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Resilient Course Design for Teaching a Project-based Engineering Course Online

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Abstract

During emergency remote teaching situations caused by the COVID-19 crisis, students and instructors in higher education may be dealing with challenges and inequities including increased uncertainty over health, employment, and finances; inequitable access to synchronous learning opportunities; increased challenges in conducting accurate and equitable online assessments. For project-based electrical and computer engineering courses that involve hardware components and group work, additional challenges include limited or no access to facilities for experimental work; students cannot meet in person to conduct group work, especially for projects involving hardware integration. This paper describes methods that aimed to address these challenges to transition a project-based *Design with Microcontrollers* course online during the COVID-19 pandemic. This course aims to teach microcontroller basics and microcontroller-based embedded system design. It is composed of weekly lectures, labs, and a term project, all based on the ARM® Cortex®-M4F based TI Tiva™ C TM4C123G LaunchPad. During the transition to online learning, a set of methods were developed to ensure the accomplishment of the student learning outcomes and to enhance resilience of students. This includes 1) combining synchronous and asynchronous learning options to provide both flexibility and humanized interactions; 2) eliminating traditional exams and designing a new *tech interview-style* coding exam.; 3) increasing social presence in the class and building a collaborative and supportive learning community; 4) adjusting the term project to address the restrictions caused by remote learning; and 5) designing and distributing surveys at multiple points of the semester to understand students' needs and learning progress. According to the course assessment results and the responses from an anonymous exit-class survey, the transition of this course was a success and received quite positive feedbacks from the students.

1. Introduction

During emergency remote teaching situations caused by the COVID-19 crisis, students and instructors in higher education may be dealing with challenges, crises, and inequities while trying to fulfill their academic and professional obligations. These include increased uncertainty over physical and mental health, employment, and finances [1]; inequitable access to synchronous learning opportunities (e.g. due to the lack of stable access to a computer or the Internet) [2]; increased challenges in conducting fair, accurate, and equitable online assessments [3]. For hands-on and project-based engineering courses and labs that involve hardware components and group work, additional challenges include limited or no access to physical labs or facilities needed for experimental work; and students cannot meet group partners in person to conduct group work, especially for projects involving integration of hardware components.

This paper presents a resilient course design for transitioning a project-based engineering course online during the COVID-19 pandemic. The *Design with Microcontrollers* course is a required undergraduate course for junior/senior level electrical and computer engineering students at San Francisco State University. This 16-week course aims to teach basic microprocessor/microcontroller architecture, common input and output interfaces, and microcontroller-based embedded system design. The course emphasizes hands-on and problem-oriented project-based learning, which, as confirmed by engineering research, provides highly effective pedagogy to enhance student learning, promote their critical thinking skills, train them to meet industry needs, and develop their "soft skills", including teamwork skills, project management, communications, engineering economics [4]–[9]. The course is composed of weekly lectures, weekly labs, and a term project, all based on the TI Tiva™ C Series TM4C123G LaunchPad featuring the ARM® Cortex®-M4F architecture, a microcontroller architecture in high demand in industry. Before the course was transitioned to the online format, both the lecture and lab sessions were held in person and students were required to form groups of two or three to complete all the labs and the term project.

A set of methods were developed to effectively transition the *Design with Microcontrollers* course online, to enhance resilience of students, and to affirm equity and accessibility for all. This paper provides a description of these methods and the course structures in both in-person mode and online mode. The paper also presents the results of an anonymous exit-class survey collected from students enrolled in the online course in the fall 2020 semester and discusses plans for future improvement.

2. Course Structure in in-Person Mode

Before the COVID-19 pandemic, the *Design with Microcontrollers* course was taught in synchronous, in-person mode. Every student purchased a TM4C123G LaunchPad ($13 per unit) as the only required course material and might purchase other optional hardware components to complete their term project. All other course materials including lecture and lab notes, reference materials, and assignments were made available to the students using *iLearn*, a web-based learning management system adopted by the University.

The course has two 75-minute lecture sessions and one 165-minute lab session in each week. Table 1 shows the lecture and lab schedule of the course in a representative semester. A series of labs with clearly defined objectives and activities were designed based on the TM4C123G LaunchPad. These labs provided students hands-on experiences to learn important concepts of microcontroller-based design, including microcontroller architecture, basic microprocessor/microcontroller architecture, common input and output interfaces, and microcontroller-based embedded system design. The topics covered in weekly lectures were specifically tailored to the lab activities of that week. A term project was designed in which the students were required to propose and develop a real-time embedded system based on the TM4C123G LaunchPad. The deliveries of the project included a proposal, a final oral presentation and project demo, and a final submission composed of a final project report, the source code of the project, and video/photo demos of the project. Figure 1 shows the photos of representative final project presentations and project demos of the course.

The course assessments consisted of six elements: a midterm exam (15%), a final exam (30%), labs (20%), the term project (20%), homework (10%), and attendance (5%).

