UNIVERSITY OF LOUISIANA AT LAFAYETTE

STEP Committee

Technology Fee Application

Continued Expansion of the Core Robotics Kit in the Mechanical Engineering Curriculum

Title

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Name of Submitter
(Faculty or Staff Only)

Department of Mechanical Engineering

Organization

Title: Continued Expansion of the Core Robotics Kit in the Mechanical Engineering Curriculum Date: 07/15/19

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ABSTRACT (250 words or less):

Each academic year, over 125 engineering students enroll in MCHE 201: Introduction to Engineering Design. In this course, the students learn about the mechanical design process and technical communication through a series of robotics projects. Each semester culminates in a final robotics contest, held at Blackham Coliseum. The contest attracts a large crowd, including students, families, friends, high school students, and representatives from industry. To support the development of the student robots, each team is issued a kit of components that has been acquired through a combination of grants and industry donations.

This proposal seeks to enhance that kit through the purchase of a time-of-flight distance sensor, a small OLED display, an analog joystick, and the associated wiring to facilitate integration with the existing kit. This modest purchase will enhance the kit by filling current gaps in its capabilities. Two of these gaps are distance sensing and feedback of system state. These are also two areas of improvement often requested by students.

The component purchase proposed here will not only directly improve the kits in MCHE201. The expansion of the capabilities of the kit also expands the solution space for student designs. As such, they help facilitate instruction of the design methodology taught in the class. In addition, students from local high schools, as part of the LPSS GEAR UP program, also take part in the MCHE201 contest and instruction developed for it. They will also benefit from this project.

Continued Expansion of the Core Robotics Kit in the Mechanical Engineering Curriculum

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1 Introduction

Objective, formalized mechanical design techniques, such as the House of Quality, functional decomposition, morphological charts, and evaluation matrices are critical components of modern engineering design. In *MCHE201: Introduction to Engineering Design*, students are taught these methods through the use of robotic examples and projects. The inclusion of robotic projects benefits students, who are able to practice the design concepts that they have been taught, while forming a strong foundation in robotics principles. For many, *MCHE201* is their first opportunity to design and build a computer-controlled machine. For most, it is their first time *ever* writing any computer code. The class also ends in a final robotics contest, which has been well attended in past semesters by not just students, but family members, friends, local high school students, and industry partners. For example, Figure 1 shows one round of a the final robotics contest from the fall 2018 section of *MCHE201: Introduction to Engineering Design*, which was held in Blackham Coliseum.

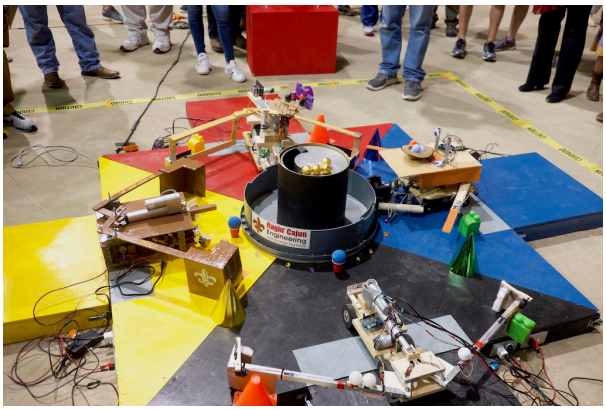

Figure 1: One Round of the Final Robot Contest from *MCHE201*

Having hands-on experiences to reinforce more-traditional, lecture-style classes is invaluable. Furthermore, the skills developed through this class and extended through the purchases proposed here are valuable and highly-marketable in the modern engineering workplace. Finally, the proposed purchases will allow students to explore more creative solutions to engineering problems, making the design process and related projects more fun for all those involved.

2 Purpose of Grant and Impact on Student Body

This proposal seeks to fund the continued expansion of a robotics kit provided to students in *MCHE201: Introduction to Engineering Design*. The purchase will extend the capabilities of the current kit of components that the students are issued in *MCHE201: Introduction to Engineering Design* to fill a few of its remaining weaknesses through the purchase of the Distance Sensor in Figure 2, the OLED display in Figure 3, and the analog joystick in Figure 4. All of these components communicate over the i^2c protocol, for which there is a connector on the custom *MCHE201* carrier board. They can be daisy chained such that all three (and more) can be connected and used simultaneously. Cables for these connections are included in the proposed budget.

