Project Title: Upgrading 3D-Printing Materials Manufacturing Capabilities for Engineering Students and Makers at WWU

Department/Organization: Engineering and Design
Project Applicant(s):
Principal Contact
Name John Misasi MS 9086 Email: John.Misasi@wwu.edu Phone x4254
Others
Name Nicole Hoekstra MS 9086 Email: Nicole.Hoekstra@wwu.edu Phone x7237
Name Cecile Grubb MS 9086 Email: Cecile.Grubb@wwu.edu Phone x2919
Name MS Email: Phone
Name MS Email: Phone

Amount Requested for Project
Proposed Budget:
1. Equipment total $ 23,120
2. Plus site preparation (not STF funded) + $ 0
3. Total Project Cost (spreadsheet total from part IV of this form, Total Project Budget) = $ 28,267
4. Less organization’s contribution – $ upkeep
5. Less site preparation – $ 0
6. STF Grant Request = $ 28,267

IMPORTANT NOTE
1. THE STF Committee will accept only complete proposals by the announced deadline. Every section (I–IX) and all items of this proposal format must be addressed.

I. Executive Summary (800 words max)

Provide a summary of the project and the benefits to be derived. Explain what the students would gain from the project, and how the acquisition would meet the Student Technology Fee mission.

STF Mission:
The Student Technology Fee provides Western students with adequate and innovative technology experiences by:
- Broadening/enhancing the quality of the academic experience
- Providing additional student access to technology
- Increasing integration of technology into the curriculum

Additive manufacturing, also known as 3D-printing, is an industry that is growing at unprecedented rates. Due to its simplicity and low cost, 3D-printing has found its way into many sectors, with industries such as aerospace and biomedical having just as much
interest and access as the average do-it-yourself “maker”. As such, WWU’s involvement in 3D-printing research and curriculum development is also rapidly growing. The Engineering and Design department’s newly formed Additive Manufacturing Research Group includes students and faculty from the Manufacturing Engineering, Plastics Engineering, Materials Science, and Physics programs and is aimed at understanding the fundamental material and process challenges affecting 3D-printing. This multidisciplinary group is focused on introducing students to state-of-the-art 3D-printing equipment, processes, and materials to further educate future engineers and scientists.

3D-printing is the layer-by-layer deposition of plastic filament material in a three dimensional shape defined by a computer drawing. Continuous, circular plastic filaments are fed through a heated nozzle which can be articulated in the x-, y-, and z-directions to create complex solid shapes. The filaments employed in 3D-printing are manufactured by a common plastic processing technique called extrusion. During the filament extrusion process, plastic pellets are fed into a heated barrel and are conveyed by a large metal screw to a heated die that shapes the plastic into the continuous circular cross-section that makes up the 3D-printing filament. “Off-the-shelf” 3D printing filament materials are limited in number and are more expensive than traditional plastic feedstocks. The average cost of one kilogram of ABS printing filament is $30\textsuperscript{1}, whereas 1 kilogram of ABS plastic pellets, which can be used to form custom filament, is approximately $1.50\textsuperscript{2}. The limited and somewhat cost prohibitive materials hinder the realization of applications and products which can be manufactured using WWU’s 3D printers and could drive printing costs to a level which would prevent student use. Therefore, the overall goal of this project is to provide students from WWU’s Engineering and maker communities a broadened library of high quality materials while reducing the overall filament cost through the purchase of new filament extrusion equipment.

The Engineering and Design department’s current extrusion equipment (a Killion single screw extruder purchased in the 1970’s) is outdated and lacks the control necessary to produce consistent diameter material, a requirement for 3D-printing filament. Likewise, the old equipment has frequent malfunctions which are safety concerns for student operators, requiring frequent repairs that leave the extruder unusable for extended periods of time. These shortcomings limit the usage of the current single screw extruder in the Engineering curriculum and research.

This proposal therefore requests funding to purchase a LabTech Engineering Company 20 mm single screw extruder, a volumetric feeder, and a FilaWinder down-stream wind-up unit. This equipment would significantly enhance student involvement and learning through increased course use and expanded research activities, as well as increasing student-operator safety through improved safety interlocks and controls. Additionally, this project will benefit multiple WWU programs and departments which utilize 3D-printers. Both the Engineering and Design Department and Student Technology Center’s new, open-use 3D-printers (5 total) are capable of printing with student-manufactured filaments, and therefore the proposed extrusion equipment will be used to manufacture filament materials for use by those interested in 3D-printing at WWU.