Table 1. *Design with Microcontrollers* lecture and lab schedule

Week	Lecture Topic	Lab activity	Week	Lecture Topic	Lab activity
1	Introduction to embedded systems	Lab 1: Introduction to the lab; Software installation	9	Analog to digital conversion (ADC)	Lab 9: ADC
2	Introduction to TM4C123G MCU and ARM Cortex M4 architecture;	Lab 2: Introduction to term project; Project management tools	10	Digital to analog conversion (DAC)	Project
3	Thumb II assembly instruction set	Lab 3: Learning ARM Cortex M4 through assembly program	11	Serial interfaces: SSI	Project
4	Switch and LED interfacing; GPIO	Lab 4: Switch and LED interfaces;	12	Serial interfaces: I2C, CAN, USB	Project
5	GPIO; Embedded C programming	Lab 5: Mini project on GPIO	13	Power management;	Project
6	Interrupt concept; Edge-triggered interrupts	Lab 6: Edge-triggered interrupts	14	Wireless communication interfaces	Project
7	Timer-triggered periodic interrupts	Lab 7: Periodic interrupts	15	Advanced topic in embedded system design	Final Project Presentation
8	Serial interfaces: UART	Lab 8: UART interface			

Figure 1. Photos of representative final project presentations and project demos of the course.

3. Course Structure in Online Mode

During the transition of this course to online learning mode, a set of methods were developed to ensure the accomplishment of the student learning outcomes, to enhance resilience of students, and to affirm equity and accessibility for all. These methods are summarized below.

1) Combine synchronous and asynchronous learning options to provide both flexibility for self-paced learning and humanized interactions in the class. [10]–[13]. All the course materials, schedules, and assignments were managed using iLearn. Weekly pre-recorded lectures, usually composed of two or three 30- to 50-minute videos, were posted to iLearn as shown in Figure 2(a). At the end of each video lecture, exercises were added to reflect the topics covered in the video. A shared Google doc was created to collect questions from the students on the video lectures. The weekly video lectures were designed tailored to the weekly lab activities. Students must watch these videos to learn the concepts that are needed for completing the lab activities of that week. Weekly Zoom meetings, which were also recorded and posted to iLearn afterwards, were used to explain the to-do things for that week (e.g., which video lectures need to be watched by next meeting time; upcoming assignments and activities), to do exercises on topics covered in the pre-recorded video lectures, and to address questions from students (see Figure 2(b) for representative weekly schedule sections on the iLearn course page). The instructor also used the Zoom poll feature and the Mentimeter interactive presentation software to do real-time, interactive exercises with students in the synchronous Zoom meetings. These interactive tools allowed the instructor to assess students' understanding of course topics in real time and to adjust the exercises and lecture content accordingly.

