UNIVERSITY OF LOUISIANA AT LAFAYETTE

STEP Committee

Technology Fee Application

Improving the Student-accessible Fabrication Studio in the Mechanical Engineering Curriculum

Title

Joshua Vaughan

Name of Submitter
(Faculty or Staff Only)

Department of Mechanical Engineering

Organization

Title: Improving the Student-accessible Fabrication Studio in the Mechanical Engineering Curriculum Date: 07/17/17

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ABSTRACT (250 words or less):

In MCHE 201: Introduction to Engineering Design, students are taught high-level mechanical design and technical communication, as well as basic robotics skills, through a series of robotics projects. The course ends in a 6-8 week final project and associated robot contest, in which teams of 3-4 students compete. Each of these teams is issued a kit of robotics components for use during the final project. However, only recently have any fabrication facilities been provided for student use. This proposal seeks to fund the purchase of a desktop CNC, directly benefiting the approximately 180 students per academic year that enroll in MCHE201.

In current versions of MCHE201, space is provided for students to test their designs but no tools are provided to them. Seeking to remedy this, the Department of Mechanical Engineering purchased a drill press, bandsaw, and desktop mill for use by students in the fabrication of their final robot designs. This fall will mark the first time that any fabrication facilities have been provided to the students. This proposal would fund the purchase of an Othermill Pro desktop CNC and associated supplies supporting its initial setup to further enhance the fabrication facilities provided to the students. These improvements will not only make the experience richer and more pleasant for the students, they will also help reinforce the concepts taught in MCHE201 by expanding the space of possible designs that the students are able to construct.

Improving the Student-accessible Fabrication Studio 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. 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, and industry partners. For example, Figure 1 shows one round of a the final robotics contest from the spring 2017 section of *MCHE201: Introduction to Engineering Design*, which was held in Blackham Coliseum.

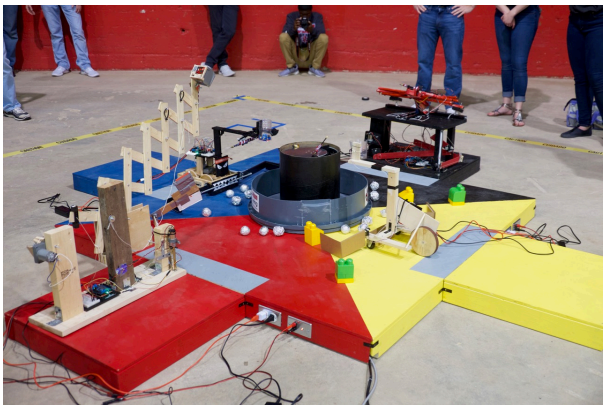

Figure 1: One Round of the Final Robot Contest from *MCHE201*

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 improvement to the fabrication facilities provided to students in the design studio for *MCHE201: Introduction to Engineering Design*. The purchase will expand the recent department-funded equipment purchases that have established a baseline fabrication lab for students enrolled in *MCHE201*. Specifically, this proposal would add an Othermill Pro tabletop CNC, shown in Figure 2, to the equipment made available to the students.

The Department of Mechanical Engineering recently purchased a drill press, band saw, and desktop manual mill, along with a Shop Vac, for use by students in *MCHE201* during the development of their final-project robots. The purchase proposed here would add the Othermill Pro desktop CNC, further enhancing the possible for the students. This enhancement will greatly improve the experience in *MCHE201*, who, to date, have had to provide most of their own fabrication equipment while

developing their robots.

Increasing the capabilities of the fabrication studio will directly impact the approximately 180 students who will take *MCHE201: Introduction to Engineering Design* each academic year. In addition to the direct impact on the students enrolled in *MCHE201*, the purchase 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 equipment. The requested equipment will also be made available to the senior design students in *MCHE482* and *MCHE484* and to department-affiliated teams competing in contests like ARLISS, RobotX, and Formula SAE. 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.

