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Delivering Hands-On Introductory Design Experiences in a Hybrid Curriculum

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Introduction

The focus of this paper is to elaborate on the changes made to the mechanical engineering introductory course in order to provide a cohesive learning experience regardless of student location during the pandemic. The paper will outline and discuss the effect of course accessibility modifications on student interaction and performance.

The previous three-credit-hour course breakdown consisted of three sections: modeling, coding, and a semester project [1]. Designed to gradually introduce foundational design concepts throughout the semester, the modeling and coding sections of the course teach students the skills they need in order to complete the semester project.

The original version of the project is student lead, with the class broken into groups consisting of a team lead, a procurement officer, and a safety officer. Students could decide between several projects that encapsulate various mechanical engineering sectors ranging from model rocket launch to a device for resonant frequencies' dynamic characterization. However, this year, the semester project was standardized into an IR-controlled robot to minimize logistics concerns and provide a consistent learning platform.

In addition to project modifications, student engagement techniques were implemented to keep the class unified and engaged regardless of location. In the online chatting platform Discord, a server for the class was created housing numerous channels that allowed students to communicate with each other and to the teaching assistants (TA's).[2]

Laboratory Structure

Method of Delivery

With a total of one hundred and nineteen students, alterations to weekly laboratory sessions revolved around minimizing exposure and keeping students safe by broadcasting the lab session live in a Zoom conference meeting while still holding an in-class session. The in-person section was properly socially distanced based on New Mexico COVID restrictions. There were two TA's available in the physical classroom to guide students, one undergraduate, and one graduate TA. The Zoom call was hosted by additional graduate and undergraduate TA's to ensure that students had the opportunity to receive support at any time throughout the lab session. All students could access necessary software through a remote server organized by the university to provide distance students with programs like SolidWorks, typically only available at the university. The blending of remote server use with class broadcasting allowed distance students to be engaged in live class time as much as their in-person peers.

Section 1: Parametric Modeling

The lab's modeling section was based in SolidWorks and aimed to provide students with the necessary skills to design their robot housing and produce mechanical drawings for TA's to

review. Students were walked through various SolidWorks tutorials and given part-building tasks to hone their skills and understanding of CAD programs.

Section 2: Basic Coding and Circuit Fabrication

The coding section of the semester gave students a surface-level introduction to circuits and programming using Arduino. This section of the course was heavily adapted. Instead of giving all students circuit kits, the class utilized online websites like TinkerCAD to demonstrate how to build simple circuits and program a microcontroller.

Section 3: The Project

Project Goals

The standardized IR-controlled robot gave students the chance to work on a project from start to finish. Students were challenged to design and build a robot that adhered to the following requirements.

I. Design and 3D print a robot body big enough to house all the required components and fit within the printing bed's specifications.
II. Follow a black line along a predetermined track using IR avoidance sensors and stop at the end of the track.
III. Attempt to blow out a candle placed at the end of the track by any means necessary.
IV. Write a code to run the robot and exhibit a basic understanding of the code used.

The line following robot allowed students to convey their newly learned SolidWorks skills for parametric modeling and coding language understanding in Arduino for programming. By leaving the exact design specifications open to interpretation, the students were encouraged to use their imagination in optimizing their design for movement. All software introduced in the course are tools necessary for future courses in the Mechanical Engineering department. The parametric modeling and programming could be conducted from a personal computer, which made it ideal for students taking the course online.

When the time came for the project, all necessary parts to complete the project were shipped to distance students and delivered to in-person students. Encouraging students to use online software like TinkerCAD to test their project circuit prototypes helped to ensure minimal problems when constructing their robot. Since the circuit was online, TAs could easily find issues and troubleshoot with students from a safe distance.

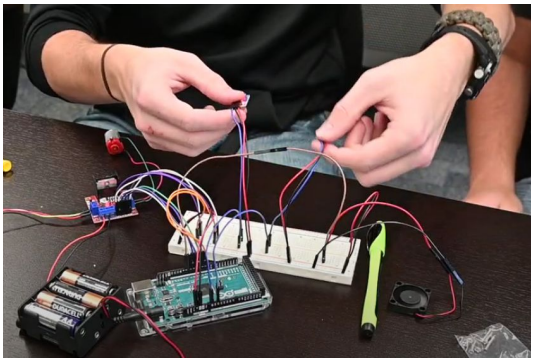

Figure 1: MENG 110 face-to-face students testing IR sensors for final project
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Photographer: Samuel Baca

