is only one cohort, we compare the midterm exam scores (contents studied during the in-person offering) to the final exam scores (contents studied during the online offering) of the same cohort. The instructors maintained the same level of difficulty for both exams. In addition, for both courses, while the homework assignments were not identical, they were of the same level of difficulty and coverage.

In both courses and for all cohorts, teaching assistants (TAs) evaluated the homework assignments using rubrics provided to them by the instructor, while the instructor graded the midterm and final exams. All the scores were recorded on the course management system, Canvas. The assignments

Table 1. Summary of the two control courses used in the study

	COURSE 1	COURSE 2
NAME	Linear System Theory	Feedback Control
RESEARCH QUESTION ADDRESSED	1	1 and 2
ENROLLMENT	36 (average)	15
IN-PERSON OFFERINGS	Fall 2019, Fall 2021	Summer 2022 (first half)
ONLINE OFFERINGS	Fall 2020	Summer 2022 (second half)
ASSESSMENT METHODS FOR THE STUDY	Homework, Exams	Homework, Exams, Survey

used in this experiment were not created specifically for it. Rather, they were created to adhere to the guidelines set by the department's curriculum committee in order to effectively evaluate students' understanding of control theory. The assignments have the same structure and level of difficulty as those used in previous semesters.

Many instructors are concerned about cheating in online exams [2]. To address this concern in Course 1, exams were conducted using the Respondus LockDown browser [11], and students' cameras were enabled for monitoring by the instructor and TAs. In contrast, since the transition to online learning for Course 2 was not motivated by a health or safety concern, the instructor decided to hold all exams in person.

We used statistical analysis for score comparisons. In Course 1, an analysis of covariance (ANCOVA) [12] was conducted for the comparisons, with GPA at the start of the semester used as the control variable to take historical academic performance into account. Additionally, Cohen's d or Hedge's g effect sizes were calculated to determine the practical significance of the differences, with values below 0.50 considered small and values 0.80 or above large [13], [14]. Hedge's g is used for small samples [15]. For Course 2, the scores from the two halves of the semester were compared using paired samples t-tests. Glass' Delta effect sizes were calculated to determine the practical significance of the differences, with values below 0.50 considered small and values of 0.80 or above large [13], [14]. Glass' Delta is often used in the case of paired samples [15]. In addition, the non-parametric analog to the t-test, the related-samples Wilcoxon signed-rank test, was run to corroborate the results of the t-test given the smaller sample size ($n = 15$) [16].

2.3. Assessment of Student Perspectives

Students' perception of the switching to remote instruction during the second half of the semester was acquired in Course 2 by conducting anonymous surveys (Table. 2). Participation in the surveys was voluntary. The student surveys were collected toward the end of the semester and before the

Table 2. Survey Questions in Course 2

Judging by your overall experience with the remote offering of this course during Summer 2022, What are the factors that helped (or didn't help) your learning of the remote modules?
Based on your experience in the second half of the semester, what would you prefer to the class meeting mode?

final exams. The answers to the survey questions were in free form. Then, the student responses were then content analyzed [17]. The survey was hosted on the University's online survey service (Qualtrics), and all the responses were securely saved on the university servers. In total, twelve survey responses were collected. Human subjects' approval (PRO18060710) was secured for these various forms of student assessment.

3. Results and Discussion

3.1. Direct Assessment of Student Performance

Table 3 summarizes the ANCOVA analysis results for Course 1. When comparing the students' scores for all assignments across the three cohorts of Course 1, our analysis shows that, on average, the students in in-person course offerings performed better in the homework assignment than their peers in the online cohort. The lower homework scores for the online cohort may be attributed to the absence of private short meetings with the instructor that students could have had immediately before or after in-person class meetings. Besides the office hour slots, the instructor makes himself available for 15 minutes before and after the class meeting for short meetings. During these short meetings, students could ask quick questions to help them with their homework assignments. The instructor has been teaching Course 1 since the fall semester of 2017 and this kind of meeting is very common in his class. However, during the online offering of the course, the instructor observed that the rate of short meetings before and after class was significantly lower. This observation is consistent with the findings of a previous research study conducted by the author during the pandemic [1], which included Course 1. The study reported a disruption in student interactions with their instructors and peers in online learning, as reported by students in surveys.