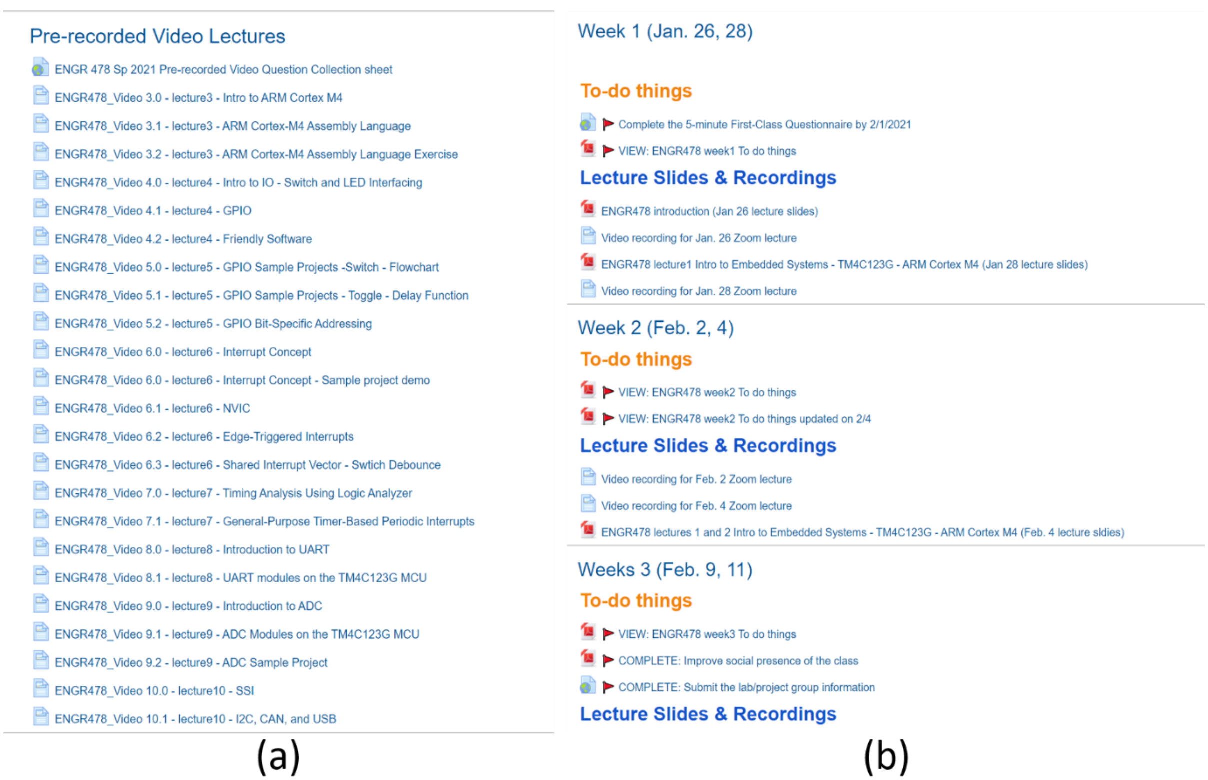

Figure 2. Screenshots of the iLearn course page. (a): The pre-recorded video section. (b): Weekly schedule sections.

2) Eliminate traditional exams, increase the weight of labs and the term project in the final grade, and design a new *tech interview-style* coding exam. This one-hour exam contained one coding problem that was closely related to the lab exercises. Just like a tech interview, each student was assigned an individual breakout room (a Zoom feature) during the exam, worked on the coding problem using a Google doc shared with the instructor (acted as the interviewer), and had to explain their thinking while writing the code step by step. The students were required to share their screen and turn on the audio during the exam. The entire exam process was video recorded and submitted to the instructor after the exam. The instructor must ensure all students have access to the required facilities (i.e., a computer, Internet connection, and an audio input device) before the exam. The *Coding Exam Guideline for Students* that details the exam procedure can be found in the Appendix section. A mock coding exam and several sample exams were provided before the actual exam to ensure all the students were familiar with the new exam format. The assessments of the course in online mode consisted of five elements: one coding exam (15%), labs (30%), the term project (30%), homework (10%), and participation and iLearn activities (15%).

3) Increase social presence in the class and build a collaborative and supportive learning community. Research has shown that improving social presence in an online learning environment helps stimulate learner experiences in the course, thereby improving learning [14]–[16]. One of the first activities done in the semester was that each instructor and student created their own online persona, which included a profile photo and a self-introduction, on the iLearn course page. In addition, a course channel was created on Slack, a communication platform offering features such as chat rooms and direct messaging, to encourage discussions and interactions in the class. Slack provides more instant communication and is also more mobile-friendly than email communication.

4) Adjust the term project so that students could choose to do a group project or an individual project. The requirements of additional hardware components for the project were minimized. The project assessment focused more on unit testing and system integration with some level of simulation instead of full hardware integration. The final presentation of the project was changed from in-person oral presentation format to virtual format. Each project group was required to make a 10-minute video of their project presentation and a project demo. All the project presentation videos were collected and posted before a Zoom meeting of Final Project Q&A session was held. During the synchronous Q&A session, each group was assigned a 10-minute slot to answer questions from the instructors, who had watched the project presentation videos before the Q&A session. The students were also encouraged to create a website for their project, which could be used to strengthen their personal profiles for later use.

5) Design and distribute surveys at multiple points of the semester to understand students' learning conditions, preferred teaching modes, feedback on the course modules, challenges, and learning outcomes to adjust the course content and teaching methods accordingly.

4. Results and Discussions

The course assessment results of the fall 2020 semester showed that the online implementation of the course was successful, and the student learning outcomes were accomplished. Despite the challenges of COVID-19, the students were able to achieve the course learning objectives and completed the term projects with quality. Figure 3 is a collage of photos of representative project demos done by the fall 2020 student cohort.