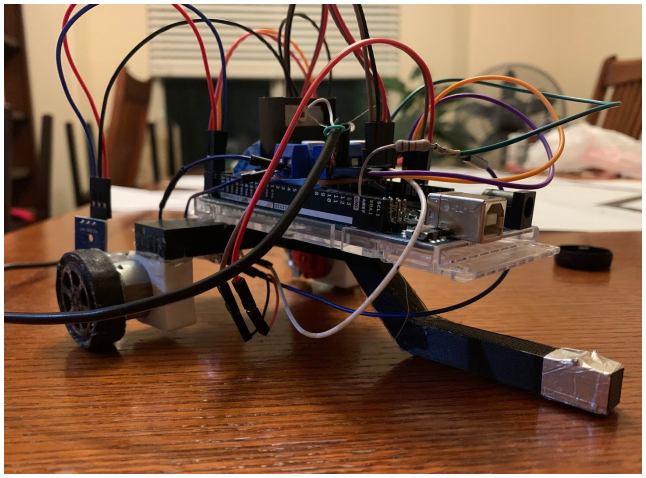

Figure 2: MENG 110 final project robot
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Figure 3: MENG 110 online student final project video submission
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Virtual Connections

The adjustment to university life is challenging even on an average year for incoming students. The Mechanical Engineering program strives for students to feel included in a community of learning. Due to the challenge that distance engagement poses, the software Discord promoted discussion and aid between the students and TAs. Utilized as a platform for people to create communities and enjoy common interests, the online software Discord was a perfect tool for bridging the gap between students and their peers.
The creation of the Discord server for the introductory course had two prime intentions focussed

on enriching the academic community of the course:

I. Generate a platform for students to build friendships and engage with one another.
II. Create open channels to discuss topics related to the course and provide general academic support by connecting TA's and Professors to students.

As soon as the server was made public to the students, the brilliance of Discord as an engagement tool shone. Students immediately began getting to know one another and even creating other Discord servers to talk about topics not related to the course. Once the semester began, weekly discussion questions related to class topics were posted to the server, and students were required to respond to the topic for a grade. Although some students would only post a singular response, most students used the weekly discussions as an opportunity to learn from topic discussions and strengthen their understanding of class material.

General academic support, the most prevalent being help with homework assignments, was offered by TA's on the server. Students would ask questions related to assignments assigned in the lecture, the lab, or their project. Frequently, a student would ask a question and almost immediately receive guidance from another student who experienced the same problem and overcame it. A relationship of sharing knowledge and support became prevalent between students and grew throughout the semester as they helped one another solve problems and come up with ideas for improvement. Only when students could come to no concrete conclusions would TA's have to clarify or answer questions directly.

The combination of purely academic channels, open discussion feeds, and channels just for unwinding and interacting helped the class transform into an environment of learning, connection, and an enriching community.

Conclusion

Engaging students in a time of unrest and uncertainty comes with a plethora of challenging decisions. Throughout the semester, students and TA's alike ran into obstacles with communication and connectivity. Creating a separate server for distance students to access online software leads to servers overloading or crashing intermittently. Due to the pandemic and the widespread location of distance students, shipping delays for parts would throw off entire project timelines. Even at the university, Wi-Fi bandwidth was spread thin, and students' access to online material could be finicky. Future improvements to alleviate these issues rely on more experience with distance learning and adapting to an online presence on a mass scale.

Nevertheless, despite all setbacks and headaches that come with attempting a new approach to delivering material, the mechanical engineering course successfully guided students through their first stage in the engineering program. In many ways, the lack of traditional engagement and teaching tools made delivering material feel less personal and distant than a typical year. However, through online tools and digital software, a new form of community and learning development was born and there was no discernible gap between the score performance of distance students in contrast to in-person students. Even when courses return to a traditional model, the use of Discord to promote student growth will continue. Its effect on students was profound to see, and because of its online presence, it will continue to be a tool for students to learn and grow from anywhere they may be.

References

[1] J. Garcia, A. Norway, V. DuPriest, C. O'Malley, "Engineering Design Applications in the Introduction to Mechanical Engineering Curriculum," in 2019 ASEE Annual Conference & Exposition, Tampa, FL, USA, June 15-19, 2019

[2] J.Garcia, L.Velásquez, E.Nunez, R. Harlow, C.O'Malley, : " The Implementation of Dynamic Learning in a Project-based Introductory Engineering Course." in 2020 ASEE Annual Conference & Exposition, Montreal, Canada, June 2020.