On the other hand, the final exam scores of students in the remote cohort were significantly higher than the scores of their peers in the in-person cohorts. No significant difference was found for the midterm exam scores, though. However, the remote cohort average is higher than the average midterm score of the in-person cohorts. To confirm these results, we combined the scores from cohorts 1 and 3 (in-person) and compared them to the scores from the second cohort (online). The results of this second comparison are summarized in Table 4 and are in agreement with the conclusions from Table 3. The higher exam scores for the online cohort could be due to the fact that online sections students have access to class recordings, thus, they could watch these recordings and clarify any misunderstanding while they prepare for their examinations. Thus, despite the shorter attention span that students might have, especially in an online classroom [1], [18], these class recordings serve as a good assist for student revision.

Table 3: Course 1 score Comparisons for the three cohorts

	Mean Score (100)			*p-value*	
	Cohort 1, In-person (*n*=38)	Cohort 2, Online (*n*=40)	Cohort 3, In-person (*n*=30)	ANCOVA test	Kruskal-Wallis test (non-parametric)
Homework	94.72	90.14	94.42	**0.017**	**0.0013**
Midterm Exam	82.18	86.19	81.39	0.22	0.316
Final Exam	61.63	69.89	63.27	**0.035**	**0.02**

Table 4: Course 1 score Comparisons, in-person vs. remote class meetings

	Mean Score (100)		*p-value*	Effect Size
	In-person (Cohorts 1 and 3) (*n*=68)	Online (Cohort 2) (*n*=40)	ANCOVA test	Hedge's g
Homework	94.4	90.14	**0.004**	0.57
Midterm Exam	81.83	86.19	0.08	0.35
Final Exam	62.3	69.89	**0.011**	0.52

In Course 2, there was no significant difference in students' scores pre or post-transitioning to online learning (Table 5). The scores of all assessment types in the in-person modules are slightly higher than the scores in the online modules. Nonetheless, the differences are not of practical significance as suggested by the Glass' Delta size effect. Based on the data in Table 5, there is no significant evidence to claim that student performance dropped after transitioning to online instruction.

3.2. Assessment of Student Perception of Transitioning to Remote Learning

The first survey question in Table 2 gathered students' perspectives on the factors that affect their learning in remote classrooms. Based on the content analysis of the collected 12 responses, the majority of students had a positive experience with the flexibility that remote learning offers. They do not have to commute to the campus to attend the class. In addition, 90% of the students mentioned that they used the recordings of the class meetings to review the course contents. Class discussions were also listed by 50% of the students as a positive experience that enabled them to maintain focus and reduce the distractors from the non-physical classroom environment.

Although all students agreed that Zoom's breakout rooms were a reasonable substitute to hold group discussions and TPS, 50% of the students indicated that they do not prefer using breakout rooms as a medium to hold class discussions due to the logistics of going in and out from the rooms. They indicated that having an entire class discussion within the main room would make better utilization of time. Also, 50% of the students indicated that it was hard for them to feel connected with their peers compared to the in-person sessions of the same class. We quote the following from one of the students' responses, "The second half of the course being online didn't hurt my ability to learn the content very much, but it was harder to feel engaged in the class."

Table 5: Course 2 scores Comparisons, pre, and post-transitioning to remote learning

	Mean Score (100)		***p-value***		**Effect Size**
	In-person (n=15)	Online (n=15)	Paired Samples t-test (parametric)	Wilcoxon Signed Rank test (non-parametric)	Glass' Delta
Homework	70.38	67.92	0.526	0.477	0.54
Exams	79.7	74.56	0.4	0.307	0.08

Finally, 30% of the students complained about distractors affecting their learning when joining the class from somewhere else outside the physical classroom. The instructor noted that the average attendance rate for Course 2 dropped from 90% during the first half of the semester (in-person meetings) to 75% in the second half of the semester (online meetings), indicating that some students would rely on the class recordings in lieu of attending the synchronous class meeting.