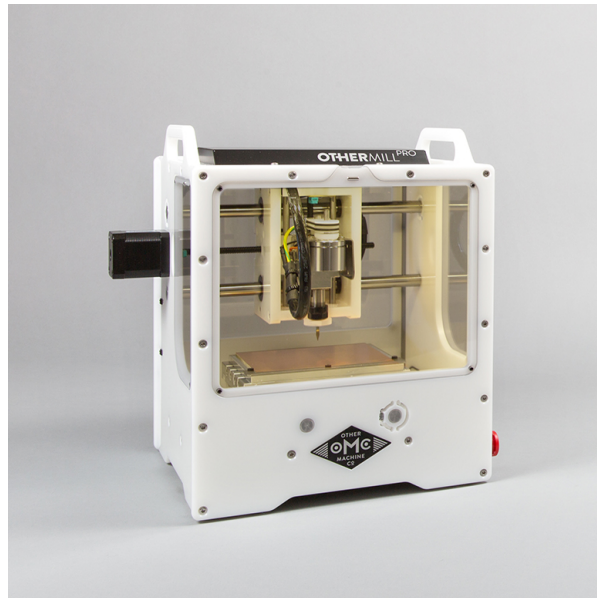

Figure 2: Othermill Pro
Image via http://othermachine.co

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 purchase of an Othermill Pro and the supplies needed to support its initial use.

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 recent 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

This proposal will fund the purchases for improving the fabrication facilities used in *MCHE201: Introduction to Engineering Design*. To illustrate what a mature version of the proposed design and fabrication studio would look like, the Invention Studio at Georgia Tech is shown in Figure 3. This design space, open to all engineering students at Georgia Tech grew out of the facilities that the PI helped establish for a class there similar to *MCHE201* [1]. This fabrication/maker space now contains multiple 3D printers, desktop mills and lathes, drill presses, band saws, laser cutters, and an abrasive waterjet.

The long-term goal is to provide an Invention Studio-like space for all students at UL Lafayette.

This proposal would move the current *MCHE201* design and fabrication studio closer to this goal and make it more likely that industry sponsorship of a larger student-accessible space could be secured.

Figure 3: The Invention Studio at Georgia Tech

The initial development of the course focused on the electrical and computing components supporting the course, including two prior STEP grants to establish a high-quality mechatronics kit that is issued to the students each semester. This concentration caused the fabrication support for the students to lag. So, in past semesters of *MCHE201*, students have been forced to fabricate their final design projects on their own, either in their dorm rooms, apartments, or in family garages. To begin addressing this need, the Department of Mechanical Engineering recently purchased a band saw, drill press, and desktop mill for the class. A Shop Vac was also purchased to keep the fabrication studio clean. While these will provide a significant and much-needed upgrade to the facilities available to students, they still fall short of the facilities present in many universities throughout the world. This proposal represents a first step toward remedying this deficiency in the UL Lafayette student experience.

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.

During the spring semester of 2018, both interactive and pdf versions of a fabrication manual that that introduces the requested equipment and how to use it will be developed. 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 Othermill.

The primary maintenance costs for this project are the replacement of the machining bits and materials used in fabrication exercises. 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.

Table 1: Components to be Purchased

Item	Price Per	Quantity	Sub-Total
Othermill Pro + Advanced Bundle	$4,054	1	$4,054
Prototyping Bundle	$299	1	$299
FR-1 PCB Blanks – 25 pack	$32	4	$128
1/8-inch Flat End Mill – 10 pack	$126	1	$126
1/16-inch Flat End Mill – 10 pack	$144	1	$144
1/32-inch Flat End Mill – 10 pack	$162	1	$162
1/64-inch Flat End Mill	$20	5	$100
1/8-inch Ball End Mill	$14	5	$70
1/16-inch Ball End Mill	$16	5	$80
30° Engraving Bit	$24	3	$72
Bit box	$19	2	$38
		Total	$5,273

5 Budget Justification

Through this proposal, a Othermill Pro desktop CNC with the Advanced Bundle and associated components for its initial setup and use. The items to be purchased are summarized in Table 1. These include the mill itself, additional bits and fixturing, and a "Prototyping Bundle" that further enhances the capabilities of the mill. In addition, the kit of components for circuit board milling will be purchased.

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 improve the fabrication equipment currently offered in *MCHE201: Introduction to Engineering Design* through the purchase of a desktop CNC machine. This purchase will support the Department of Mechanical Engineering's commitment to continual improvement of instruction facilities. Specifically, the Othermill Desktop CNC will expand the fabrication capabilities accessible to the students during their design process, thus improving the design education and their understanding of methods taught in *MCHE201*.

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**	**$ 5,273.00**
4.	**Maintenance**	**$**
5.	**Personnel**	**$**
6.	**Other**	**$**
TOTAL:		**$ 5,273.00**

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

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

- 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

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 purchase of components for the *MCHE201* kit, including wireless communication modules, a linear actuator, a stepper motor, and associated components required to support those.

Dr. Vaughan also recently received funding in the amount of $4,903 for a STEP project titled *Improving the Core Robotics Kit in the Mechanical Engineering Curriculum*, which expands 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.

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 improve the fabrications facilities to match the quality of the mechatronic kits given.