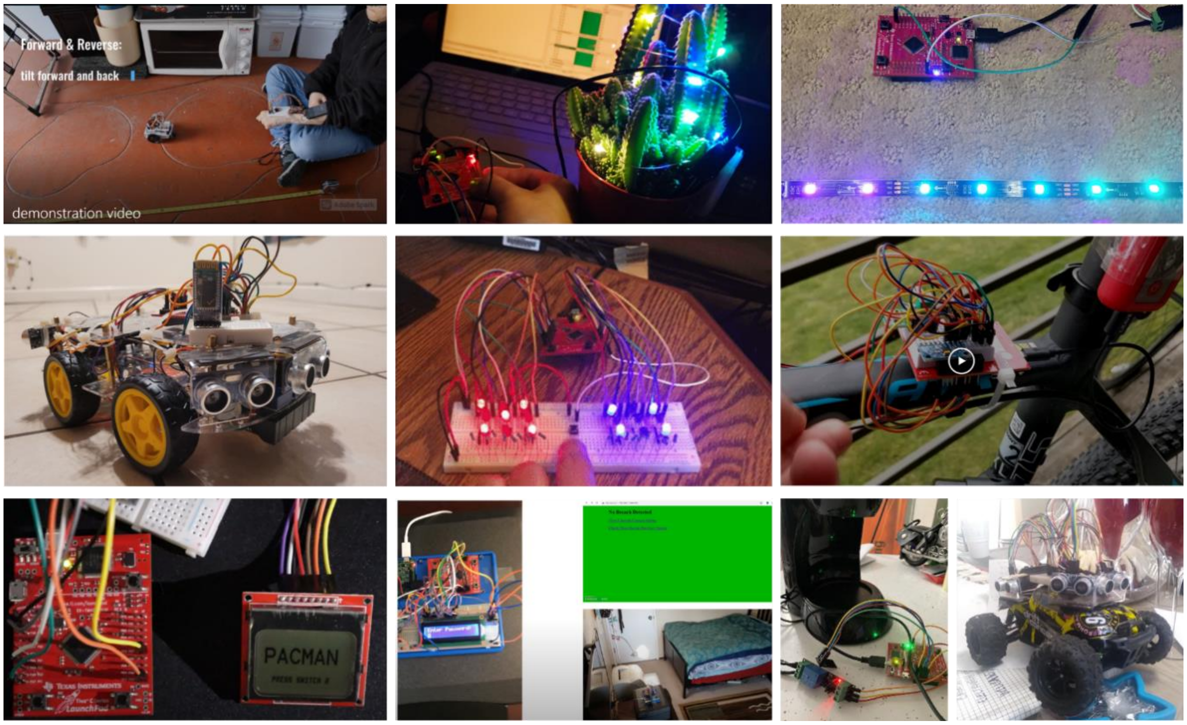

Figure 3. Photos of representative final project demos of the course in the fall 2020 semester.

An anonymous exit-class survey was designed in Qualtrics and was distributed after the semester ended. 36 out of 47 students responded to the survey. Table 2 summarizes the students' level of agreement with achieving the course learning objectives. Overall, over 96% of the students strongly agreed or somewhat agreed that they had achieved the stated learning objectives. Table 3 summarizes the results of survey on student perceptions of the effectiveness of various course components in enhancing their learning in the course subjects. The components with the highest ratings are "sample projects, sample/mock exams, and other reference materials" and "term project", followed by the "weekly Zoom lectures". This implies that the students found hands-on and project-based learning most effective for their learning and providing good supporting materials such as samples and reference materials are important for students to learn. Table 4 shows the results of survey on student perceptions of the effectiveness of various techniques in enhancing the class communication. Over 94% of the students found the "weekly to-do-things summary", "separate sections for project, labs, exam, etc. on iLearn", "weekly course materials updates on iLearn", and "Email notifications and communications" to be most effective. In the comments section, many students appreciated the use of Slack, which provided an effective alternative to email to have easy communications with the instructor and other students.

The responses to the survey question "Do you think the format of the coding exam is fair and reasonable?" indicate that all the responded students considered the new *tech interview-style* coding exam to be fair, reasonable, and straightforward. Some students commented that the exam was a good way to test their knowledge and prepare them for future job interviews.

Overall, the online teaching format of this course received quite positive feedbacks from the students. An interesting finding, as shown in Tables 5 and 6, is that 60% of the respondents preferred the lecture portion of the class to be fully online even after the pandemic; 34.29% of them preferred a mix of online and in-person lectures; only 5.71% preferred the in-person only mode. For the lab portion, 51.43% of the respondents preferred a mix of online and in-person labs; 31.43% preferred the fully online mode; only 17.14% preferred in-person only labs. Although the COVID-19 crisis and the transition to remote learning has posed many challenges to the *Design with Microcontrollers* course, a resilient design for online teaching of this course has also shown some advantages over the traditional in-person teaching mode. The combination of synchronous and asynchronous learning options can provide much more flexibility for self-paced learning and reviewing of the course content. San Francisco State University is a commuter school so the online learning mode can save a lot of commuting time for both the students and instructors. It also allows for larger class capacity and easier scheduling. For an engineering class that involves intensive coding, the Zoom meeting with the computer screenshare function is more convenient than the projector and screen in a traditional classroom to show live coding and project demos to the students. The interactive tools such as Zoom polls and Mentimeter also make the students' participation in class activities easier and can collect and analyze students' responses immediately. The survey results have implied that the efforts that have been made to transition the *Design with Microcontrollers* online could also be utilized to develop more effective and efficient hybrid teaching methods that can be used in the future, even after the COVID-19 pandemic.

Table 2. Summary of students' level of agreement with achieving stated learning objectives

Question: Please indicate your level of agreement with the following statements.

