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Enabling Student Success in an Online Lab-based Circuits Course

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ABSTRACT

In this work, the online offering of a sophomore electrical and computer engineering hands-on course at UC Davis during COVID-19 pandemic is discussed. In response to California's social distancing guidelines, the course was abruptly moved from in-person to remote instruction. To overcome the challenges inherent in remote instruction, we employed novel policies, "Boost Points" (BP) and "Student Assistants" (SA), to incentivize early action on lab assignments and interaction between students. We present survey and participation data that show students favor these techniques. Finally, we outline future directions for SA/BP in lab-based circuits courses.

Key words: Analog and Digital Systems, Remote Learning, Laboratory Course

INTRODUCTION

In this paper, we discuss the UC Davis Spring 2020 offering of the sophomore electrical and computer engineering (EEC) course, EEC10 - "Introduction to Analog and Digital Systems." EEC10 is a lab-based course that introduces EEC undergraduates to building and debugging analog circuits and microcontroller programming [1].

In response to California's social distancing guidelines, the course was abruptly moved from in-person to remote instruction. Prior work has investigated techniques for online instruction in lab-based circuits courses [2–4], but the abrupt transition to remote teaching prevented the teaching staff from implementing these techniques. We faced challenges in delivering instruction and assistance, as remote instruction disrupts typical feedback loops and hinders issue resolution. We also faced logistical challenges such as the distribution of hardware to students living in different parts of the state, the country, or the world as well as software installation on heterogeneous devices.

To tighten the feedback loop, we employed new techniques and policies including incentivizing early action on lab assignments, and distributing responsibility for assisting other students as well as more established practices such as providing students with video tutorials for asynchronous learning. We present survey and participation data that show students favor these techniques, and we discuss future directions for remote lab-based circuits courses.

METHODS

For remote labs, we conducted daily lab video conferencing sessions (Zoom). Conducting labs remotely impedes students engagement in at least two ways:

1. **Circuit debugging** – Remote labs over video conferencing complicate getting feedback on circuits, as it is difficult to point to specific locations on a circuit through a camera.
2. **One-on-one attention** – For each lab session, one TA was responsible for twenty students. If the TA is not mindful of time spent with each student, then the TA might not address every student before the session ends.

To remedy these barriers to student engagement, we implemented the following policies:

Student Assistants/Boost Points

The primary issue faced during lab sections is lack of one-on-one attention for students. To provide more human resources, we implemented a Student Assistant policy. First, we incentivized students to finish labs early by offering extra credit in the form of Boost Points (BP). For each day before the deadline that students finished the lab, they would earn 2 BP up to a maximum of 10.

Students who submitted early could join a lab session as Student Assistants (SAs). The TA would take students with similar questions, pair them with a SA and create a private Breakout Room for them to work (see Figure 1). The SAs were made aware that they did not need to know all of the answers as the TAs were always available if the group was stuck. The early submission extra credit had a synergistic effect with SAs, as the more students that finished labs early, the more SAs that participated.

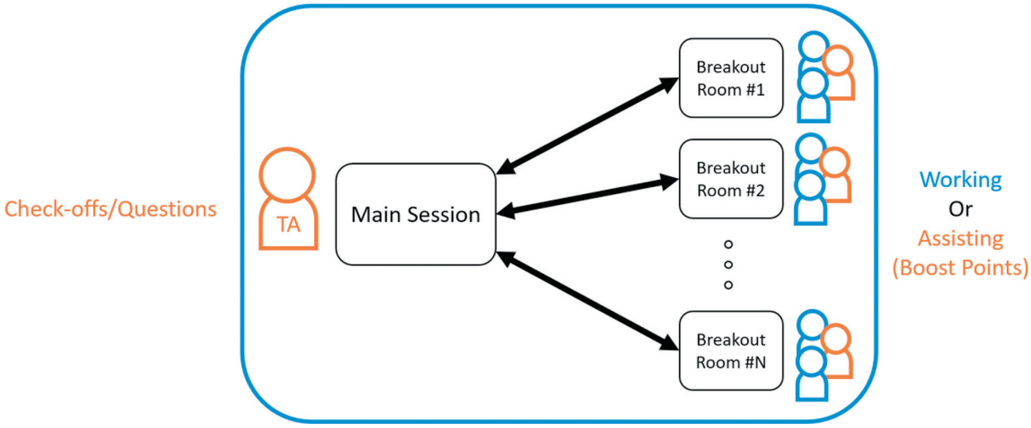

Figure 1. Hierarchy of breakout rooms/main rooms used to enable Student Assistants.

Video Tutorials

Instead of synchronously demonstrating labs via video conferencing, an asynchronous approach was more efficient to present the information. TAs recorded and edited videos describing each week's lab as well as the final project and addressing some of the common lab issues.

PRELIMINARY RESULTS

Participation Rates

Table 1 shows the participation rates for the two BP interventions. At least one-quarter of the class participated as an SA at one point, and five students volunteered as SAs every week of the quarter. A majority of students (88%) took advantage of the Early Submission (ES) intervention, and the average (median) cumulative number of days ahead of the deadline which students submitted assignments was 13.6 (10) days.

Table 1. Participation numbers (N) and rates (%) for students. Total class enrollment was 65.

