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[1]

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

Course No.	**Course Description**	**No. of Students**	**Offered**
MCHE 201	Introduction to Engineering Design	47	Fall 2021
		40	Spring 2021
MCHE 365	Manufacturing Processes	45	Fall 2021
		47	Spring 2021
MCHE 303	Engineering Graphics and Solid Modeling	44	Fall 2021
		54	Spring 2021
MCHE 363	Kinematics of Machines	40	Fall 2021
		57	Spring 2021
MCHE 467	Machine Design I	40	Fall 2021
		36	Spring 2021
MCHE 468	Machine Design II	17	Fall 2021
		38	Spring 2021
MCHE 482	Engineering Project I	87	Fall 2021
		49	Spring 2021
MCHE 484	Engineering Project II	55	Fall 2021
		66	Spring 2021
ITEC 270	Introduction to CAD	14	Fall 2021
		21	Spring 2021
ITEC 370	Advanced CAD	32	Fall 2021
		24	Spring 2021
INDN 301	Industrial Design III	14	Fall 2021
INDN 236	Industrial Design Tech I	15	Spring 2021
INDN 336	Industrial Design Tech II	14	Fall 2021
INDN 312	Industrial Des Form Dev	15	Spring 2021
Total		911	

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 2: Budget Proposal

1.	**Equipment**	**$ 9097 (1X MakerBot Method X at $ 6499 and 2 MakerBot Sketch Classroom at 2598)**
2.	**Software**	**$ 0**
3.	**Supplies**	**$245** MakerBot sketch filament 4 pack Tough **$276** 4X ABS Precision Material for MakerBot METHOD X **$144** 2X MakerBot Nylon Specialty Model Material for METHOD X
4.	**Maintenance**	**$ 0**
5.	**Personnel**	**$ 0**
6.	**Other**	**$ 0**
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.

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

PRINTING	
Print Technology	Fused deposition modeling (FDM)
Build Volume	19 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
Maximum Layer Resolution	20 – 400 microns
Nozzle Diameter	0.4 mm
Print File Type	.makerbot
SOFTWARE	
Software Bundle	MakerBot Print, MakerBot Mobile
Supported File Types	MakerBot (.makerbot), STL (.stl), SolidWorks (.sldprt, .sldasm), InventorOBJ (.ipt, .iam), IGES (.iges, .igs), STEP AP203/214 (.step, .stp), CATIA (.CATPart, .CATProduct), Wavefront Object (.obj), Unigraphics/NX (.prt), Solid Edge (.par, .asm), ProE/Creo (.prt, .asm), VRML (.wrl), Parasolid (.x_t, .x_b)
PHYSICAL DIMENSIONS	
Printer	64.9 H x 41.3 W x 43.7 D centimeters [25.6 H x 16.3 W x 17.2 D inches]
Shipping Box	76.5 H x 50.0 W x 55.5 D centimeters [30.1 H x 19.7 W x 21.9 D inches]
Printer Weight	65 lbs
Shipping Weight	81.7 lbs
TEMPERATURE	
Ambient Operating Temperature	15 - 26º C / 59 - 78º F, 10 - 70% RH non-condensing
Storage Temperature	0 - 38º C / 32 - 100º F
ELECTRICAL	
POWER REQUIREMENTS : MAKERBOT METHOD (PACT56) MAKERBOT METHOD X (PADJ56)	 100 - 240 VAC, 50/ 60 HZ, 400 W MAX 3.9A -1.6A 100 - 240 VAC, 50/ 60 HZ, 800 W MAX 8.1A- 3.4A
Connectivity	USB 2.0, Unshielded Ethernet: 10/100Base -T, WiFi 802.11 a/b/g/n 2.5GHz, 5GHz
CAMERA	
Camera Resolution	640 by 480 pixels

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.