The second question examines the students' overall experience with remote learning in the second half of Course 2 and whether they preferred in-person meetings instead. Eleven students gave a direct answer to this question, while one student indicated it was hard for them to reflect on a preference. The results of this question are summarized in Figure 1. The majority of students (50%) would prefer an in-person offering to a remote offering. However, a considerable amount of students (~45%) indicated they prefer remote meetings, or at least find the remote experience comparable to the in-person experience. Indeed, being remote impacts student focus span, and the remote experience is still incomparable to the in-person experience in terms of the feelings of being connected and engaged. However, the class activities and discussions could help close the gaps between in-person and remote class meetings.

4. Conclusions

The COVID-19 pandemic has affected education at all levels. Both instructors and students faced challenges dealing with remote classes. The instructors were worried most about their students' performance, attention, and involvement with the class materials while off-campus. Previous research conducted qualitative and in-direct assessments of college students' perceptions of remote learning during the pandemic. However, we could not find quantitative studies on their performance in remote setups; especially for the ECE curriculum. In this work, we studied student performance in two ECE control courses to assess the performance of students in online cohorts to their peers in in-person cohorts. We statistically analyzed the scores of students from two in-person cohorts and one online cohort of the linear systems theory course offered at the ECE department hosting this study. Surprisingly, the exam scores for the online cohort were significantly higher than the scores of the in-person cohorts. When the same cohort of students transitioned from in-person meetings to remote meetings, in Course 2, no significant difference in student scores due to the transition to remote learning was observed. Flexibility and access to class

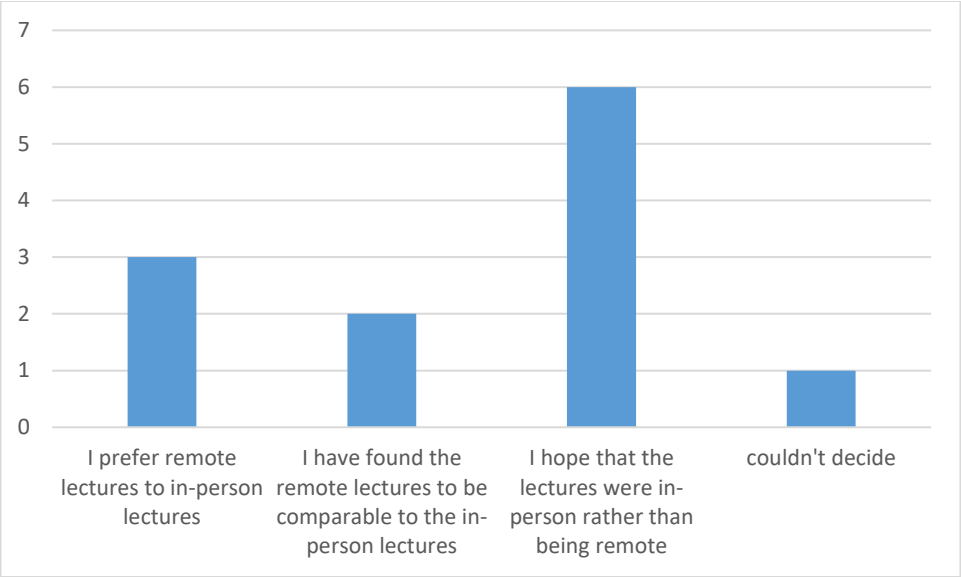

Figure 1. Students' preferences of remote vs in-person offering for the second half of Course 2.

