UNIVERSITY OF LOUISIANA
AT LAFAYETTE

STEP Committee

Technology Fee Application

Integrating Hands-on Prototyping into Design-Based Courses in the Mechanical Engineering Curriculum

Title

Ayotunde Olayinka
Name of Submitter
(Faculty or Staff Only)

Department of Mechanical Engineering
Organization
Title: Integrating Hands-on Prototyping into Design-Based Courses in the Mechanical Engineering Curriculum

Date: 1/15/2022

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Department/College/Org: Department of Mechanical Engineering (MCHE)

ABSTRACT (250 words or less):

This request is to acquire three 3D printers to enhance our curricular offerings through a hands-on learning culture. The last decade has brought about tremendous growth in the production and use of desktop 3D printers in industrial settings. Integrating 3D printing into the curriculum of mechanical engineering classes, especially in mechanical design-based courses, will inspire students' concepts, imagination, and creativity. It would enhance prototype development, design exploration, and component/process visualization. This technology will expose students to techniques and processes relevant to contemporary practices and prepare them for the real world of industry 4.0. The acquisition of these 3D printers that will be situated in Frank’s STEP LAB Room 217 Rougeau Hall would provide unrestricted access for about 400 undergraduate and graduate students in the Mechanical Engineering and other departments in the college of engineering and beyond.
A. Purpose of Grant

Education in a digital age should be multi-dimensional, giving equal importance to theoretical and a hands-on, project-based learning approach. Integrating 3D printing into the design-based classes will ensure this. This grant request aims to enhance the learning outcomes for students in the department of mechanical engineering, especially in the design-based courses through digital prototyping, by providing students with hands-on training with innovative technology that is also used in businesses today. The Department of Mechanical Engineering has always striven to bring advanced technologies into the classroom/lab to improve learning experiences and maintain pace with developments in our disciplines. This equipment will unlock the potential in every student by allowing them to conceptualize, design, and transform ideas into tangible objects that they can physically calibrate by utilizing digitally based skills learned in solid modeling classes and other classes. It is essential to integrate this technology into our course offerings to give students a chance to use equipment currently being used within design and manufacturing companies in today’s industry 4.0. The 3D printed gearbox system shown here in Figure 1 is an excellent example of the impact of 3D printers in engineering design classes.

Figure 1: 3D Printed Gearbox

This grant proposal aims to acquire two (2) MakerBot Classroom Sketch and one (1) MakerBot METHOD X 3D printers manufactured by MakerBot inc. These two categories of MakerBot 3D printers provide seamless CAD to part workflow with CAD software the University subscribed to, such as SolidWorks and Autodesk. MakerBot specifically designed the MakerBot Classroom Sketch 3D printer to be the most reliable 3D printing setup for the classroom. It provides a complete education ecosystem, providing students resources needed to succeed. The MakerBot Method X has more advanced 3D printing capabilities than the classroom sketch as it is entry-level industrial equipment. It can print more materials and has better quality, allowing students to focus on real-world applications increasingly. The MakerBot Method X would be very helpful for students working on their senior capstone projects and for students graduate students working on 3D printing research.

Impact on Student Body
This initiative will impact students in the following ways:

1 https://all3dp.com/2/3d-printed-gearbox-how-to-design-your-own-box
1. **Create a Hands-On Learning Environment:** For students, 3D printing is a valuable tool for turning their ideas into reality while building the experience and skills they would need for their careers. To allow students to work in real-world business situations

2. **Empower Creativity and Innovation:** Students face challenges and difficulties directly and use 3D printing as a problem-solving technique to realize or produce parts, products, or carry out projects; this would fuel limitless creativity and collaboration, empowering students to envision, hold and test their ideas in real spaces. Thereby transforming them into an active creator

3. **Facilitate Real-World Understanding and Improve Problem Solving Skills:** Learning occurs best when students engage in finding real solutions to real-world problems. Students will be able to move from abstract ideas to a 3D printed object; understanding concepts are interrelated