#	Statement	Strongly Agree		Somewhat Agree		Neutral		Somewhat Disagree		Strongly Disagree		Total
1	I understand the basics of ARM Cortex-M4 architecture and microcontroller-based design.	58.33%	21	41.67%	15	0.00%	0	0.00%	0	0.00%	0	36
2	I have the ability to design and implement ARM Cortex-M4 microcontroller-based embedded systems.	50.00%	18	47.22%	17	2.78%	1	0.00%	0	0.00%	0	36
3	I have improved my ability to read user guides and reference manuals and utilize Internet resources to find useful information for my project.	61.11%	22	36.11%	13	2.78%	1	0.00%	0	0.00%	0	36
4	I have improved my ability to program in embedded C language.	47.22%	17	50.00%	18	2.78%	1	0.00%	0	0.00%	0	36
5	I have improved my ability to design experiments and analyze data and results.	60.00%	21	40.00%	14	0.00%	0	0.00%	0	0.00%	0	35
6	I have improved my oral and written presentation skills.	47.22%	17	44.44%	16	8.33%	3	0.00%	0	0.00%	0	36
7	I developed interests in related fields after taking this course.	63.89%	23	33.33%	12	2.78%	1	0.00%	0	0.00%	0	36
8	I have more confidence in finding a major-related job or pursuing higher education after taking this class.	52.78%	19	36.11%	13	11.11%	4	0.00%	0	0.00%	0	36

Table 3. Results of survey on student perceptions of the effectiveness of various course components

Question: How effective is each of the following course components in enhancing your learning in the course subjects? 1 being MOST effective and 3 being LEAST effective.

#	Question	1 (most effective)		2		3 (least effective)		Total
1	Weekly Zoom lectures	77.78%	28	16.67%	6	5.56%	2	36
2	Pre-recorded lecture videos	61.11%	22	27.78%	10	11.11%	4	36
3	Weekly labs	58.33%	21	36.11%	13	5.56%	2	36
4	Coding exam	58.33%	21	33.33%	12	8.33%	3	36
5	Homework assignments	72.22%	26	25.00%	9	2.78%	1	36
6	Term Project	83.33%	30	13.89%	5	2.78%	1	36
7	Sample projects, sample/mock exams, and other reference materials	88.89%	32	5.56%	2	5.56%	2	36
8	Instructors' out-of-class help (e.g., office hours, Slack/email messages)	72.22%	26	25.00%	9	2.78%	1	36

Table 4. Results of survey on student perceptions of the effectiveness of various class communication techniques

Question: How effective is each of the following techniques in enhancing the class communication (such as instructor/student communication, student/class communication, student/student communication)? 1 being MOST effective and 3 being LEAST effective.

#	Question	1 (most effective)		2		3 (least effective)		Total
1	Weekly course materials updates on iLearn	94.29%	33	2.86%	1	2.86%	1	35
2	Separate sections for project, labs, exam, etc. on iLearn	94.29%	33	5.71%	2	0.00%	0	35
3	Weekly To-do-things summary	97.14%	34	0.00%	0	2.86%	1	35
4	Email notifications and communications	94.29%	33	2.86%	1	2.86%	1	35
5	Course channel on Slack	74.29%	26	17.14%	6	8.57%	3	35
6	Surveys via Qualtrics	69.70%	23	30.30%	10	0.00%	0	33

Table 5. Results of survey on students' preferred teaching mode after the pandemic for the lecture portion of the class

Question: Thinking about your personal experience with remote learning for this class, would you prefer the lecture portion of this class to be (i) fully online, (ii) a mix of online & in-person classes, (iii) only in-person classes?

#	Answer	%	Count
1	Fully online (pre-recorded lecture videos + weekly Zoom meetings for Q&A and exercises; like what we did this semester)	51.43%	18
2	Fully online (weekly lectures via Zoom; no pre-recorded lectures; Zoom recordings posted to iLearn afterwards)	8.57%	3
3	A mix of online & in-person class (pre-recorded lecture videos + in-person meetings for Q&A and exercises)	34.29%	12
4	Only in-person classes	5.71%	2
	Total	100%	35

Table 6. Results of survey on students' preferred teaching mode after the pandemic for the lab portion of the class

Question: Thinking about your personal experience with remote learning for this class, would you prefer the lab portion of this class to be (i) fully online, (ii) a mix of online & in-person classes, (iii) only in-person classes?

#	Answer	%	Count
1	Fully online	31.43%	11
2	A mix of online & in-person labs	51.43%	18
3	Only in-person labs	17.14%	6
	Total	100%	35

5. Conclusions and Future Work

This paper presented a resilient course design for teaching a project-based engineering course *Design with Microcontrollers* online during the COVID-19 pandemic. A set of methods were developed to ensure the accomplishment of the student learning outcomes and to affirm equity and accessibility for students. The course assessment results and the responses from an anonymous exit-class survey showed that the online teaching of this course was a success. To further improve online teaching effectiveness and enhance resilience of students, efforts will be focused on adding more interactive activities in online lectures to better engage students, exploring more convenient and equitable platforms for online assessment, and adding self and peer evaluation into group work assessment.