recordings were the main factors that aided student learning during the remote learning phase. We also conducted student surveys to gather their perception of the transition to remote learning in the middle of the semester. Our results showed that there is no significant evidence for a negative effect of online instruction on students' academic performance. However, half of the students in our study still prefer in-person class meetings as they find it challenging to remain engaged in a remote learning setup. While most of the school returned to regular in-person operation, the remote option is still available in case of sickness or a potential outbreak of COVID again. Remote instructions can also be used to serve pedagogical needs or for personal convenience when in-person classes are not a feasible option. To reduce the shortfalls of class engagements in remote meetings, instructors can stimulate engagement by asking questions regularly and by increasing the rate of class discussions and activities. Finally, to further support the outcomes of this study and as future work, the author plans to expand the research and consider more offerings of Course 2 to increase the sample size.

References

[1] A. Hassan, A. Dallal, and M. Zaghloul, "A survey-based study of students' perspective on different remote teaching styles during COVID-19," in *ASEE Annual Conference & Exposition*, 2021.

[2] A. Dallal, M. Zaghloul, and A. Hassan, "New Instructors Perspectives on Remote Teaching Methods," in *ASEE Annual Conference and Exposition*, 2021.

[3] C. Carrillo and M. A. Flores, "COVID-19 and teacher education: a literature review of online teaching and learning practices," *Eur. J. Teach. Educ.*, vol. 43, no. 4, pp. 466–487, Aug. 2020.

[4] A. K. Singh, M. A. Yusoff, and N. Oo, "A Comparative Study between Traditional Learning and E-Learning," *Proc. Teach. Learn. Open Forum 2009*, pp. 1–7, Sep. 2010.

[5] L. Moller, W. R. Foshay, and J. Huett, "The evolution of distance education: Implications for instructional design on the potential of the Web," *TechTrends*, vol. 52, no. 4, pp. 66–70, Jul. 2008.

[6] L. Darling-Hammond and M. E. Hyler, "Preparing educators for the time of COVID … and beyond," *Eur. J. Teach. Educ.*, vol. 43, no. 4, pp. 457–465, Aug. 2020.

[7] A. J. Bowers and M. D. Dixson, "Student experience with traditional in-person learning: A review of the literature," *Educ. Res. Rev.*, vol. 8, no. 2, pp. 97–112.

[8] A. Dallal, "Students performance in remote flipped signals classes," in *ASEE Annual Conference & Exposition*, 2021.

[9] A. Dallal, M. Zaghloul, and A. Hassan, "Effect of Active Learning on Students' Performance in Remote ECE Classes with Lab Sections," in *2022 ASEE Annual Conference & Exposition*, 2022.

[10] A. Dallal, M. Zaghloul, and A. Hassan, "A Study of Students Perspectives on Different Pedagogical Practices for Remote Digital Signal Processing Courses," in *IEEE Frontiers in Education Conference (FIE)*, 2021, pp. 1–5.

[11] "LockDown Browser - Respondus." [Online]. Available: https://web.respondus.com/he/lockdownbrowser/. [Accessed: 14-Apr-2023].

[12] D. Quade, "Rank Analysis of Covariance," *J. Am. Stat. Assoc.*, vol. 62, no. 320, pp. 1187–1200, Dec. 1967.

[13] J. Cohen, *Statistical power analysis for the behavioral sciences*. 2013.

[14] G. M. Sullivan and R. Feinn, "Using Effect Size—or Why the *P* Value Is Not Enough," *J. Grad. Med. Educ.*, vol. 4, no. 3, pp. 279–282, Sep. 2012.

[15] D. Lakens, "Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs," *Front. Psychol.*, vol. 4, 2013.

[16] M. Norusis, *SPSS 14.0 Statistical Procedures Companion*. Upper Saddle River, NJ: Prentice Hall, 2005.

[17] K. Neuendorf, *The content analysis guidebook*. Sage, 2016.

[18] N. A. Bradbury, "Attention span during lectures: 8 seconds, 10 minutes, or more?," *Adv. Physiol. Educ.*, vol. 40, no. 4, pp. 509–513, 2016.