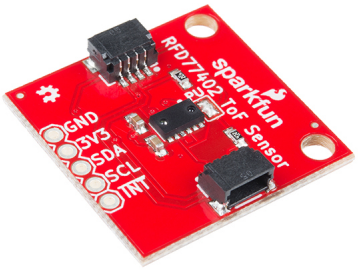

Figure 2: Distance Sensor
(Image from SparkFun.com)

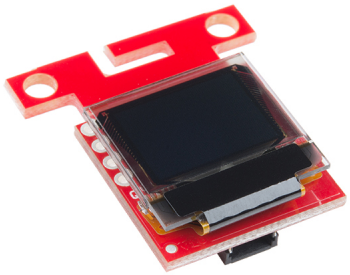

Figure 3: OLED Display
(Image from SparkFun.com)

Figure 4: Joystick
(Image from SparkFun.com)

These changes will push the capabilities and protocols used in the kit to be more similar to the types of electronics that the students will see in their professional lives. A custom carrier board, shown in Figure 5, has been developed as part of a prior-awarded STEP grant. The development of that carrier, funded by that prior STEP grant, has enabled the further expansion of the kit.

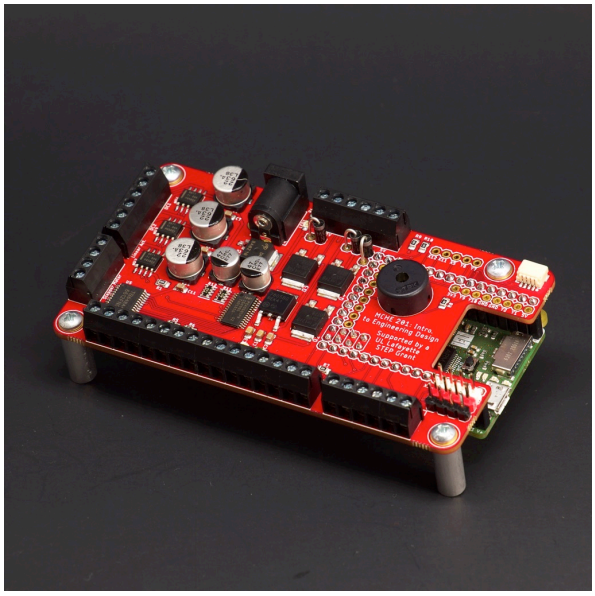

Figure 5: The STEP-funded Custom *MCHE201* Carrier Board

Increasing the capabilities of the robotics kit will directly impact the over 125 students who take *MCHE201: Introduction to Engineering Design* each academic year. In addition to the direct impact the kit will have on the students enrolled in *MCHE201*, the kit will enable these students to enhance later design courses, such as *MCHE482: Senior Projects I* and *MCHE484: Senior Projects II*, with the knowledge they have gained through using the kits. In addition, the class is scheduled to become a requirement for the under-development Robotics minor in the College of Engineering. Once this minor is approved, the number of students directly impacted by this project will further increase.

The course has also begun hosting students from the Lafayette Parish School System GEAR UP program (https://lpssgearup.com) as part of a collaboration between the PI and that program. GEAR UP is an acronym for Gaining Early Awareness and Readiness for Undergraduate Programs. The goal of this program is to increase "the number of low-income students who are prepared to enter and succeed in postsecondary education." Through this program, students from four local high schools work directly with PI Vaughan and attend the robotics contest. Soon, a team from each high school will also compete in the final robotics contest of the class. So, this project has the capability to not just help current UL Lafayette students, but also local high school students, who will hopefully be UL Lafayette students in the near future.

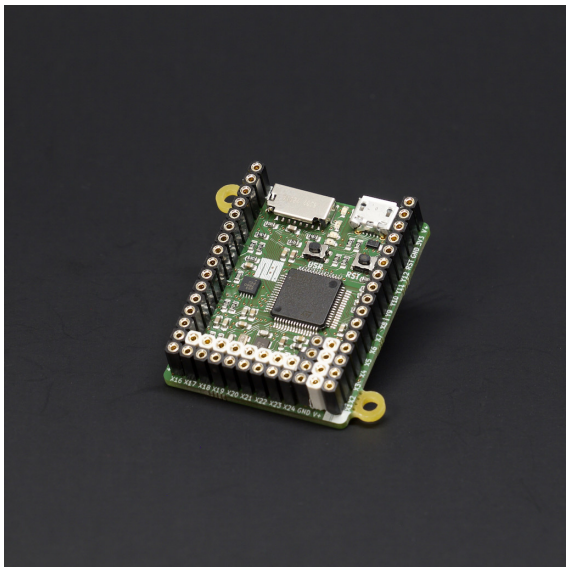

Figure 6: The Microcontroller Currently Purchased by Students

Figure 7: Some of the Components Included in Current *MCHE201* Kit

2.1 Grant Objectives

The primary objective of this project is to provide students with an enhanced undergraduate mechanical design education. This will be accomplished through the continued improvement of *MCHE201: Introduction to Engineering Design*, primarily through expansion and improvement of a kit of robotics components that are issued to teams of students in the class.