Acknowledgement

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Bibliography

[1] "Dealing with Uncertainty During the Coronavirus Pandemic - HelpGuide.org," Apr. 2020. https://www.helpguide.org/articles/anxiety/dealing-with-uncertainty.htm.
[2] J. McEvoy, "No Home Wi-Fi, No Virtual Classroom: How Low-Income Students Lose Out During a Pandemic," *KQED*, Apr. 20, 2020. https://www.kqed.org/news/11813045/no-home-wifi-no-virtual-classroom-how-low-income-students-lose-out-during-a-pandemic.
[3] C. Flaherty, "Big Proctor," May 11, 2020. https://www.insidehighered.com/news/2020/05/11/online-proctoring-surging-during-covid-19.
[4] J. E. Mills and D. F. Treagust, "Engineering education—Is problem-based or project-based learning the answer," *Australas. J. Eng. Educ.*, vol. 3, no. 2, pp. 2–16, 2003.
[5] H. A. Hadim and S. K. Esche, "Enhancing the engineering curriculum through project-based learning," in *32nd Annual Frontiers in Education*, 2002, vol. 2, pp. F3F-F3F.
[6] M. Frank, I. Lavy, and D. Elata, "Implementing the project-based learning approach in an academic engineering course," *Int. J. Technol. Des. Educ.*, vol. 13, no. 3, pp. 273–288, 2003.
[7] M. Lehmann, P. Christensen, X. Du, and M. Thrane, "Problem-oriented and project-based learning (POPBL) as an innovative learning strategy for sustainable development in engineering education," *Eur. J. Eng. Educ.*, vol. 33, no. 3, pp. 283–295, 2008.
[8] C. Zhou, A. Kolmos, and J. F. D. Nielsen, "A problem and project-based learning (PBL) approach to motivate group creativity in engineering education," *Int. J. Eng. Educ.*, vol. 28, no. 1, pp. 3–16, 2012.
[9] C. L. Dym, A. M. Agogino, O. Eris, D. D. Frey, and L. J. Leifer, "Engineering design thinking, teaching, and learning," *J. Eng. Educ.*, vol. 94, no. 1, pp. 103–120, 2005.
[10] O. Marjanovic, "Learning and teaching in a synchronous collaborative environment," *J. Comput. Assist. Learn.*, vol. 15, no. 2, pp. 129–138, 1999.
[11] N.-S. Chen, H.-C. Ko, Kinshuk*, and T. Lin, "A model for synchronous learning using the Internet," *Innov. Educ. Teach. Int.*, vol. 42, no. 2, pp. 181–194, 2005.
[12] L. V. Morris, H. Xu, and C. L. Finnegan, "Roles of faculty in teaching asynchronous undergraduate courses," *J. Asynchronous Learn. Netw.*, vol. 9, no. 1, pp. 65–82, 2005.
[13] E. Murphy, M. A. Rodríguez-Manzanares, and M. Barbour, "Asynchronous and synchronous online teaching: Perspectives of Canadian high school distance education teachers," *Br. J. Educ. Technol.*, vol. 42, no. 4, pp. 583–591, 2011.
[14] S. R. Aragon, "Creating social presence in online environments," *New Dir. Adult Contin. Educ.*, vol. 2003, no. 100, pp. 57–68, 2003.
[15] J. Richardson and K. Swan, "Examing social presence in online courses in relation to students' perceived learning and satisfaction," 2003.
[16] J. C. Richardson, Y. Maeda, J. Lv, and S. Caskurlu, "Social presence in relation to students' satisfaction and learning in the online environment: A meta-analysis," *Comput. Hum. Behav.*, vol. 71, pp. 402–417, 2017.

Appendix: Coding Exam Guideline for Students

Design with Microcontrollers
Coding Exam Guideline (for Students)

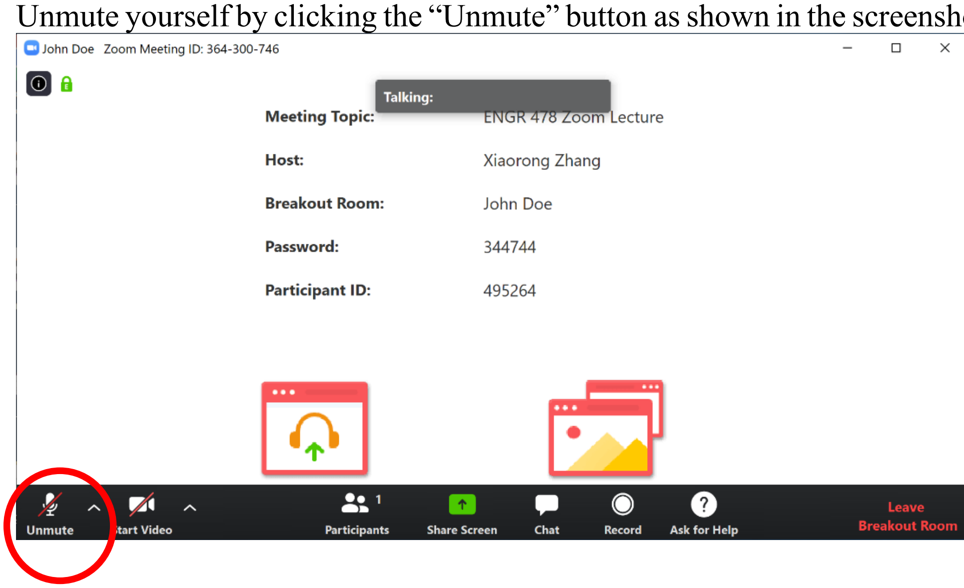
You have up to one hour to finish this exam. The exam is open book and open notes. You must complete the exam independently. Cheating on exams will be reported to the Office of Student Conduct, and the exam will receive zero credit.