4. **Multidisciplinary use across the college of engineering and beyond.** See the projected course impact list in Table 1

### Table 1: Multidisciplinary Design Classes in Engineering and Beyond

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Course Description</th>
<th>No. of Students</th>
<th>Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCHE 201</td>
<td>Introduction to Engineering Design</td>
<td>47</td>
<td>Fall 2021</td>
</tr>
<tr>
<td>MCHE 201</td>
<td></td>
<td>40</td>
<td>Spring 2021</td>
</tr>
<tr>
<td>MCHE 365</td>
<td>Manufacturing Processes</td>
<td>45</td>
<td>Fall 2021</td>
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<tr>
<td>MCHE 365</td>
<td></td>
<td>47</td>
<td>Spring 2021</td>
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<tr>
<td>MCHE 303</td>
<td>Engineering Graphics and Solid Modeling</td>
<td>44</td>
<td>Fall 2021</td>
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<tr>
<td>MCHE 303</td>
<td></td>
<td>54</td>
<td>Spring 2021</td>
</tr>
<tr>
<td>MCHE 363</td>
<td>Kinematics of Machines</td>
<td>40</td>
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<td>MCHE 363</td>
<td></td>
<td>57</td>
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<tr>
<td>MCHE 467</td>
<td>Machine Design I</td>
<td>40</td>
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<tr>
<td>MCHE 468</td>
<td>Machine Design II</td>
<td>17</td>
<td>Fall 2021</td>
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<tr>
<td>MCHE 468</td>
<td></td>
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<td>Spring 2021</td>
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<tr>
<td>MCHE 482</td>
<td>Engineering Project I</td>
<td>87</td>
<td>Fall 2021</td>
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<tr>
<td>MCHE 482</td>
<td></td>
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<td>Spring 2021</td>
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<tr>
<td>MCHE 484</td>
<td>Engineering Project II</td>
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<td>Fall 2021</td>
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<tr>
<td>MCHE 484</td>
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<td>Spring 2021</td>
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<tr>
<td>ITEC 270</td>
<td>Introduction to CAD</td>
<td>14</td>
<td>Fall 2021</td>
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<td>ITEC 270</td>
<td></td>
<td>21</td>
<td>Spring 2021</td>
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<tr>
<td>ITEC 370</td>
<td>Advanced CAD</td>
<td>32</td>
<td>Fall 2021</td>
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<tr>
<td>ITEC 370</td>
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<td>24</td>
<td>Spring 2021</td>
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<tr>
<td>INDN 301</td>
<td>Industrial Design III</td>
<td>14</td>
<td>Fall 2021</td>
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<tr>
<td>INDN 236</td>
<td>Industrial Design Tech I</td>
<td>15</td>
<td>Spring 2021</td>
</tr>
<tr>
<td>INDN 336</td>
<td>Industrial Design Tech II</td>
<td>14</td>
<td>Fall 2021</td>
</tr>
<tr>
<td>INDN 312</td>
<td>Industrial Design Tech II</td>
<td>15</td>
<td>Spring 2021</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>911</td>
<td></td>
</tr>
</tbody>
</table>
B. The Project Lifetime of Enhancement

We believe that the MakerBot Sketch Classroom and the Method X 3D printers can be projected to last up to 10 years of heavy use.

C. Persons Responsible for the Project

i. Implementation

Dr. Olayinka, who is currently the instructor for MCHE 303, MCHE 467, and MCHE 468, would coordinate with the Departmental Head of Mechanical Engineering for placing the purchasing orders and ensuring timely delivery of the equipment and accessories.

ii. Installation

Equipment will be installed in Rougeau Hall Room 211, the Frank's CAD Student Education Laboratory, by Dr. Olayinka with the help of Mr. Harvey Ozbirn, the College of Engineering computer system administrator responsible for computer facility management in Frank's CAD laboratory.

