UNIVERSITY OF LOUISIANA AT LAFAYETTE

STEP Committee

Technology Fee Application

Supporting Hands-on Robotics Projects in the Mechanical Engineering Curriculum

Title

Joshua Vaughan

Name of Submitter
(Faculty or Staff Only)

Department of Mechanical Engineering

Organization

Title: Supporting Hands-on Robotics Projects in the Mechanical Engineering Curriculum Date: 07/15/16

Name (Contact Person): Joshua Vaughan
Address: Rougeou Hall, P.O. Box 44170, Lafayette, LA 70504
Phone Number: x2-1207 Email: joshua.vaughan@louisiana.edu
Department/College/Org: Dept. of Mechanical Engineering / College of Engineering

ABSTRACT (250 words or less):

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 a fun way to learn. In MCHE201: Introduction to Engineering Design, students are taught mechanical design, technical communication, and basic robotics skills through a series of robotics projects. This proposal seeks to fund the purchase of components needed to dramatically improve the robotics kits used in the class. Approximately 150 students per academic year will directly benefit from these improvements.

Currently, students are asked to buy a basic robotic kit instead of a textbook. However, this student-purchased kit needs to be supplemented in order to create a sufficiently-open design space for the robot projects. So, currently, each team of 3–4 students is provided with a kit of basic robotics parts for use in their projects. However, the existing kits still lack some components critical to modern, robust robotic design. The kits lack the parts necessary for wireless communication, fine positioning, and linear actuation. This proposal seeks to fill these holes in the capabilities of the current kit.

Supporting Hands-on Robotics Projects in the Mechanical Engineering Curriculum

Joshua Vaughan
Department of Mechanical Engineering
joshua.vaughan@louisiana.edu

1 Introduction

One subject in which robotics naturally serves as a vehicle for course material is mechanical design. Students can be taught traditional mechanical design techniques, such as planning tools, evaluation matrices, and functional decomposition 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. The projects are also rewarding, as they often afford the students their first opportunity to design and build a computer-controlled machine. The classes also present the chance to make the education fun through class contests. For example, Figure 1 shows one round of a the final robotics contest from the fall 2016 section of *MCHE201: Introduction to Engineering Design*.

Engineering design courses also provide an opportunity to integrate oral and written technical communication with a two-fold benefit for the students. First, the students gain experience in the basic tasks of describing and presenting designs. Second, in presenting the design tools used to develop their robots, the students display their understanding of the course material, allowing instructors to assess student learning and revisit those topics that the students have not mastered.

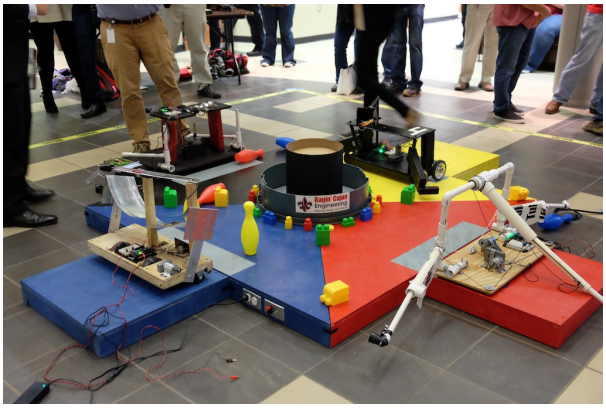

Figure 1: One Round of the Final Robot Contest from *MCHE201*

For the students, 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. In addition, 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 expansion of a robotics kit provided to students in *MCHE201: Introduction to Engineering Design*. The purchase will *dramatically* extend the capabilities of the kit. The expanded capabilities of the kit will not only make the student robots more capable, they will also providing students with experience valuable in the modern workplace, including working with networked systems. More specifically, the expansion will include wireless communication modules, a linear actuator, a stepper motor, and associated components required to support these.

Increasing the capabilities of the robotics kit will directly impact the approximately 150 students who will 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. Finally, 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.