Preparation:
You will need the items below in order to participate in the coding exam. If you do not have these items, please let the instructor know as soon as possible.

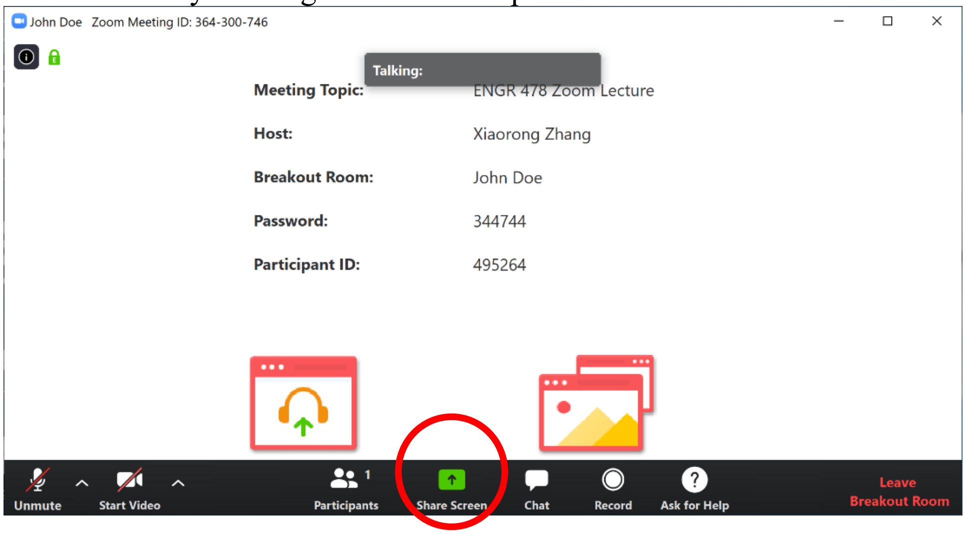
- A computer with web browser
- A microphone to record your voice during the exam. Most computers have built-in microphones. If you do not have a microphone, please let the instructor know before the exam.
- Access to the Internet
- Have the Slack app and/or your email ready so you can contact the instructor for help in case you get dropped from the Zoom meeting during the exam.

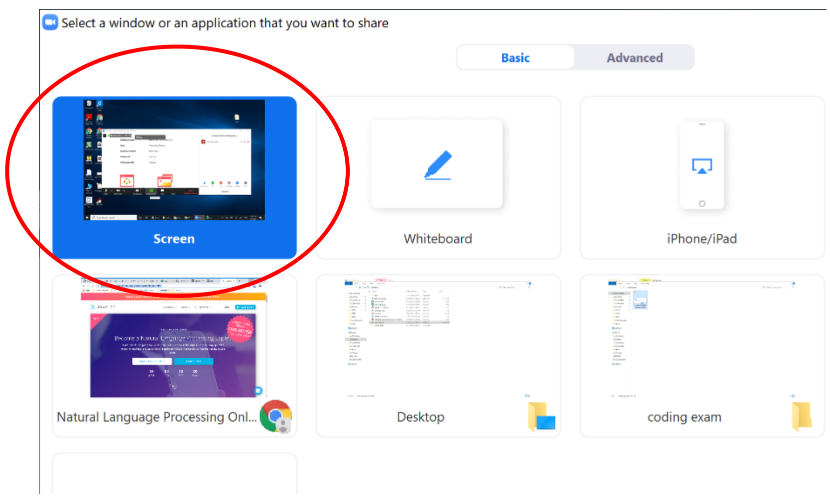
Exam procedure:

1. You will receive the link of your coding exam answer sheet (a Google doc shared with the instructor) in your email on the exam date at 3:25 pm.
2. Join the Coding Exam Zoom meeting on the exam date at 3:30 pm.
3. You will then be assigned to a breakout room by the instructor. Once the breakout room is open, you will see an invitation window.
4. Click the "Join" button to join the breakout room assigned to you. Once you join the breakout room, you can only see yourself in the breakout room and you will stay in this room until you complete the coding exam. The instructor may send you broadcasting messages during the exam.
5. Before you start to work on the coding question, please do the three things below:
    a. Unmute yourself by clicking the "Unmute" button as shown in the screenshot below:

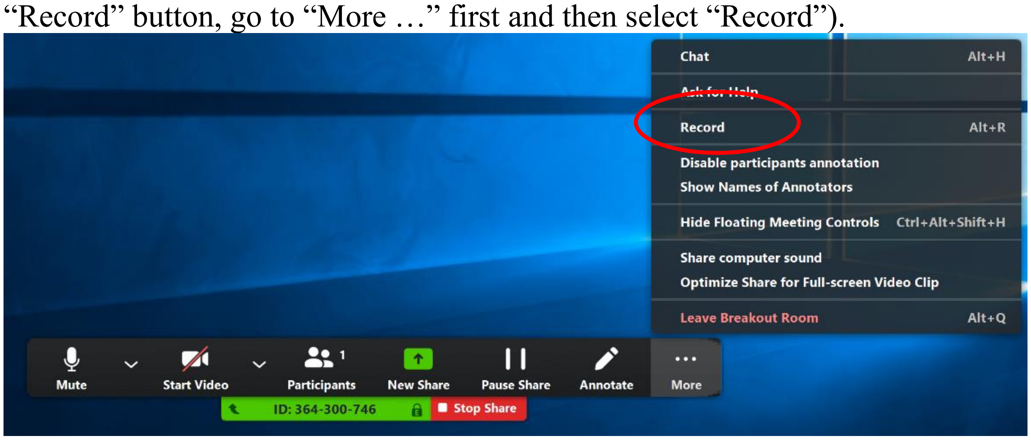


b. Share your screen by clicking the “Share Screen” button and choose to share the entire screen by clicking the “Screen” option as shown below:

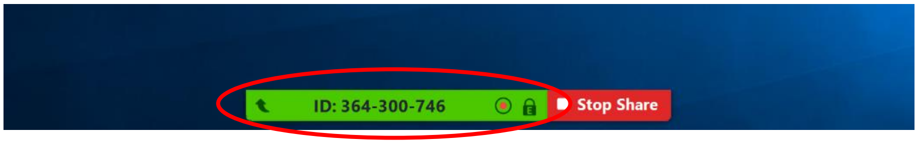




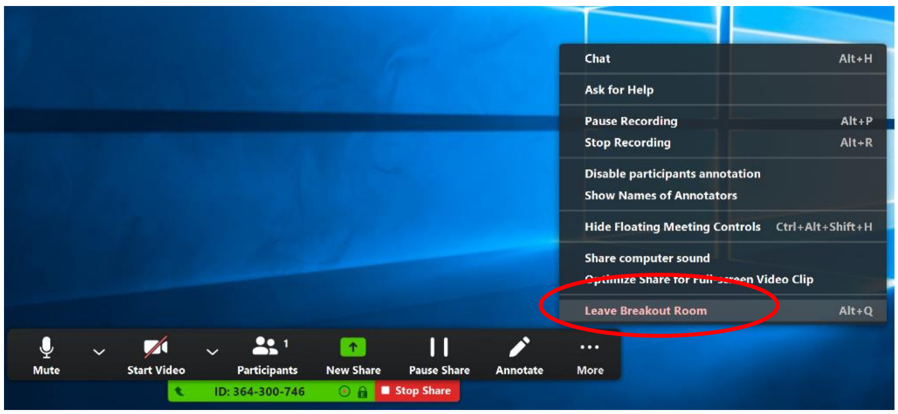
c. Start to record your session by clicking the “Record” button (if you do not see the “Record” button, go to “More …” first and then select “Record”).



Once these are all done, you will see the “Recording” icon as shown below:



6. Now you can start to work on the coding question using the Google doc of the coding exam answer sheet. You will need to explain what you are thinking and/or doing while writing the code step by step. This process will be recorded and will need to be submitted to iLearn or a Box folder later as a supplemental material for the grading purpose.
7. Once you finish answering the coding question and are ready to submit the answer sheet, you can leave the Breakout room by clicking the "Leave Breakout Room" button and then clicking the "Return to Main Session" as shown below:



8. Once you are in the main session and the instructor confirms you are ready to leave. You can leave the meeting by clicking the "Leave the Meeting" button. You will then see a window with a progress bar showing your meeting recording is being converted. Please wait till the conversion is done. It might take some time depending on how fast your computer is. Once the conversion is done, please specify a location on your computer to store the video and audio files of the recording. By default, the audio/video file (MP4) will be named **Zoom_0.mp4**. The audio only file (M4A) is named **audio_only.m4a**.

Note:

- If you have any questions or need assistance from the instructor during the exam, you can click the "Ask for Help" button on the bottom menu bar of the Zoom window (see screenshot below). The instructor will then join your breakout room and help you. You can also send a Slack direct message or email to the instructor if needing any help. The instructor will be monitoring the Slack channel and email during the exam too.
- If anything happens during the exam such as bad Internet connection, issues with your computer or microphone, do not panic. Let the instructor know as soon as possible and she will help you. You can still work on the Google doc even when the Internet is down.