iii. Maintenance

Maintenance routine will be performed after every 30 days of regular use or if the printer has been unused for a few months using PTFE-based Grease supplied with the equipment. Three months and yearly maintenance shall involve system lubrication, residual cleaning, tube replacement, and other maintenance activities prescribed by the manufacturer. Dr. Olayinka will oversee the maintenance of all the equipment. Every faculty will be responsible for the supervision of the student using the equipment during their respective classes.

iv. Operation

This facility is proposed to provide students with hands-on experience in their respective design-based classes. The Department of Mechanical Engineering will coordinate the operation, and Faculty, Staffs, and students will have access to the facility.

v. Training

Dr. Olayinka and the Department of Mechanical Engineering shall coordinate the training required to use the machines. Students shall be provided with a general training document on the operation of the equipment.

Qualification

Ayotunde Olayinka is an instructor in the Department of Mechanical Engineering. He earned his Ph.D. in mechanical engineering from the University of Louisiana at Lafayette and teaches machine design, graphic design, and solid modeling courses. Ayotunde is familiar with the operation and maintenance of 3D printers.

D. Grant Purpose and Justification
The purchase of these 3D printers intends to enhance student hands-on in design-based courses in the Department of Mechanical Engineering and beyond. Undergraduate and graduate students will use these machines to execute their class projects and assignment through rapid prototyping and transforming concepts into tangible objects. These will improve the knowledge of students in digital technology that is currently driving the fourth industrial revolution (Industry 4.0).

The total cost estimate for the equipment is $9762.00, which is the cost of three (3) 3D printers and ten (10) filament materials. This estimated cost is the regular cost of the equipment. The cost breakdown is provided in the budget proposal in Table 2.

(i) **MakerBot Sketch Classroom Two Printer Setup:** This is a comprehensive 3D printer solution designed by MakerBot to accelerate learning and design-thinking. (See Appendix)

(ii) **MakerBot Method X:** This printer can produce industrial-quality parts. It can print manufacturing tools and production parts to spec with actual manufacturing grade materials. (See Appendix)

<table>
<thead>
<tr>
<th>Table 2: Budget Proposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Equipment</td>
</tr>
<tr>
<td>2. Software</td>
</tr>
<tr>
<td>4. Maintenance</td>
</tr>
<tr>
<td>5. Personnel</td>
</tr>
<tr>
<td>6. Other</td>
</tr>
</tbody>
</table>

**TOTAL:** $9762.00
Timeline

The new technology will be integrated into the solid modeling class (MCHE 303), Machine design 1&2 (MCHE 467 & MCHE 468), and will be available for senior design projects the semester after the purchase. Further implementation into existing and potential new courses would commence by the second year.

E. Previously Funded STEP Projects

a. Ayotunde Olayinka has no previously funded STEP grants.
The Appendix

ABOUT THE MAKERBOT METHOD

HOW THE MAKERBOT METHOD WORKS
The MakerBot Method makes three-dimensional objects out of different types of melted materials. First, download a model from the internet or design a part, then use MakerBot Print to translate 3D design files into a .makerbot file, which creates instructions for the MakerBot printer. Then, transfer the .makerbot file to the MakerBot printer via your local network, USB drive, or USB cable.

The MakerBot Method will melt materials and extrude it out onto the build plate in thin lines to build your object layer by layer. The heated build chamber allows the extruded material to cool slowly, minimizing warping and curling. This 3D printing technology is called fused deposition modeling (FDM).