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 evolution and extension 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 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 industrial sponsors.

2.2 Impact on Student Body

More specifically, this proposal will fund the purchases for the expansion of a robotics kit that is issued to teams of 3-4 students in *MCHE201: Introduction to Engineering Design* during their enrollment in the class. To illustrate the type of components that a mature version of this kit would contain, the kit issued to students in a similar class that the PI helped develop at Georgia Tech is shown in Figure 2 [1]. At the heart of the kit is a controller box that includes a micro-controller, motor drives, A/D converters, and digital I/O needed to utilize the remainder of the kit. The controller box is issued along with several DC motors, a stepper motor, two solenoids, an IR distance sensor, two types of switches, and an encoder. Also included are the components to use two pneumatic actuators, including the pressure vessel, pneumatic valves, and tubing.

Figure 2: The Kit Issued to Students in ME2110 at Georgia Tech

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 the kit in Figure 3 instead of a textbook. This student-purchased kit includes some of the core components needed for robot development, including the micro-controller and several sensors. However, the kit is missing pieces critical to the design and build of robust robotic platforms. For example, only a single small, weak DC motor

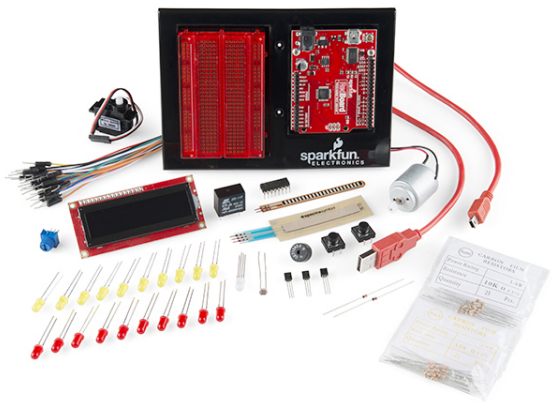

Figure 3: The Kit Purchased by Students
(Image from SparkFun.com)

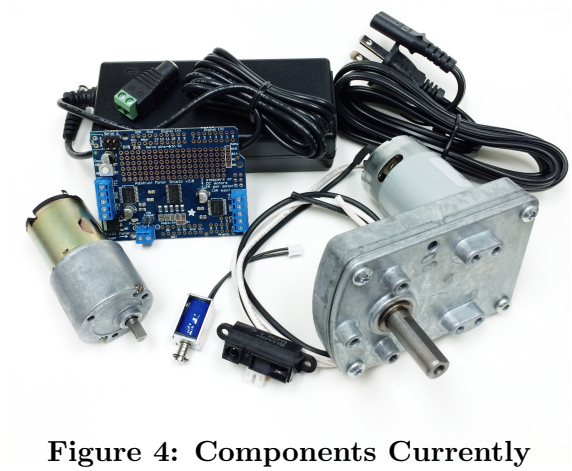

Figure 4: Components Currently Included in the *MCHE201* Kit

is included. So, each student team is currently issued the components shown in Figure 4, which include two DC motors, a power supply, and a motor driver. Further extension of the kit will *dramatically* increase the scope of the possible mechanical designs and will therefore increase the impact of the design concepts being taught.

The increased capabilities of the kit will also allow the student teams to pursue more innovative, creative solutions to the engineering challenges that compose their projects. The creative application of concepts is an important step in their mastery. In addition, the greater variation in the possible solutions makes the robot competition more exciting and enjoyable for all those involved, while providing a larger possible solution space over which to discuss the design process.

3 Projected Lifetime and Timetable

All the components requested through this proposal would be purchased during the first year. 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. Students are made personally responsible for care of the kit components; the students' robot performance largely depends on their kits being well cared for, providing significant motivation to do so.

