Affordable Learning Georgia Textbook Transformation Grants

Final Report

General Information

Date: 5/22/20

Grant Round: R13

Grant Number: 418

Institution Name(s): Georgia Institute of Technology

Project Lead: Christopher Saldana

Team Members (Name, Title, Department, Institutions if different, and email address for each):

Course Name(s) and Course Numbers: Creative Decisions and Design (ME2110)

Semester Project Began: Spring 2019

Final Semester of Implementation: Fall 2020

Total Number of Students Affected During Project: 546 students

1. Narrative

The course that this work focused on was ME2110 (Creative Decisions and Design), a required sophomore-level course for students majoring in Mechanical Engineering. It is cross-listed as a Denning Technology & Management (T&M) Program requirement for College of Business students. It has a total enrollment of 600 students per academic year and is taught in the fall, spring and summer semesters. The goal of the course is to introduce students to a range of topics that include structured design, fabrication, mechatronics, and technical communication. The course teaches important principles and tools to students critical to other courses at Georgia Tech, including ME3057 (Experimental Methods Laboratory), ME3210 (Design Materials and Manufacture) and ME4182 (Capstone Design), as well as students activities in extracurricular build programs, including the Vertically Integrated Projects (VIP) Program, Create-X, the Invention Studio, and various student competition teams (Robojackets, GT Motorsports, EcoCar, GT Off-Road, GT Solar Racing, HyTech Racing, Wreck Racing). The course is the highest rated mechanical engineering course in formal senior exit surveys as students have recognized the importance of these principles in their development throughout their academic careers. Prior to the course improvement, students were required to obtain an embedded student device (cost $243.75) that is used by the students in building mechatronic systems throughout the course. The proposed development effort was focused on significantly reducing this cost, while also introducing new and more modern course materials that cover topics of substantially greater utility to the students considering the technological advancements in the field as well as the improvements in so-called 'maker space' facilities at Georgia Tech.

The primary course improvement made was to develop and deploy use of a low-cost embedded device that relies on open-source programming implementations. The prior system prescribed for students to purchase is a closed and relatively high-cost system wherein students and professionals are essentially designing within a hardware ecosystem that limits opportunities for exploring low-cost devices and, in a similar manner, student entrepreneurial pursuits. To address this deficiency, the new course materials developed and deployed sought to introduce low-cost embedded systems (e.g., Raspberry Pi, Particle Photon, Beaglebone) for students mechatronics designs. These systems make use of open-source computing languages like Python that are far more advantageous for students to learn relative to closed programming systems, especially in terms of future applicability and relevant career skills. These low-cost embedded systems are critical especially in the broader viewpoint as many advancements in the consumer electronics, mobile computing, and internet-of-things sectors are based on these open platforms. Further, in accessing these open-source programming capabilities, students will have access to a rich and interactive developer community, which will open opportunities for learning outside of the classroom. New course materials were developed to train students on these systems and programming languages and example code repositories (e.g., GitHub) leveraged for providing a student-oriented developer community in this class and around the world. These materials were provided open source to students in this course and to students around the world through the main course website (http://2110.me.gatech.edu/).

Our first effort focused on the Raspberry Pi platform. We developed instructional materials for using the Raspberry Pi for mechatronic systems, including programming training, IDE training, integration of sensors and actuators to the Raspberry Pi. We uncovered that the use of standard code libraries dramatically increased the speed that students had through training needed to produce a functioning mechatronic system. One issue we noticed on the Raspberry Pi was the high overhead associated with the functions of the device. We migrated our developments to Arduino in the second semester and again developed unique materials for the Arduino platform. We saw much less issues in that development and student satisfaction was much higher. While we could not do a formal assessment at the end of Spring 2020 due to the COVID-19 outbreak, we have used this data to migrate the entire course to Arduino and the impact on students in future terms will be very significant. Online resources like TinkerCad circuits are compatible with our learning materials and we will have significant opportunities for cross-material learning.

2. Quotes

- I really appreciate the preparedness to make the Raspberry Pi work in this class. I think it worked very well.
- There is a huge network of online makers and code repositories based off of raspberry pi's and this class would be a great opportunity to dive into that universe.
- Arduino was much faster for us to learn and deploy code using the libraries provided.

3. Quantitative and Qualitative Measures

A. Uniform Measurements Questions

The following are uniform questions asked to all grant teams. Please answer these to the best of your knowledge.