SPECIFICATIONS

<table>
<thead>
<tr>
<th>PRINTING</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Print Technology</td>
<td>Fused deposition modeling (FDM)</td>
</tr>
<tr>
<td>Build Volume</td>
<td>19.1 L x 19 W x 19.6 H cm / 7.5 x 7.5 x 7.75 in single extrusion 15.2 L x 19 W x 19.6 H cm / 6.0 x 7.5 x 7.75 in dual extrusion</td>
</tr>
<tr>
<td>Maximum Layer Resolution</td>
<td>20 – 400 microns</td>
</tr>
<tr>
<td>Nozzle Diameter</td>
<td>0.4 mm</td>
</tr>
<tr>
<td>Print File Type</td>
<td>.makerbot</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SOFTWARE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Software Bundle</td>
<td>MakerBot Print, MakerBot Mobile</td>
</tr>
<tr>
<td>Supported File Types</td>
<td>MakerBot (.makerbot), STL (.stl), SolidWorks (.slddrt, .sldasm), Inventor (.ipt, .iam), IGES (.iges, .igs), STEP AP203/214 (.step, .stp), CATIA (.CATPart, .CATProduct), Wavefront Object (.obj), Unigraphics/NX (.prt), Solid Edge (.par, .asm), Pro/E Creo (.prt, .asm), VRML (.wrl), Parasolid (.x_t, .x_b)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHYSICAL DIMENSIONS</th>
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</thead>
<tbody>
<tr>
<td>Printer</td>
<td>64.9 H x 41.3 W x 43.7 D centimeters (25.6 H x 16.3 W x 17.2 D inches)</td>
</tr>
<tr>
<td>Shipping Box</td>
<td>76.5 H x 50.0 W x 55.5 D centimeters (30.1 H x 19.7 W x 21.9 D inches)</td>
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<tr>
<td>Printer Weight</td>
<td>65 lbs</td>
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<tr>
<td>Shipping Weight</td>
<td>81.7 lbs</td>
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<table>
<thead>
<tr>
<th>TEMPERATURE</th>
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</thead>
<tbody>
<tr>
<td>Ambient Operating Temperature</td>
<td>15 - 26°C / 59 - 78°F, 10 - 70% RH non-condensing</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>0 - 38°C / 32 - 100°F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ELECTRICAL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MAKERBOT METHOD (BUILT55)</td>
<td>100 - 240 VAC, 50/60 Hz, 400 W MAX 3.9A / 1.6A</td>
</tr>
<tr>
<td>MAKERBOT METHOD X (BUILT64)</td>
<td>100 - 240 VAC, 50/60 Hz, 800 W MAX 8.1A / 3.4A</td>
</tr>
<tr>
<td>Connectivity</td>
<td>USB 2.0, Unshielded Ethernet: 10/100Base-T, WiFi 802.11a/b/g/n 2.4GHz, 5GHz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CAMERA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera Resolution</td>
<td>640 by 480 pixels</td>
</tr>
</tbody>
</table>
MakerBot Method

**TWICE THE STRENGTH. TWICE THE ACCURACY.**

- Patented VECT™ 110 (Variable Environmental Controlled Temperature) Thermal Regulation evenly heats and controls the print environment leading to parts that are 2x stronger on the z-axis, and 2x more accurate across the board.

- Print continuously for hours, days, or weeks, thanks to METHOD's unmatched industrial build quality.

**METALS, COMPOSITES, AND POLYMERS PRINTER BETTER ON METHOD X.**

Print real ABS parts with RapidRinse™ supports that dissolve faster than anything else.

- 15 patented features allow for better environmental controls than on any other desktop 3D printer.

- Go from 25+ tuned materials to infinite 3rd party options with the LABS GEN 2 Experimental Extruder.

- The Clean Air™ Dual Filtration System ensures worry-free printing with engineering materials in any environment.

- 6-in-1 Modular Performance Extruders allow for quick change between material groups, preventing cross-contamination.

**INDUSTRIAL POWER WITH DESKTOP EASE.**

- CloudPrint™ gives you and your team secure access to 3D print from anywhere.

- CloudPrint™ natively accepts the most popular CAD file types.

- 5” capacitive touchscreen provides an intuitive step-by-step setup and real-time controls on your jobs.

- Auto-Calibration takes the guesswork out of setup and ensures a level build plate and extruder-alignment.

