Workshop: The Integration of Technical Skills Within a First-Year Engineering Design and Innovation Course Featuring Hands-On Electronics

Summary for the Conference Program:

Introduction

Our college of engineering offers first-year engineering students an interdisciplinary hands-on project-based engineering design course. The students learn several technical skills, such as computer-aided drawing and shop skills, as well as non-technical skills, such as team building and creativity. To facilitate the prototyping process, a curriculum has been developed to integrate more technical skills that are deemed critical. The first phase of the developed curriculum allows students to experience 3D printing and laser cutting. Students learn how to design a part, splice a file, set up the respective equipment, and perform the desired 3D print or laser cut. Recently, a second phase of the curriculum was added to include a hands-on introduction to electronics, where students learn the basics of microcontrollers and sensors. Through the development of this curriculum, the first-year course has seen a large increase in the quality of products produced by students at the end of the semester. The team wishes to share the phase 2 electronics portion of the curriculum with conference attendees as a workshop, while also having the opportunity to discuss and receive feedback on other integrative technical skills modules being developed or implemented on a larger scale.

Goals of Workshop

The purpose of this workshop is to expose and train instructors on how to deliver and integrate this electronics fundamentals module into their courses. While experiencing the fun hands-on activities from a "student's perspective" the team will share their scalability strategy, lessons learned, and then open up for further discussion regarding other integrative engineering educational approaches. This workshop is intended to serve as an additional resource on best practices for adding and scaling effective technical skills modules to first-year engineering design courses, and to foster discussion of integrative education.

Summary of workshop goals:

- How to scale technical skills modules in a large course
- How to introduce Microcontrollers and Sensors to first-year students
- Discuss core engineering technical skills first-year students need
- Discuss other integrative approaches currently being used in Academia

Electronics Kits will be provided to attendees

Materials Required by Attendees: Attendees should bring a laptop

***Software Required by Attendees*:** Attendees should download the Arduino IDE here

Full Workshop Proposal:

Workshop: The Integration of Technical Skills Within a First-Year Engineering Design and Innovation Course Featuring Hands-On Electronics

Introduction

Our college of engineering offers first-year engineering students an interdisciplinary hands-on project-based engineering design course. In this course, students work in teams of 6-8 to design and build prototypes that solve a problem for a real client. The students learn several technical skills, such as computer-aided drawing and shop skills, as well as non-technical skills, such as team building and creativity. To facilitate the prototyping process, a curriculum has been developed to integrate more technical skills that are deemed critical. Within the past four years, the team has created and scaled time efficient and cost effective 2-part rapid prototyping modules that are provided for approximately 320-400 first-year engineering students each year, in 7-12 lab sections each semester. The modules were designed for first-year engineering students; however, the content can be easily scaled to other classroom and lab settings. The first phase of the developed curriculum allows students to experience 3D printing and laser cutting. Students learn how to design a part, splice a file, set up the respective equipment, and perform the desired 3D print or laser cut. Recently, a second phase of the curriculum was added to include a hands-on introduction to electronics, where students learn the basics of microcontrollers and sensors. Through the development of this curriculum, the first-year course has seen a large increase in the quality of products produced by students at the end of the semester. The team wishes to share the phase 2 electronics portion of the curriculum with conference attendees as a workshop, while also having the opportunity to discuss and receive feedback on other integrative technical skills modules being developed or implemented on a larger scale.

Electronics Module

This electronics module is presented as phase 2 of integrative rapid prototyping hands-on modules delivered during the lab portion of a first-year engineering course. Products containing electrical components have increased exponentially and will likely continue this trend [1]. Our first-year students need these skills to not only keep up with this trend, but also to safely and effectively incorporate electronics into their prototypes. This module also contributes to the innovative active learning concept to promote deeper learning [2]. By creating a hands-on immersive experience, it allows students to make connections between engineering concepts that can later be applied to future novel and complex issues or challenges they may experience throughout and beyond their education [3].

