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Introduction of Students to Engineering Design Practices of Remote and Distributed Collaboration: Lessons Learnt from COVID-19

SEAN ALLING

AND

ANDRÉ KNOESEN
University of California Davis
Davis, CA

ABSTRACT

The onset of COVID-19 required drastic changes on how students interacted in EE-Emerge, a course where the students design and build exhibits demonstrating engineering to the public. COVID-19 was used as an opportunity to expose students on how teams in industry collaborate effectively on a project remotely across time zones, and how to communicate their results on sites like GitHub and Hackster.

Key words: Project based learning, Electrical engineering, Computer engineering

INTRODUCTION

EE-Emerge is a yearlong course sequence offered to electrical and computer engineering juniors and advanced sophomores where students design and build interactive electronic exhibits for K-12 students to promote engineering education to the general public. This course sequence, now in its eighth year, brings out the creativity of our engineering students, emphasizes teamwork, provides experience in project management and communication, while also building new practical technical skills.

At the beginning of the school year, students propose project ideas and as the quarter progresses, these ideas are fine-tuned, and four teams are formed. Team designs and subcomponents are developed early to mid-winter and project integration occurs early spring. All EE-Emerge projects must be thoroughly tested to be robust, which is in contrast with some senior design projects that are often proof-of-concept demonstrations. During mid to late spring, students develop their

communication skills by presenting their projects at public events such as Picnic Day which is a campus event in early Spring, Makers Fair in San Mateo, and the College of Engineering Design Showcase.

METHODS

COVID-19 began to affect EE-Emerge operations in late February when supply lines in Asia were shutting down and student teams lost access to preferred printed circuit board supplier. This presented the opportunity to engage students on the importance of considering supply line stability and how this could influence their projects. Campus closures as a result of COVID-19 occurred in the last weeks of winter and directly affected the EE-Emerge student's ability to present their designs to the public. We also shut down all EE-Emerge activities as not to add additional stress on the students. Instead of canceling the spring quarter offering, we decided to swivel EE-Emerge objectives for spring from interacting with the public, to instead use the opportunity of restricted social interaction as an opportunity to expose students how to collaborate effectively on a project remotely and how to communicate their results on sites like GitHub and Hackster. Once the decision was made, we informed the students of the plan and 86% of the 29 students decided to continue into the Spring, which is much higher than the 62% of students the previous year.

At the beginning of spring, each team reviewed their designs and made adjustments so that projects could be completed with students not having access to other teams and or campus facilities. The largest challenges faced by students was how to test software on real hardware and how to assemble their projects. Luckily, each team had several members within close proximity of UC Davis's campus, and these members performed the final software and hardware testing, project assembly, and final testing in a manner that met COVID related safety concerns. Instructors ordered parts and delivered them to team members located in Davis and any subcomponents, such as printed circuit boards and 3D printed parts were outsourced based on what services were available at specific times. Team members at the remote locations focused on electronic design, evaluation of hardware subassemblies, developing software, and documentation.

The remote collaboration demanded significant changes in how teams needed to communicate with each other as well with instructors. Slack, a team collaborating app, was found to be an effective communication tool for inter-team collaboration. Slack allows effective channels of communication where the students were able to ask questions, discuss topics, and receive answers in a timely manner.

Additionally, students had to find new ways to share the project's digital assets. Under normal conditions, they would share software, design files, and other digital assets in person. However, with students distributed across the country, GitHub was selected for storing and syncing a project's digital assets and allowed the students to work concurrently and seamlessly on software development.

Some final challenges faced in EE-Emerge were how to host office hours and provide live training as well as troubleshoot projects during the assembly phase. Zoom, a video conferencing app, was used to meet each of these challenges by allowing a way for students to meet while maintaining a safe environment. A key benefit of Zoom was that training sessions could be recorded and uploaded to the course website after each session so students who were unable to synchronously attend training to review the recording later.

The cancelation of spring quarter events allowed students to explore alternative ways to present and communicate the outcomes of their projects to the public at large. Students were tasked to create two websites for their projects. GitHub was used for the first website and contains detailed information on the project's design, background information, technical details, and a team bio. Hackster was to communicate with a different audience that has a more hardware interest and focuses on the high-level design of the project.

PRELIMINARY RESULTS

Student demographics for EE-Emerge are shown in Figure 1.

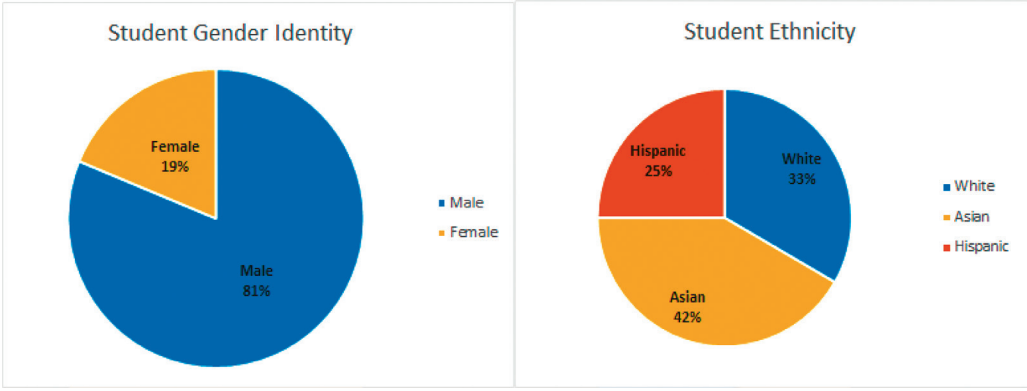

Figure 1. Student Demographics.