- SmartAssist Material Loading makes material changing a breeze from material bay to extruder, hands-free.
WHAT'S INCLUDED:

- 1 MakerBot METHOD X 3D Printer
- 1 Spring Steel Build Plate
- 1 Model 1XA Performance Extruder Version 1
- 1 Support 2XA Performance Extruder Version 1
- 1 Nozzle Brush
- 1 Hex Key
- 1 USB A-to-B Cable
- 1 US Power Cord
- 1 EU Power Cord

Please Note: MakerBot materials sold separately. Removal of SR-30 support material requires Circulation Tank and Ecoworks™ cleaning agent available from 3rd-party resellers. For more information, click here.
THE IDEAL CLASSROOM SETUP

Meet the all-new Sketch Classroom, the comprehensive 3D printer solution designed to accelerate learning and design-thinking.

Featuring a dual-printer set up, educators can offer the ideal student-to-printer ratio to drive 3D printing classroom success right from the start.

With teacher and student certifications and more than 600+ lesson plans included, educators can integrate more interactive design projects and increase student engagement.

Classroom 3D printer management is easier than ever with one queue management dashboard via MakerBot Cloud. Students can share design projects wirelessly and teachers can manage queues easily between printers.

FEATURES

- Easy to use, Dual Printer Set Up with reliable, tinker-free performance
- ISTE-Certified self-paced 3D printer training for both teachers and students
- Cloud-based, 3D printing file management with MakerBot Cloud® printing file management software, integrated with TinkerCad & Fusion 360
- 600+ certified lesson plans from educators all across the country

WHAT'S INCLUDED:

- (2) Sketch Printers
- (6) Spools of PLA
- (4) Build Plates
- (2) Spatulas
- (2) Snips
- (2) Seats in Teacher Certifications
- (10) Seats in Student Certifications
- MakerBot Cloud with Print Queuing
- 1 year warranty

To purchase additional certification seats, contact us here.
Technical Specs

PRINTING
Print Technology
Fused Deposition Modeling

Build Volume
150mm x 150mm x 150mm
[5.9in x 5.9in x 5.9in]

Layer Resolution
100-400 microns [0.0039 IN-0.0157 IN]
Print mode tuned for 200 microns

Material Diameter
1.75 mm [0.069 in]

Material Compatibility
MakerBot Sketch PLA Material
MakerBot Sketch Tough Material

Extruder Compatibility
MakerBot Sketch Extruder

Nozzle Diameter
0.4 MM [0.015 IN]

Print File Type
.MAKERBOT

TEMPERATURE
Ambient Operating Temperature
15-30°C [59-86°F]

Storage Temperature
0-55°C [32-131°F]

SIZE & WEIGHT
Product Dimensions
433.4mm (H) x 423.1mm (W) x 365.0mm (D)
[17in (H) x 16.6in (W) x 14.4in (D)]

Shipping Box
549mm (H) x 517mm (W) x 46mm (D)
[21.525in (H) x 20.375in (W) x 1.825in (D)]

Product Weight
11.8 kg [26 lb]

Shipping Weight
17kg [37.5 lb]

MECHANICAL
Build Surface
Grip Surface

Build Plate Leveling
Heated with removable flexible build surface

SOFTWARE
Software Bundle
MakerBot Print Software

Supported File Types
MakerBot (.makerbot)
STL (.stl)
SolidWorks (.slpdrt,.slddasm)
InventorOBJ (.ipt,.iam)
IGES (.igs,.iges)
STEP AP203/214 (.step,.stp)
CATIA (.CATPart,.CATProduct)
Wavefront Object (.obj)
Unigraphics/NX (.prt)
Solid Edge (.par,.asm)
ProE/Creo (.prt,.asm,.asm,
VRML (.wrl)

Operating Systems
Windows (7, 10)
Mac OS X (10.12+)
NOTE: Does not support Mac Catalina

CAD Plugins
SolidWorks, Autodesk Fusion 360,
Onshape, Autodesk Inventor

SAFETY & COMPLIANCE
Safety
Fully enclosed
Particulate Filter
UL, CE, FCC
IEC/EN/UL60950-1, IEC/EN/UL 62368-1

ELECTRICAL
Power Requirements
100-240 V, 50-60 Hz
2.7-1.3A

Connectivity
USB, Ethernet, Wifi

CAMERA
Camera resolution
2 megapixels