During the fall semester of 2016, both interactive and pdf versions of a manual that that introduces the current kit and how to use it with the student-purchased portion of the kit will be completed. In the spring semester of 2017, once new components are purchased, these materials will be extended to integrate them into the course manual. In addition, a series of lab exercises that have been developed to lead the students through the use of the various components and prepares them to use the full kit in the construction of their robot for the final project of the class will be updated to include the new components.

The primary maintenance costs for this project are the replacement of components. Most compo-

Table 1: Components to be Purchased

Item	Price Per	Quantity	Sub-Total
Linear Actuator & mounts	$151.97	30	$4559.10
NMEA-17 Stepper Motor	$12.60	30	$378.00
WiFi Shield	$11.96	30	$358.80
Proto-Screwshield	$13.46	30	$403.80
Inline Fuse Holder	$3.16	60	$189.60
Fuses	$3.18	60	$190.80
Stacking Headers	$1.56	160	$249.60
Banana-plugs	$9.73	30	$291.90
Hookup Wire (200ft spool)	$20.36	2	$40.72
		Total	$6,662.32

nents are fairly robust, but the motor drivers are susceptible to over-currenting damage through improper use. As such, it is estimated that a number of these motor drivers will need to be replaced each semester. Departmental funds will be used cover their replacement.

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

Through this proposal, components for 30 kits will be purchased. The components to be purchased, summarized in Table 1, include a linear actuator with mounts, a stepper motor, a WiFi Arduino Shield, a screw terminal Arduino Shield, connectors used to connect to the robot competition track, fuses and fuse holders, and headers for the shields.

The current kit only contains two DC motors. These are good as drive motors, but do a poor job at precise positioning tasks. The linear actuator and stepper motor included in this proposed extension to the kit fill this void; they are much better at positioning tasks than the DC gearmotors.

The WiFI shield will allow the student devices to be run untethered, yet communicate with each other and/or the competition arena. This dramatically extends the possible solution space and more accurately reflects how most systems interact with the world, not isolated, but interacting with it. In addition, these two components will provide students with experience working with connected devices, an important and highly-marketable skill as the Internet-of-Things continues its march toward ubiquity.

The Proto-Screwshield will provide the students with more reliable connections between the components of the kit and the microcontroller, rectifying a common complaint from the first sections of the course. The fuses will help prevent damage to the motor driver board and actuators. Fi-

nally, hookup wire and banana-plug style connectors are requested to be used to connect to the competition arena.

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 seeks to extend a kit currently offered in *MCHE201: Introduction to Engineering Design* by adding several actuators and communication devices. By adding the devices, the set of skills that students can gain through use of the kit is expanded. Furthermore, the components open additional possibilities for the end-of-term contest, helping to reinforce the necessity of following the objective design procedures taught in the class.

References

[1] J. Vaughan, J. Fortgang, W. Singhose, J. Donnell, and T. Kurfess, "Using mechatronics to teach mechanical design and technical communication," *Mechatronics*, vol. 18, no. 4, pp. 179–186, May 2008.

Budget Proposal

1.	**Equipment**	**$**
2.	**Software**	**$**
3.	**Supplies**	**$ 6,662.32**
4.	**Maintenance**	**$**
5.	**Personnel**	**$**
6.	**Other**	**$**
TOTAL:		**$ 6,662.32**

Additional Information

Supporting Hands-on Robotics Projects in the Mechanical Engineering Curriculum

Joshua Vaughan
Department of Mechanical Engineering
joshua.vaughan@louisiana.edu

Additional information on the class to be improved by the extension of the robotics kit can be found at:

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

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

- Spring 2016 – https://flic.kr/s/aHskp9KxSN
- Fall 2015 – https://flic.kr/s/aHskhxxhi7
- Spring 2015 – https://flic.kr/s/aHsjWAuyU8

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

Supporting Hands-on Robotics Projects in the Mechanical Engineering Curriculum

Joshua Vaughan
Department of Mechanical Engineering
joshua.vaughan@louisiana.edu

To date, Dr. Vaughan has received no funding via STEP projects.