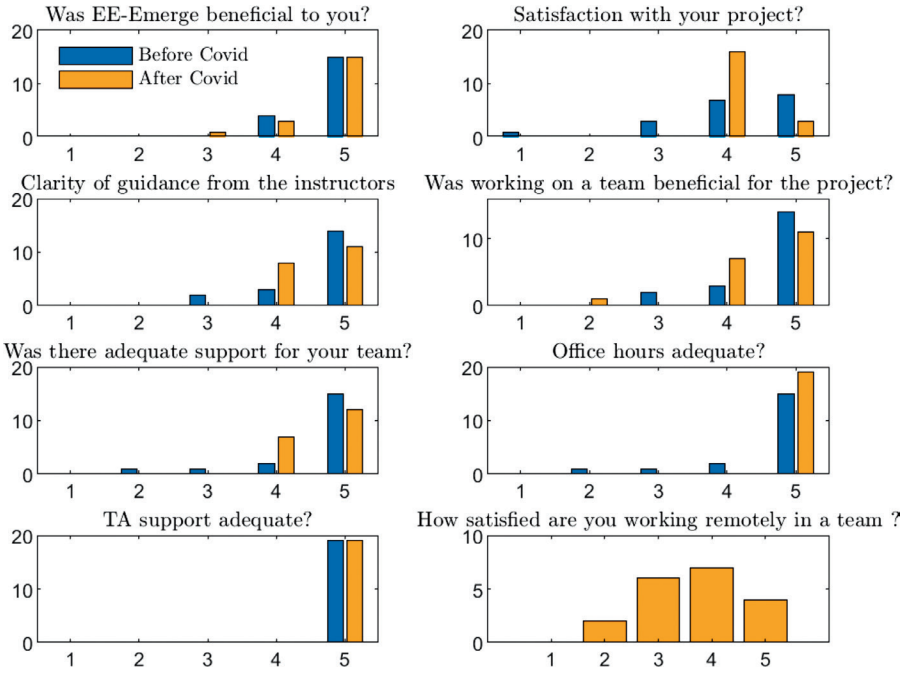

Figure 2. Student Survey Results.

Survey data from students before the onset of COVID-19 (fall and winter quarter), and after COVID-19 restrictions were put into place (spring quarter) are summarized in Figure 2. In general, the results indicate that the student experience in the course remained to a large extent unchanged, and most students were satisfied with how they were able to adapt to remote and distributed collaborations. Polling of students showed that they returned for spring quarter for one of or both of the following:

1. Students felt that they had already dedicated so much time to the project that they wanted to see the project to completion.
2. Since the student was part of a team, they felt that they needed to come back not just for themselves but also for the team. If they dropped the course, they would of let themselves and their team down.

The results in general support the conclusion that even with the challenge of COVID-19, EE-Emerge was a success for the 2019/2020 academic year. In some cases, results pre-COVID show that satisfaction was higher, compared to during COVID. Discussions with students revealed that this was due to projects not reaching the level of development that the teams envisioned. Each project exceeded all criteria that students initially proposed, but with the lack of in person interaction and teams spread across the country, teams were unable to go above and beyond their proposed criteria.

While in-person events were canceled, each of the four teams was able to present their project to the public both through their websites and the UC Davis Virtual Design Showcase, which was a campus event held by the College of Engineering. The completion rate for this year's projects was at 100%, while the previous two offerings of the course had completion rates of 75% and 50%, with the higher level of completion this year due to teams feeling they needed to complete their projects not just for themselves, but also for the other members of the team. Links to each project's websites and produced videos are provided in Appendix A.

NEXT STEPS

With COVID-19 still affecting academic operation, EE-Emerge for the upcoming academic year will be offered online. Remote and distributed collaboration will be a major emphasis from the beginning of the course with Zoom and Github being critical pieces of the course.

Fall quarter will use zoom extensively to provide an easy way to share and record training sessions and course meetings. After each training session and course meeting the recorded video will be uploaded to the course website to allow students unable to attend to view the sessions on their own time.

~~Soldering of PCBs will not be allowed since students will not have access to on campus lab facilities. Instead students will be taught how to use PCB fabrication services~~.

If COVID-19 continues into winter and spring, fully remote learning makes it harder to build larger projects that students are satisfied with. The scope will be reduced to have at least four projects that are simpler. Zoom again will be used here for all student interaction, like office hours and individual team meetings. All interaction will be recorded and uploaded when appropriate.

AUTHORS

Sean Alling received his BSEE and BSCE in 2015 from the University of California At Davis. He is currently pursuing his Ph.D. in Electrical and Computer Engineering at the University of California at Davis. Concurrently with his Ph.D., he works in the elevator control system industry as an R&D engineer. His research interests include embedded systems, low power design, and engineering education. Mr. Alling is a member of IEEE and ACM.

André Knoesen is a Professor and Department Chair of the Department of Electrical Engineering, University of California, Davis. He received his Ph.D. degree from the Georgia Institute of Technology, Atlanta in 1987. He is the principal author of a popular interactive online textbook "Introduction to MATLAB" published by zyBooks. His current research is in cyber-physical systems and sensor networks. Dr. Knoesen is a fellow of the Optical Society of America.

APPENDIX A: TEAM PROJECT RESOURCES

Four Face

1. Github presentation
2. Hackster
3. Project Poster
4. Project Video

Light Fight

1. Github
2. Hackster
3. Project Poster
4. Project Video

Snap Lights

1. Github
2. Hackster
3. Project Poster
4. Project Video

LoopMaster

1. Github
2. Hackster
3. Project Poster
4. Project Video