Addition of Arduino Kits to Introductory Engineering Course

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Abstract

Currently, there are too many students who start in engineering programs but move to other majors after their first year. Problem areas appear to be student weaknesses in mathematics and physical sciences, and educators not providing enough hands-on interaction with engineering manipulatives. To help rectify the situation, the authors have revamped the Introductory Engineering course (EGR-101) to have more hands on "tinkering". Students received their own Arduino kits and accessories. Throughout the semester, labs using the Arduino kits were conducted and students were tested on building a given Arduino setup. This approach should assist in demonstrating engineering principles in action so that students can make a better-informed career decision. Overall, preliminary results show that students in the course are more engaged and feel they have a clearer sense of engineering.

Keywords

introductory engineering course, undergraduate engineering, Arduino kits

Introduction

A tinkerer is an "unskillful mender" and tinkering is "to repair, adjust, or work with something in an unskilled or experimental manner"[1]. Problem-based learning is on the rise, and it is guided by the many kits. that provide a straightforward interface for the user that is readily expandable over a very flexible and complex underlying structure[1]. A kit that can readily link your PC to your project for rapid prototyping has captured the imagination of students and faculty alike. The objective is to have students who start as "unskillful mender" realize, through hands on activities, that they have the capability to do quite a lot while learning and gaining "skills". The cost is low ($150 a student) to provide an Arduino kit with 12 different experiments, an LCD add on, pH probe accessory, safety glasses, soldering iron kit and mat. And it is no surprise to see the approach take off. Arduino search on Google Scholar in 2013 had over 490 articles[1] and currently there are 19,600. But many challenges remain: 1. how to evaluate an Arduino project? 2. how to customize the experiments to cover, Chemical, Electrical and Computer engineering first year students?

But the real question: will this problem-based learning approach lead to better retention of our underclass engineers? Students leave not having truly been exposed to many concrete examples of engineering: they are making a career decision without truly understanding what engineering is. By the addition of Arduino kits coupled with problem-based learning approach, the goal is to have students see, use, and test engineering projects. One study done in 2014 in mechatronics looked at 1st and 2nd year retentions[2] and summarized it succinctly, "It can be difficult to retain modern students in an engineering programme given their demand for instant gratification" [2]. Project cases done in [3] and [6] provide nice framework for later classes to build on knowledge

gained in EGR-101. All studies reviewed here have reported increased student enthusiasm and better grades obtained.

Methodology

Louis Stokes Alliance for Minority Participation (LSAMP) Pre-College Summer Bridge Program

Preliminary efforts to include Arduinos in the EGR-101 curricula began in the School of Engineering and Technology LSAMP Pre-College Summer Bridge Program. Due to the limited supply of kits, students were put into groups and were not permitted to bring the Uno boards home. This limited chance for hands-on experience did not foster individualized and extended exploration that most of the students desired. Further, condensing a 15-week class to 5 weeks did not allow for an efficient bridging of engineering topics with the EGR-101 course and the Arduino supplement. Despite the complications, students were able to gather some takeaways and many performed well on three Arduino builds during the final examination.

Fall 2018 EGR-101

1. Instruction on Use of Arduinos

A grant from Virginia Space Grant Consortium provided sufficient kits for all students in Fall 2018. Each student now had access to their own kit so they could do homework and laboratory assignments outside of the classroom and tinker at their leisure. Inaugural classes were dedicated to discussing Arduinos kits' design and function as well as the breadboard, as it is often used in conjunction with the Arduino for prototyping circuitry. Pre-assignment generalizations about the circuitry and setup were given with more in-depth dialog following completion of the task.

2. Assessments

For homework, students followed the assigned circuit tutorial in their Arduino experiment guide book. They documented building circuits, uploading code, and running the circuit correctly. Through a report or discussion, they explored components and hypothesized how the components interfaced to make the circuit function.

For the midterm, students built an assigned Arduino circuit given instructions and code. To help prepare them for this non-traditional exam, a dry-run was done a week earlier. The majority of points were awarded for proper selection and placement of major components in the circuit. A penalty was given for a non-functioning circuit and if assistance was needed in installing software.

For the Temperature Sensor Lab, the manual details the theory behind the temperature sensor and instructions for building the circuit. Students took data points of temperature and millivolt signals for multiple trials of various environmental conditions from a freezer to a hairdryer. Data analysis and report write-up were taught to the students, and Excel used to obtain correlations.

In the Soldering Pins to LCD lab, students were presented a soldering kit and learned proper use of a soldering iron. Students took two jump wires and connected them with solder to form a ring. Having successfully soldered, they were ready to do the actual task of putting the pins in the LCD.

Presently students are conducting a pH Lab, in which they measure pH values of household fluids.

Results

The vast majority of the students were engaged in completing their homework assignments. Many attempted to troubleshoot their own circuit when facing problems in functionality, even at times abandoning their present build and beginning from scratch. When unsuccessful in troubleshooting, students actively sought out assistance. Students were vested in seeing functional circuits. Students would seek the expertise of peers who had sound understanding and who were successful in their constructs. Avid homework participation could be attributed to a combination of factors such as: 15% of the overall grade coming from homework, that a major part of the homework credit comes from a properly operating circuit, or just a sincere desire to understand what is taking place.

Overall, the students performed excellently on their midterm exam with scores ranging from 63 to 100 with a mean of 90.8 and a standard deviation of 12.9. By doing the practice run, students were clearly prepared for the task of building an Arduino kit as an exam.

Students did face some obstacles while attempting to complete the Temperature Sensor Lab. There were difficulties with wiring the LCD correctly, in large part because the LCD that had not yet utilized soldered pins but used jumper wires to connect the LCD slots to the breadboard.

Students completed a three question Likert-style survey about the revamped project-based intro to engineering course. Eighty-three percent (83.3%) of the students surveyed strongly agreed or agreed that the course improved their understanding about engineering. Eighty-nine percent (88.8%) of the students indicated that the Arduino projects increased their motivation in the class. Fifty-five percent (55.6%) of the students are confident that they have chosen the correct major based on what they have learned in the course. However, 33.3% selected Neither Agree nor Disagree and 11.1% selected Disagree about their confidence in being an engineering major.

Discussion and Conclusions

Here are some early conclusions: 1. Students who completed the LSAMP Summer Bridge Program performed well in midterm grades. 2. Students now taking EGR-101 are very much in favor of the problem-based approach and feel they have a better understanding what engineering entails much more clearly. 3. Students have skills in soldering and building Arduino kits and are prepared to work in the Tinkering/Maker Spaces.

Future work includes testing the incorporation of Arduino kits in the Summer Bridge program despite time constraints. Another area of improvement is to bring more engineering into circuit design lessons, making less use of "canned" activities.

Beyond the EGR-101 course, it is critical that Arduinos kits continue to be used for microcontrollers, as sensors for unit operations equipment, and in our more advanced classes, including process control for Chemical engineers[4][5], computer-electrical interface class for Computer engineers[3], and microcontrollers for Electrical engineers[6].

In conclusion, project-based kits motivate students to learn and better understand engineering. It remains to be seen if such kits increase retention. The main point is the project-based approach allows students to make informed decisions regarding continuation of their engineering major.

Acknowledgments

Louis Stokes Alliance for Minority Participation and Virginia Space Grant Consortium funding.

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