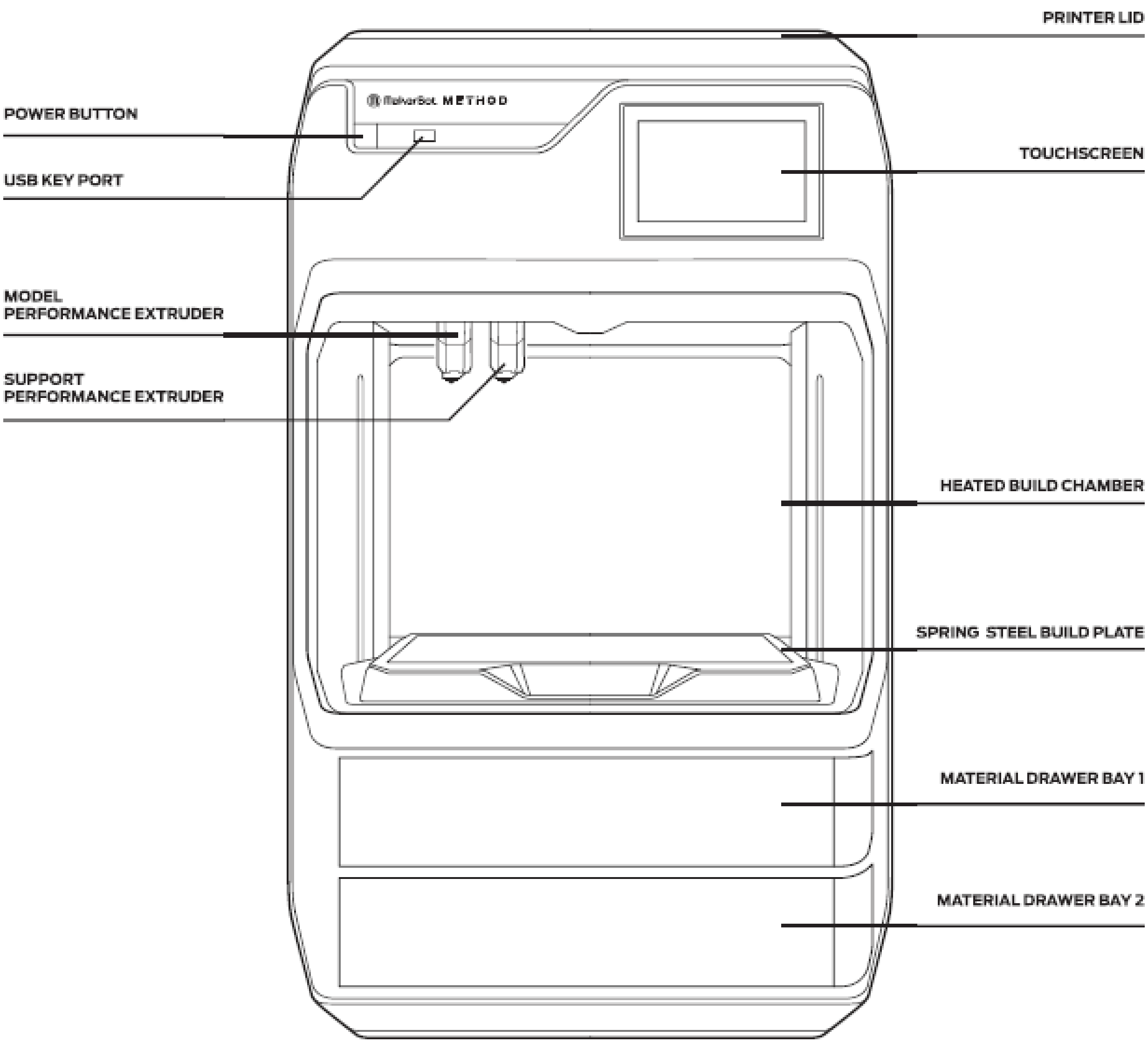
- CloudPrint™ gives you and your team secure access to 3D print from anywhere
- CloudPrint™ natively accepts the most popular CAD file types
- 5" capacitive touchscreen provides an intuitive step-by-step setup and real-time controls on your jobs
- Auto-Calibration takes the guesswork out of setup and 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.

MAKERBOT METHOD DIAGRAM



MakerBot Sketch Classroom

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)
[21.625in (H) x 20.375in (W) X 18.25in (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

SAFETY & COMPLIANCE

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

SOFTWARE

Software Bundle
MakerBot Print Software

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

ELECTRICAL

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

Connectivity
USB, Ethernet, Wifi

CAMERA

Camera resolution
2 megapixels

MAKERBOT SKETCH DIAGRAM