Description	N	%
Students that participated as a student assistant (SA) at least once	16	25%
Students that participated as SA every week	5	8%
Students that earned early submission (ES) boost points	57	88%
Students that never earned boost points	8	12%

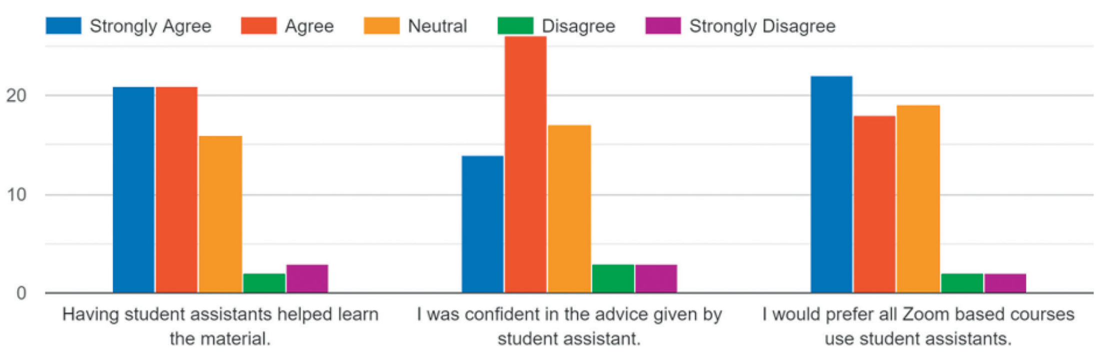

Figure 2. Student sentiments about student assistants.

Student Sentiments

At the end of the quarter, we surveyed students regarding the efficacy of SAs. Figure 2 shows student sentiments about the SAs. Most students held positive sentiments about SAs, with 42 out of 63 (66.7%) respondents expressing that SAs helped students learn the material. More respondents "Agreed" than "Strongly Agreed"(25 vs. 14 respondents) on the second question, indicating that students had moderately good confidence in the advice of the SAs.

NEXT STEPS

Regarding ES, we observe that most students took advantage of ES points, which helped reduce student procrastination. This was critical, as remote learning made it easy to skip lab sessions and become out of sync with the cadence of the course. Considering this, implementing an ES incentive will likely be a staple in future iterations of the course.

Regarding the efficacy of SAs, our preliminary results indicate that students' general impression of SAs was positive, implying that students were getting high-quality engagement with their peers. We provisionally conclude that SAs offer a promising mechanism for promoting online collaborative learning, but we acknowledge that we cannot conclude that SAs improved aggregate student performance without a control population.

In future iterations of the course, we would like to implement the SA/BP policies such that we can answer the question: "Do student learning outcomes improve when students are incentivized to help one another?" Since the SA/BP incentivization mechanism increases students' grades, grades cannot be the only vehicle which we use to assess outcomes. Prior work has shown that collaborative learning improves a range of student outcomes, including student attitudes and student retention [5], and

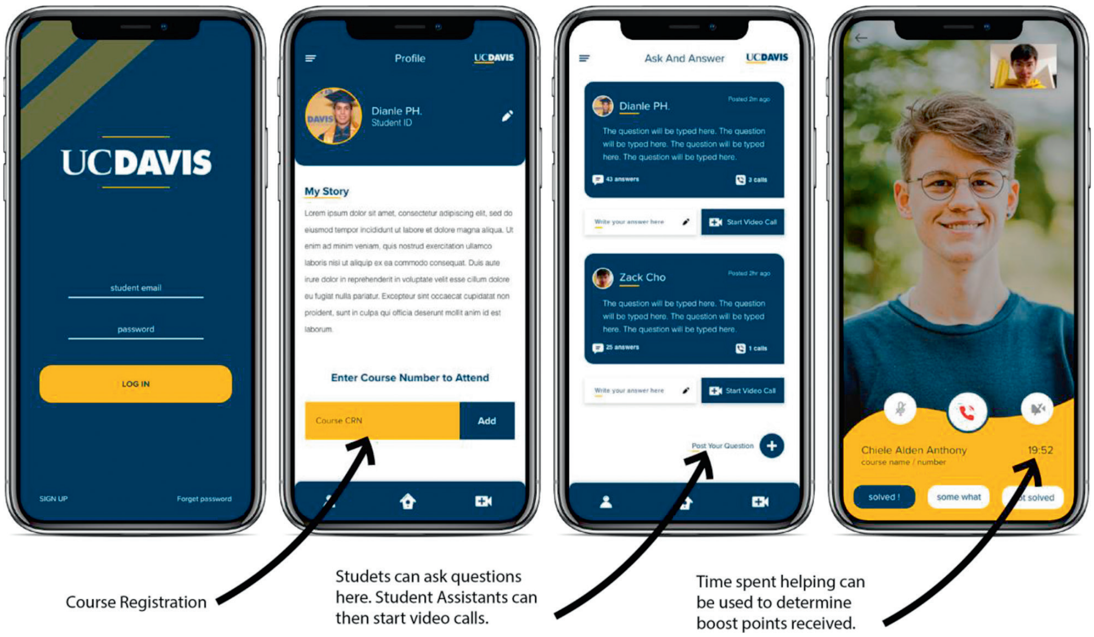

Figure 3. Student Assistant App.

in future course offerings, we can utilize recurring surveys to gauge whether students feel engaged under the SA/BP framework.

To further bolster student engagement and achievement, we plan to investigate variations on the SA policy, such as selectively pairing SAs with students who are on the low end of the grade distribution and students who have not reached out for help. Also, we would like to study the impact of these policies on increasing SAs' self-efficacy, self-confidence and sense of belonging in engineering. There is also consideration for an app which will allow SAs to help other students outside of lab hours for 24/7 support (Figure 3).

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