A survey-based study of students' perspectives on remote electronics and electronics lab courses during COVID-19 pandemic

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***Abstract*—Electronics courses were commonly completed with hardware and software labs to complement teaching electronics theory and enrich the learning experience for students. The COVID-19 pandemic has adversely affected the practical implementation of electronic circuits and the quality of electronics teaching. In this survey-based study, instructors of electronics book courses and labs, during the first year of the pandemic, discuss how to alleviate the limitations of the pandemic on electronics teaching. This study is a work-in-progress.**

Keywords—remote teaching, asynchronous lectures, synchronous lectures, electronics book courses, electronics labs.

I. Introduction

The COVID-19 pandemic has disrupted mankind practices in many ways. The way we teach classes and conduct laboratory sessions were no different than all other activities [1]. In March of 2020, instructors were rushed to transform their teaching to online platforms. Most of whom were inexperienced and were using online platforms for the first time and had difficulties in modifying their courses for online learning [2, 3]. Students too have been asked to adapt to online classes and various remote learning and assessments methods; also, for most students, this was a first-time experience.

In this survey-based study, the students' perspectives on remote electronics and electronics lab courses and the challenges they face in remote learning are presented. One-hundred and thirteen students were surveyed across the sophomore; junior; and senior years of the Electrical and Computer Engineering department of the school hosting this study. Before the pandemic hit, the students have reported deeper understanding of the electronics circuit theory when they were permitted to implement electronic circuits during lab sessions [4-6]. Different delivery methods for the online classes and lab setups have been attempted during the period of this study. At the end of each semester, the students were surveyed to gage the level of satisfaction to the applied content delivery method and lab setup. The study considers four core courses in the undergraduate curriculum, offered from Spring of 2020 to Summer of 2021. These are electronics book courses and labs, covering a broad spectrum of remote class meetings delivery styles like synchronous and asynchronous teaching.

II. Emergency Electronics Lectures and Labs

A. Emergency Electronics Lectures and Labs

First, when the pandemic hit North America March of 2020, the instructors were forced to transfer their courses fully to online platforms. The instructors have transformed their lectures materials to learning management systems like Blackboard® and Canvas® and have used web/video conferencing platforms like Zoom®, Microsoft Teams®, and Skype for Business® to deliver the courses contents. The main obstacle that faced electronics courses instructors was the lack of the practical aspect of the course. Before the pandemic, all electronics book courses were complemented by a lab component to enable student to practice theory and maximize the gains from the course [7, 8]. Students utilized electronic components constituting hardware-kits to implement electronic circuits. Student have also designed and implemented analog and digital electronic circuits in higher-level courses. In some of these courses, students will use PSPICE in their lab and homework assignments as an additional supplement. The urgent transformation meant that, in the best scenario, the students can only be dealing with PSPICE software, and no hardware implementation. This was mainly because the students can no longer access the laboratories at school, where they can use common equipment that are not included in their personal kits like oscilloscopes, function generators, power supplies, and multimeters. For some electronics class, the situation was worse. The PSPICE software was licensed to be used only on computers at school. Students were not allowed to remotely access those computers, because of the school's network security regulations. For those courses, the lab component was simply substituted with a theoretical part, which most students have considered this as a downgrade to learning electronics.

B. Completing the Transformation to Remote Learning, A More Sustainable Solution

The following summer of 2020, the instructors had to do a better job to addresses the problems from last spring semester. The school still did not allow the instructor nor the students back to classroom yet, and much improvement had to be done for remote learning. The lectures have been fully transformed to electronic versions to be presented as slides. The instructors have procured gear like tablets, stylus pens, cameras, microphones, ...etc., to engage in work-from-home teaching. They have also had a better chance to train on how to effectively use learning management systems and online meeting platforms to fully engage their students and allow for better instructor-to-student, and student-to-student interactions [9].

Special take-home lab kits were also prepared and mailed-out to students' homes to enable them to engage hardware electronics as well as PSPICE [10]. The kits were augmented with the ADALM1000® and the ADALM2000®. These learning modules are all-in-one oscilloscopes, function generators, power supplies, and multimeters, hence enabling students to fully engage electronic hardware like the in-person electronics labs. Instructors had to help students install the

licensed PSPICE software on various operating systems and had to provide free alternatives as well. Free student licenses were offered by OrCAD® for their Computer Aided Design (CAD) tools like Capture CIS® which worked on Microsoft Windows®. Open-source alternatives like LTSPICE® were a good alternative for those with Apple® Mac OS.

TABLE I. A SUMMARY OF THE ELECTRONICS COURSES IN THIS STUDY

Course Identifier	A	B	C	D
Course Description	Fundamentals of Electronics	Electronics Measurements	Electronics Design	Fundamentals of Electronics
Course Type	Book Course[a]	Laboratory	Laboratory	Book Course[a]
Semester	Spring 2020	Spring 2020	Summer 2020	Summer 2020
Students' Level	Sophomores	Sophomores and Juniors	Sophomores and Juniors	Sophomores
Number of Surveyed Students	32	26	26	29
Lecture Delivery Method	Synchronous- Recorded	Asynchronous	Synchronous- Not recorded	Synchronous- Recorded

[a.] Same electronics book course with a lab supplement.