The first iteration of the electronics module was delivered in the 2019 Spring semester during designated lab times by graduate students. The setting for these modules is a classroom with a capacity for 25 students and access to a pre-assembled electronics kit and a computer. Each

student is provided with an electronics kit that they get to keep after the module to promote further exploration. The current kit contains about ~$15 worth of materials and includes: Arduino Nano (1), Small breadboard (1), 220 Ohm resistors (3), 5mm LEDs (3), male to male jumper wires (10), and an ultrasonic distance sensor (1). The module content teaches students how to create a basic circuit, code an Arduino, make LEDs blink, receive an output from an Ultrasonic Distance Sensor, and combine both the LED and Sensor into a circuit with defined parameters.

Overall, it has been observed that students enjoy and learn a lot from this module, which has contributed to their overall confidence in engineering and quality of deliverables. Although the first iteration was successful, there were additional needs identified and incorporated into the subsequent semesters. Some of the improvements included: more background on why electronics are important, additional hands-on practice opportunities, and access to information covered within the module along with links to additional learning resources. The module was forced online during the COVID-19 pandemic and was delivered to students virtually. Due to this, it now has two formats, online and in-person, therefore increasing accessibility. As this electronics module continues to be developed, the following issues will be addressed: resource training, software bug identification, and optimal semester scheduling. Additional team members will need to complete a brief training in order to feel comfortable teaching and answering questions about the electronics module. Occasionally there are software issues with the Arduino Nano, so additional troubleshooting methods will be developed to cover all possible challenges that may occur. The team continues to evaluate what part of the semester is most beneficial to deliver the content to students in order for it to align properly with their course project. Future modules will include Ohm's Law and examples of application, use of actuators (motors), and how to safely power a system via a battery or other external power source.

Goals of Workshop

The purpose of this workshop is to expose and train instructors on how to deliver and integrate this electronics fundamentals module into their courses. While experiencing the fun hands-on activities from a “student’s perspective” the team will share their scalability strategy, lessons learned, and then open up for further discussion regarding other integrative engineering educational approaches. This workshop is intended to serve as an additional resource on best practices for adding and scaling effective technical skills modules to first-year engineering design courses, and to foster discussion of integrative education.

Summary of workshop goals:

- How to scale technical skills modules in a large course
- How to introduce Microcontrollers and Sensors to first-year students
- Discuss core engineering technical skills first-year students need
- Discuss other integrative approaches currently being used in Academia

Workshop Content

***Duration*:** 2 Hours

Workshop Slides: Provided in final workshop summary

Materials (provided by presenters): Arduino Nano w/cable (1), Breadboard (1), LEDs (3), Jumper Wires (10), 220 Ohm Resistors (3), and Ultrasonic Distance Sensor (1)

***Software Required by Attendees*:** Attendees should download the Arduino IDE here

***Proposed Timeline*:**

- Facilitator introductions (10 min)
- Introduction to first-year engineering design course and its goals (10min)
- Development of the Electronics module (10min)
- Complete Electronics module from student's perspective (1 hour)
- Open discussion of integrative engineering educational activities (30 min)

References

[1]"Global Electronic Products Opportunities and Strategies Market Report," *The Business Research Company*. [Online]. Available: https://www.thebusinessresearchcompany.com/report/electronic-products-market. [Accessed: 14-Apr-2022].

[2] Hernández-de-Menéndez, M., Vallejo Guevara, A., Tudón Martínez, J.C. et al. Active learning in engineering education. A review of fundamentals, best practices and experiences. Int J Interact Des Manuf 13, 909–922 (2019).

[3] L. Prendergast and E. Etkina, "Review of a first-Year engineering design course," *2014 ASEE Annual Conference & Exposition Proceedings*. [Online]. Available: https://peer.asee.org/review-of-a-first-year-engineering-design-course. [Accessed: 14-Apr-2022].