Student Opinion of Materials

Was the overall student opinion about the materials used in the course positive, neutral, or negative?

Total number of students affected in this project: ___546_____

- Positive: ___100____ % of ___546_____ number of respondents
- Neutral: _____ % of _____ number of respondents
- Negative: _____ % of _____ number of respondents

Student Learning Outcomes and Grades

Was the overall comparative impact on student performance in terms of learning outcomes and grades in the semester(s) of implementation over previous semesters positive, neutral, or negative?

Student outcomes should be described in detail in Section 3b.

Choose One:

- __x_ Positive: Higher performance outcomes measured over previous semester(s)
- ___ Neutral: Same performance outcomes over previous semester(s)
- ___ Negative: Lower performance outcomes over previous semester(s)

Student Drop/Fail/Withdraw (DFW) Rates

Was the overall comparative impact on Drop/Fail/Withdraw (DFW) rates in the semester(s) of implementation over previous semesters positive, neutral, or negative?

Drop/Fail/Withdraw Rate:

Depending on what you and your institution can measure, this may also be known as a drop/failure rate or a withdraw/failure rate.

___1.1____% of students, out of a total ___182 ____ students affected, dropped/failed/withdrew from the course in the final semester of implementation.

Choose One:

- ___ Positive: This is a lower percentage of students with D/F/W than previous semester(s)
- __x_ Neutral: This is the same percentage of students with D/F/W than previous semester(s)
- ___ Negative: This is a higher percentage of students with D/F/W than previous semester(s)

B. Measures Narrative

Data is provided regarding overall course instructor and outcomes survey. This CIOS data represents the required evaluation of the course outcomes. While the data for the Spring 2020 semester is unavailable due to the cancellation of course surveys with the rapid move to online learning after the spring break period, data from Fall 2019 and Spring 2019 were collected to measure improvements in the course. The data from these semesters were compared to data from the previous delivery of the course without the materials that were developed in this project. The course had reported an increase in instructor effectiveness from a previous value of 4.1 to higher values of 4.5 and 4.6 with the course improvements. Clearly these improvements have had a positive impact on student satisfaction with the course and the delivery of the material. Additionally, data is provided on fail/withdraw rates as well as average GPA for students in these semesters. From the data, it is clear that these improvements haven't negatively affected these measures, while improving the perceived course satisfaction. Finally, we directly measured the time taken to complete assignments with the improved course materials, and the improvements resulted in 30% faster completion of the course materials, thereby

reducing the time requirement for students which was one our major goals. Thus, with the totality of data considered, the impact of the project is that the satisfaction of the course objectives and outcomes by students were consistent, while also reducing cost of materials for the students and their perceived satisfaction with the course delivery.

4. Sustainability Plan

As part of the project development, open code libraries were developed that can be integrated into future mechatronics courses. These libraries are hosted on the course website. As the technology matures, it will be relatively straightforward to adapt these libraries within the Arduino development platform. Further, emulation platforms are now becoming available through TinkerCad that will allow us to use the code libraries and we intend to deploy virtual sections of the course that will make use of the developments here for virtual course offerings. The maintenance of the Arduino platform will be significantly more possible due to the use of low-cost microcontrollers in the development project. The GWW School will update these platforms with no cost to the students.

5. Future Affordable Materials Plans

In this project effort, we developed course materials for a low-cost machine controller that significantly increased the speed and effectiveness of training for our students in mechatronics. Adapting these materials for online delivery using microcontroller emulators such as TinkerCad circuits will be something that will allow us to transition to environments that are more virtual. With the impact of COVID-19 on our students this term, we are unsure what the impact will be to our ability to deliver classroom instruction in the Fall 2020 semester and beyond. In the case that learning transitions to a more virtual format, it will be very attractive for us to adapt these materials so that our students can use virtual environments to program and evaluate whether their mechatronic systems are responding as expected. We are starting to work on this this summer.

6. Future Scholarship Plans

We anticipate participating in the 2021 ASEE Conference to present our findings related to the course development of the use of open source libraries, as well as potential adaptation of the materials to online virtual learning environments.

7. Description of Photograph (optional)

The picture depicts the class picture at our semester robotic competition. The student pictured here benefited from the open source materials and microcontrollers provided during the class for their robotic systems.