III. STUDENTS SURVEYED ABOUT REMOTE LEARNING ELECTRONICS

The four electronics courses in this study are summarized in Table I, of which one is an electronics book course with a lab component, offered in two semesters, A and D, and two are electronics lab courses, B and C. The courses were chosen so that A and B are from Spring of 2020, when in-person classes were shut down and shifted to online platforms, while C and D are from the semester that followed, Summer of 2020 during complete shutdown. Course A, and D, is book course that introduces students to the fundamentals of linear electronic circuits. This course is complemented by a lab component, where student deals with electronic hardware components like resistors, capacitors, inductors, transformers, and relay circuits. The labs also introduce the students to signal generators, and power supplies, and measurement equipment like multimeters, and oscilloscopes. The labs are also structured such as students will use PSPICE in the implementation of some of the labs.

Courses B and C, on the other hand, are electronics laboratory classes. Course B is an electronics lab where students obtain signal measurements and characterization of analog and digital electrical circuits they implement in the lab sessions. In the more advanced electronics lab C, the students will design, as well as implement, high-specification analog and digital electronic circuits like active and passive filters, various amplifier designs, adders, comparators, integrators, multiple oscillator designs, and current mirrors, and counters. For courses A and B, the labs were discontinued due to the reasons discussed before, while the shortcomings of the complete transformation to online platforms were addressed in courses C and D. Additionally, the lecture-delivery methods for the courses varied between asynchronous, or pre-recorded lectures, with live discussions during the lecture time; and live, or synchronous, lecturing with and without recording the meeting.

One-hundred and thirteen students in the four electronics courses were surveyed about their experience with remote electronics lectures and labs. The students were asked to volunteer to complete the survey presented on Qualtrics®. Human subjects' approval (PRO18060710) was secured for these various forms of assessment. The survey questions firstly, asked the students about the lecture delivery method applied in the respective class, and whether if they preferred a different delivery method. Secondly, the students were asked about the issues they have faced when setting up the remote labs at their homes. Additional survey questions were devised to gage the level of satisfaction towards remote lectures and labs, and inquire about their preferences regarding remote or in-person classes. An additional space was provided for the students to provide any feedback, unaccounted for in the survey questions, or if they had any remarks or comments about remote electronics classes.

A. Results for Electronics Lectures

Approximately 66% of students in the four electronic classes, were satisfied with the synchronous lectures, as opposed to 36% for the asynchronous delivery method. Over 83% of the surveyed students chose the lecture to be recorded regardless of whether the lecture is delivered synchronously, or asynchronously. The subsequent question in the survey inquired to the reason for preferring the recorded sessions, to which 46% of the students explained that they had found it more convenient to playback parts of the lecture recording without having to ask the instructor. Additionally, about 13.7% explained they were not comfortable participating in class, and only 9% explained that lecture recordings make them more prepared to classroom activities and discussions.

The last question in the online lectures section of the survey was: "When things are back to normal, given your experience this semester, would you consider remote learning as an alternative to in-class learning?" The response of the students to the last question is illustrated in Fig. 1. According to the students, 54.8% prefer the in-person electronics lectures, while 4.4% prefer the remote electronics lectures. The remainder 40.7% were fine with both options.

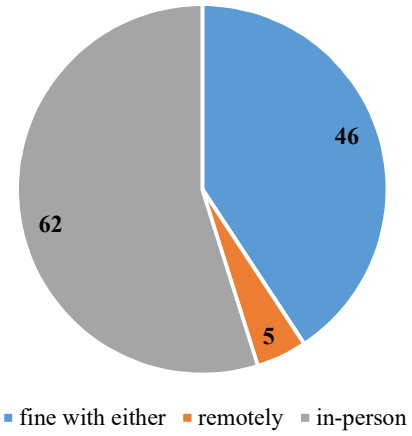

Fig. 1. Students' preferences to electronics lectures.

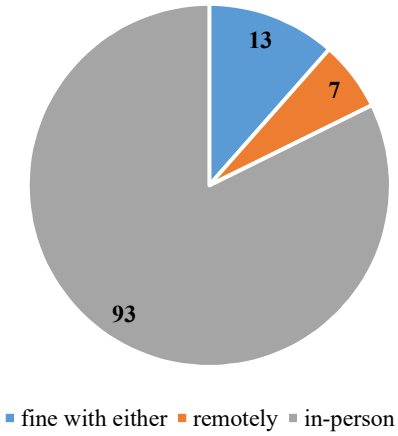

Fig. 2. Students' preferences to electronics labs.