A secondary objective is to establish a strong base from which to approach potential industrial sponsors for the class. The funding provided by prior STEP grants has allowed industry sponsors to be approached and impressed with the course, leading to the donation of 40 sets of pneumatic components to be included in the kit of mechatronic components given to the students each semester. Continued funding from the University through the STEP program, such as that requested through this proposal, will not only fund an immediate improvement in the student experience, it will also help demonstrate the vision for what the class can become. Demonstrating this vision, and the University's support of it, is a key ingredient to attracting additional industrial sponsors.

2.2 Impact on Student Body

More specifically, this proposal will fund the purchases for improving the robotics kit that is issued to teams of 3-4 students in *MCHE201: Introduction to Engineering Design* during their enrollment in the class. While the long-term goal is to provide students with all of the components that they need during the class, *MCHE201* students are currently asked to purchase a kit of electronic components instead of a textbook. At the core of the kit is the pyboard microcontroller, shown in Figure 6. The student-purchased kit also includes some of the core components needed for robot development, including the hobby-style servo, pushbutton switches, and several sensors. However, the kit is missing pieces critical to the design and build of robust robotic platforms. For example, the kit does not include any high-torque actuators or distance sensors.

In order to remedy the deficiencies of the student-purchased kit, each student team is currently

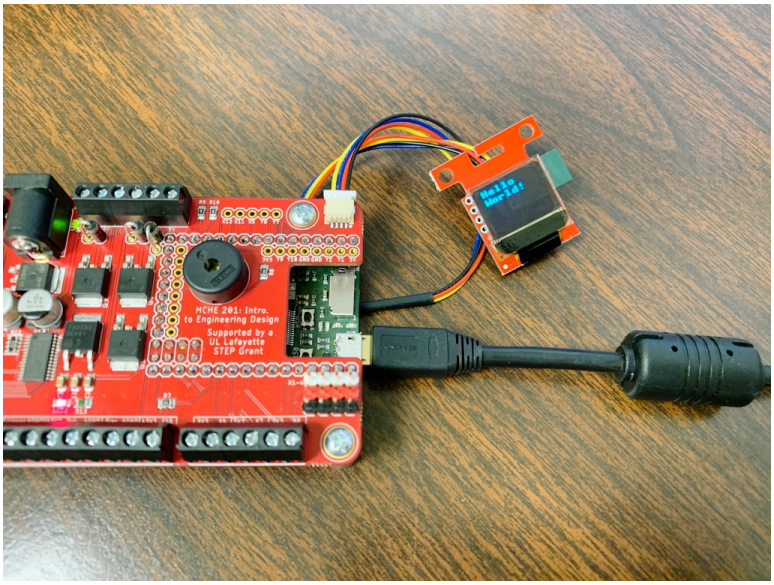

Figure 8: The Qwiic OLED Connected to the *MCHE201* Custom carrier

issued an additional set of components to use during their final project. The current kit, most of which is shown in Figure 7, includes two DC motors, a small solenoid, an electric linear actuator (not shown in Figure 7), a stepper motor (also not shown), an IR distance sensor, a magnetic proximity switch, and a power supply. Also included are the components to use a pneumatic actuator, including the pressure vessel, pneumatic valve, and tubing, which were all part of a recent donation from Parker Hannifin. The kit is all connected through the custom carrier board previously shown in Figure 5 and funded by a prior STEP project.

Currently, the student kit does not have a way to robustly sense distances beyond 30cm. The IR sensor in the kit can only sense distances between 4cm and 30cm under ideal conditions. The range over which it can reliably and robustly sense is much smaller. However, the student robots often need to interact with objects 50cm and further away. To remedy this, the small (1-inch $\times$ 1-inch) time-of-flight distance sensor, shown previously in Figure 2, will be purchased to be included in the kits issued to the students.

In addition, the students often struggle to interpret the current state of their devices, making debugging and development difficult. This is especially true given that most of the students are both building a robotic device and programming for the first time. The lack of visual feedback is a common student complaint regarding the currently-issued kit. A small display is an easy, intuitive way to provide feedback of system state. The small OLED display, shown previously in Figure 3, will be purchased to fill this role and aide the students in this aspect of their project. An example of it displaying a simple "Hello World!" message when connected to the *MCHE201* carrier board is shown in Figure 8. Using this display, the students could write messages from their control programs to help them debug operations and improve their robot's operation.

To further improve the ease at which students can debug and improve their robots, funding to purchase a class set of the Qwiic analog joystick, like the one shown previously in Figure 4, is requested. This joystick would not only help speed the develop-and-debug cycle for the students, it

would also provide an opportunity to teach user interaction and user experience design, a critical component of all human-facing systems.

As mentioned, all of these components easily integrate with the custom carrier board, as it was developed with such an expansion in mind.

3 Projected Lifetime and Timetable

All the equipment requested through this proposal would be purchased immediately following the funding announcement. However, the useful lifetime of the components acquired is approximately seven years. The majority of the components are robust and can continue to be used from one semester to the next.