II. Relationship to STF Objectives / Impact on Current Academic Programs

The STF Committee will use as its primary assessment criteria the three objectives—quality, access, and integration—defined in the STF mission (above). Given this criteria, describe your proposed project in detail.
1. Tell us—focusing on what the students will gain from the project—how the project would provide positive benefits to specific courses or instructional programs. Specifically, answer at least one of a, b, and c below:

a. How would this project **provide additional student access** to technological resources?

The requested equipment will improve student throughput for laboratory courses and research activities by reducing the necessary machine maintenance time. The ability of students to use the extrusion equipment is currently intermittent, at best, and frequently impeded by equipment malfunctions, many of which become safety concerns which further increase machine downtime. Following implementation of the new extrusion system, unexpected downtime will decrease and active equipment time per student will increase, resulting in greatly improved access. Additionally, as of April 2016 there are five 3D-printers on campus that are open for student use, but given WWU’s student body at 15,000, heavy printer use and material consumption is projected. Continuous use and access to the printers will be improved by a library of WWU-manufactured filament materials by reducing filament purchasing and shipping downtimes as well as by keeping filament cost at a minimum.

b. How would this project **broaden or enhance the quality** of the student’s academic experience through the proposed technology?

The principle goal of this project is to broaden the impacts of 3D-printing around Western’s campus. The requested extrusion equipment will improve student understanding of extrusion manufacturing processes by increasing the degree of control over the temperature, extrusion rate, and dimensional consistency of extruded parts. These enhanced controls will allow students to develop a strong fundamental understanding of plastics processing which will translate to many state-of-the-art processes, including 3D-printing. The controls on a new extrusion system will more accurately represent those in which graduates will see and use in industry, further enhancing the development of competent engineers. This improved equipment will also allow for additional student research opportunities with industrial sponsors such as Avante, R&D Plastics, Nike, and Tethers Unlimited. Furthermore, using this equipment to produce high quality 3D-printing materials will expand the ability of other departments to become involved in 3D printing by increasing the quantity, types, and accessibility of printing filament. Finally, officers and members of two plastics and composites professional society student chapters will spend a portion of their required volunteer time to help in the manufacturing WWU filament materials. Not only will these students gain additional experience in their field, they will also be helping provide a product and service to the makers on campus. This service-learning experience will add to the holistic formation of future engineers by enhancing not only technical competence, but 21st century skills such as entrepreneurship, supporting sustainability, creativity.

c. How would this project **increase integration** of technology into coursework?

3D-printing is an important and growing technological discipline in plastics research, engineering, manufacturing, and design. A new extrusion system would allow WWU to create a cradle-to-cradle learning environment where students from multiple disciplines, such as Engineering, Design, Education or Marketing, can engage in research, design, and manufacturing practices related to the development of 3D-printing materials, processes, and applications. Following implementation of the new equipment, the courses listed in Section III, Table 1 will both continue to utilize and further develop in-class extrusion experiments, with the goal of allowing students to create their own 3D-printing materials. Likewise, with materials for 3D-printing more
accessible, programs such as Art and Design, Education, and Marketing will be more prone to incorporate 3D-printing and related technologies into student research and class projects.

2. Would other departments be involved with this project?

Yes ☐ No ☐ If yes, describe.

The Student Technology Center (STC) and the Engineering and Design (E&D) department both have 3D printers that could utilize filaments developed and manufactured by students. The STC and E&D department respectively have three and two printers which students would benefit from having additional, low-cost filaments. Further, four additional faculty/research printers exist within the Engineering and Design department which research students have the potential for using and would utilize student manufactured filaments.

3. Has any part of this project previously been funded by the Student Technology Fee?

No ☐ Yes ☐ If yes, describe.

4. Is the proposed project a pilot project?

No ☐ Yes ☐

III. Utilization

List the anticipated number of times and duration per each use—per quarter or per academic year—that students would use the proposed technology. The committee is looking for total student hours and total number of unique students who would use the technology in that time period. Explain how you arrived at this utilization.