It is worth to note here that the survey results were not different from spring and summer semesters of 2020. That is to say, the students' preferences have not changed between A and B of spring 2020, and C and D of summer of 2020. Also, there was no trend detected comparing the results from A and D, which is the same course and same delivery method, but offered during spring and summer of 2020.

B. Electronics labs

The previous surveys were augmented with questions about the lab component of the course. The students' responses to the lab surveys in [10] were analyzed to gage the student satisfaction with remote electronics labs, and pinpoint the main challenges that the students faced when conducting the electronics labs at home.

As expected, over 50% of the students have complained that they were having problems with the electronic-kit installation and PSPICE installation. Twenty-two percent of the students have either received their kits late or had defective electronic components in their kits. Replacing those items required the instructors to mail out replacement parts to the students, which admittedly was not cost-effective. Another major challenge was communicating with lab-partners and with instructors. Thirty-two percent have had issues working their lab partners, while 56% had issues communicating with the lab instructors. Only 9% reported no issues with the remote experience.

Undoubtedly, the students' satisfaction with the remote lab experience was eclipsed by all the shortcomings of the transition to remote electronics labs. Ninety-three students of the surveyed 113, or 82%, preferred the in-person electronics labs, while only 7 students, or 6%, preferred the remote electronics labs. The remaining 11.5% were fine with either as illustrated in Fig. 2. It is note-worthy to report here that the addition of hardware-kits to the electronics labs have slightly elevated the student satisfaction levels from ~41% in A and B to ~48% in C and D.

IV. Discussion and Conclusions

In spring of 2020, during shutdown, most instructors and students have faced unprecedented challenges. The greatest of which for an instructor of an electronics course is offering the same learning experience for the students. The lecture aspect of the electronics courses has not suffered greatly, for most instructors were already using slides and availing the course's materials to students on learning management systems. The students' responses to the surveys had shown that a synchronous lecture with the class meeting being recorded is the preferred method of electronics lecture delivery by 66%. A ubiquitous response in many of the students' feedbacks was the live lecture will derive its pace from the level of understanding of the students, something that an asynchronous lecture recording often lacks. Other responses claimed that the students appreciated the remote-class live activities and problem solving by the instructors.

Nevertheless, it was the electronics-labs and lab components of the electronics book courses that suffered greatly and needed an urgently terrific effort. Electronics students were instructed to use PSPICE software as a substitute for the hands-on hardware-labs in the beginning of shutdown. It was certainly the fastest way to allow students to carry-on with the electronic circuits' implementations. However, the students voiced their concerns about the quality of their education being compromised when they were not exposed to electronics hardware. One student reacted to course B: "I paid to get hands on experience, but It seems like I'm taking 257 (*a book course from the old curriculum, without a lab component*) all over again. If that's the case I might as well get a refund for the semester cause that's not what I paid for." The students' satisfaction with electronics labs was at 40.5%. This put the burden upon electronics instructors' shoulders that they should provide take-home lab kits that mimics the in-person lab experience.

The following summer of 2020, the students in all electronic classes were sent lab kits to their homes to carry-out hardware labs during shutdown, improving student satisfaction to ~48%. Even when the lab kits were provided, the surveys showed that ~82% of the surveyed students were highly dissatisfied with the lack of experience they are getting from the remote labs and preferred the in-person labs. The survey data show that the students mainly struggled with setting up the remote electronics labs, and could not promptly

get the assistance they needed from their instructors. They have further faced communication challenges with their lab partners and lab instructors. A student testimonial summarizes the students' problems with the emergency electronics labs: "For the nature of a lab class, it is difficult to run this remotely because of equipment and technology barriers, but also because getting help from just the professor and TA during class time was sometimes delayed because of the different breakout groups. In a normal class setting, it would be easier to get help by either asking another classmate or being more direct with the TA or professor."

While there remains a state of uncertainty to when the normal in-person classes can be resumed with full capacity, the electronics classes remain one the most hurt topics of the study of Electrical and Computer Engineering. While other topics like digital signal processing, computer languages and architecture depend heavily on compilers running codes and simulators for signals and systems, Electronics courses and labs still depend on hardware implementation of electrical components. Although CAD tools are quite beneficial in electronic circuit design, the majority of students prefer dealing with hardware components in their implementation.

Accordingly, while our society still deals with the pandemic for the months, and may be years to come, an electronics classroom can better be served as a cross between in-person and remote classes. The lectures for the theoretical aspects of the course and labs can be delivered online fully, while the practical experience of a lab is better catered to in-person. Since, most school still cannot open the classes to full capacity, it is advised to limit the attendance to the safe maximum capacity of the room, dictated by the school. Take-home lab kits must still be provided for all students, although of a higher cost to the school, but would save money and time in case of another emergency shutdown on all operations. And most of all, would ensure continuity of the lab sessions and will help provide the students with a decent electronics lab experience.

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