Upon notice of funding, both interactive and pdf versions of a lab manual that that introduces the mechatronics kit and how to use it will be extended to include the new components. In addition, a series of lab exercises that have been developed to lead the students through the use of the current equipment associated with the course will be extended to include the new components.

The primary maintenance costs for this project are the repair of wiring to the sensors and replacement of sensors damaged during the contest. In most semesters, these costs are fairly low. These costs will be covered by the Department of Mechanical Engineering and lab fees associated with the design curriculum in the department.

4 Responsibilities

The person responsible for *i.)* Implementation, *ii.)* Installation, *iii.)* Maintenance, *iv.)* Operation, and *v.)* Training is the PI, Dr. Joshua Vaughan. Dr. Vaughan is responsible for the *MCHE201* class and has extensive robotics experience, through both research and teaching.

5 Budget Justification

The items to be purchased are summarized in Table 1. The items are class sets of a time-of-flight distance sensor, a small OLED display, and an analog joystick, shown previously in Figures 2, 3, and 4, respectively. Finally, the necessary cabling to integrate these sensors with the current kit will be included. Fifty of each component is requested to facilitate the purchase of a complete class set.

6 Conclusion

Robotics presents an excellent tool to teach, and learn, about a wide variety of mechanical engineering topics. It is also a rapidly-expanding area of need for both local and global industry. The experience of building a robot while learning about mechanical design and technical communication has significant benefits for students, while providing an *extremely* fun way to learn. This project

Table 1: Components to be Purchased

Item	Price Per	Quantity	Sub-Total
SparkFun Qwiic Distance Sensor	$15.95	50	$797.50
SparkFun Qwiic OLED Display	$16.95	50	$847.50
SparkFun Qwiic Joystick	$9.95	50	$497.50
100mm Qwiic Cable	$1.50	50	$75.00
200mm Qwiic Cable	$1.50	50	$75.00
500mm Qwiic Cable	$1.95	50	$97.50
		Total	$2,390.00

will dramatically extend the capabilities of a kit of mechatronic components issued to students in *MCHE 201: Introduction to Engineering Design*. In doing so, the student experience will be enhanced and two major pain points for students will be alleviated.

Budget Proposal

1.	**Equipment**	**$**
2.	**Software**	**$**
3.	**Supplies**	**$**2,390
4.	**Maintenance**	**$**
5.	**Personnel**	**$**
6.	**Other**	**$**
TOTAL:		**$**2,390

Additional Information

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Additional information on the class to be improved by the purchase proposed here can be found at:

http://www.ucs.louisiana.edu/~jev9637/MCHE201.html

A flickr photosets containing images of the current kit components can be found at:

https://flic.kr/s/aHskGGERY2

A flickr photoset containing pictures and videos from the development, assembly, and testing of the STEP-supported custom carrier board can be found at:

https://flic.kr/s/aHsmqmnJYJ

Flickr photosets from past sections of the class can be found at:

- Spring 2019 – https://flic.kr/s/aHsmtPMqas
- Fall 2018 – https://flic.kr/s/aHsmq92mry
- Spring 2018 – https://flic.kr/s/aHsmbW159G
- Fall 2017 – https://flic.kr/s/aHskSk5vfb
- Spring 2017 – https://flic.kr/s/aHskSk5vfb
- Fall 2016 – https://flic.kr/s/aHskGKmP4m
- Spring 2016 – https://flic.kr/s/aHskp9KxSN
- Fall 2015 – https://flic.kr/s/aHskhxxhi7
- Spring 2015 – https://flic.kr/s/aHsjWAuyU8

Videos from past contests can be found at:

https://vimeo.com/channels/mche201/

Pictures and video from an earlier, related special-topics course can be found at:

- Pictures – https://flic.kr/s/aHsjHJq5Ph
- Video – https://youtu.be/u8LExuKTDqw

Prior-funded STEP Projects

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In the fall semester of 2016, Dr. Vaughan received funding in the amount of $6,662.32 for a STEP project titled *Supporting Hands-on Robotics Projects in the Mechanical Engineering Curriculum*. That project funded the initial expansion of the *MCHE201* kit to include a linear actuator, a stepper motor, and associated components required to support those.

Dr. Vaughan also received funding in the amount of $4,903 for a STEP project titled *Improving the Core Robotics Kit in the Mechanical Engineering Curriculum*, which expanded on the components purchased through the STEP project mentioned above to further push the *MCHE201* kit toward the type of components that students will see once they graduate. The primary result of this project was a custom carrier board that dramatically reduced the complexity of using the components in both the student-purchased and issued kits.

These two projects established a strong core of mechatronic components for the students to use during the *MCHE201* design process. As such, they have enabled the request made here, which seeks to further improve the mechatronic kits given.