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Number of Students</th>
<th>Hours Used Per Student</th>
<th>Total Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCE 371 – Intro Plastics Materials &amp; Processing</td>
<td>Introduction to Extrusion Processes</td>
<td>72</td>
<td>4</td>
<td>288</td>
</tr>
<tr>
<td>PCE 431 – Advanced Materials &amp; Processing</td>
<td>Material Blending and Compounding</td>
<td>24</td>
<td>10</td>
<td>240</td>
</tr>
<tr>
<td>PCE 471* – Advanced Materials &amp; Characterization</td>
<td>3D Printing Filament Property Characterization</td>
<td>24</td>
<td>10</td>
<td>240</td>
</tr>
<tr>
<td>MSCI 410* – Materials Characterization</td>
<td>3D Printing Filament Property Characterization</td>
<td>16</td>
<td>5</td>
<td>80</td>
</tr>
<tr>
<td>ID 380* – Materials for Design</td>
<td>Introduction to Extrusion Processes</td>
<td>24</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>Research</td>
<td>Students from PCE, MFGE, MSCI and PHYS</td>
<td>10</td>
<td>45</td>
<td>450</td>
</tr>
</tbody>
</table>

*signifies courses that do not currently utilize single screw extruder
Total student hours = 1394
Total unique students = 120 (some overlap for courses)

These estimates are based upon available seats in each course, planned lab activities, and previous filament manufacturing experience. Manufacturing 1 kg of filament, the standard reel amount, requires approximately 2 hours of extrusion.

IV. Total Project Budget

This section details the estimated total cost of the project. Include costs that would be covered—by your department or another source—for ongoing costs such as personnel or operating expenses.

1. For assistance in preparing your budget, please consult with relevant campus support departments (ATUS, Purchasing, Space Administration, etc.).

2. For more information about these contacts and helpful tools/links: from the STF website home page (http://www.wwu.edu/stf), choose “STF Tech Initiatives” on sidebar, then section “II. Tech Initiatives Forms and Instructions.”

Attach an Excel spreadsheet if you have additional details.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Item Cost ($)</th>
<th>Total ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) LabTech 20mm, 40 L/D Single Screw Extruder</td>
<td>1</td>
<td>18,750</td>
<td>18,750</td>
</tr>
<tr>
<td>(2) Movacolor Volumetric Feeder</td>
<td>1</td>
<td>4,200</td>
<td>4,200</td>
</tr>
<tr>
<td>(3) Filawinder Filament Winding System</td>
<td>1</td>
<td>170</td>
<td>170</td>
</tr>
</tbody>
</table>

Subtotal: 23,120

Allowance for price increases (3% of subtotal): 694

Shipping (taxable): 2,380

Tax (8.7%): 2,072

Total: 28,267

Important Notes from the STF Committee:

- We recognize your proposed budget as an estimate. Final funding for successful projects will be established after thorough technical review; some costs may need adjusting due to price changes.

- We recommend that you include a 3 percent cushion to allow for price increases.

- We may impose special conditions on a proposal before approval. See STF Proposal Guidelines.
• Funding is not provided directly to departments for purchases. All purchasing is done via the Office of the VPIT/CIO and savings are retained in the STF fund.

3. What funding or contributions are available from your department or other sources?

Note: “Contribution” is defined as a monetary contribution. A vendor discount, for example, is not considered a contribution.

Laboratory course fees will be contributed towards the upkeep of proposed equipment.

4. Could this project be divided into discrete elements that could be funded separately?

Note: A “no” response to this question creates an “all or nothing” proposal. That is, if the STF Committee decides against funding your entire proposal, it will not consider any elements for partial funding. If elements could be funded separately, the applicant is responsible for prioritizing them before submitting the proposal.

No ☐ Yes ☒ If yes, summarize and prioritize project elements with cost estimate for each.

The requested funds can be prioritized as follows:
(1) LabTech Single Screw Extruder - $18,750
(2) Volumetric Feeder - $4200
(3) Filawinder - $170

5. Are course or lab fees charged for any of the courses that will use this equipment?

No ☐ Yes ☒ If yes, describe. Please note: The total funding requested from the Student Technology Fee must reflect the amount collected from course fees for equipment replacement and/or equipment acquisition.

Lab fees are charged for every course in Table 1 with research courses (PCE 495) having a variable lab fee dependent on consumable use. It is anticipated that extruder and equipment maintenance will be less than $500 per year and will not exceed current course and lab fees collected by the above classes (~$25,000/academic year).

V. Impact on Existing Resources

Your proposal must address the project’s potential impact on existing resources. Give special attention to the impact on data transmission networks (e.g., sources accessed, networking equipment, etc.), and personnel (e.g., staffing, administrative support, faculty support, etc.).

1. Describe how existing equipment is used. Contrast this to projected use if your project were funded.

   The Engineering and Design department’s current, 1970’s extrusion equipment is outdated and lacks the control necessary to produce consistent diameter 3D printing filament materials. Also, the existing extrusion equipment is prone to malfunctions which are potential safety concerns for student operators. The frequent repairs to improve safety and consistency leave the extruder unusable for extended periods of time which generates a bottleneck in course laboratories and research. These shortcomings limit the usage of the current single screw extruder in the Engineering curriculum and research.

   By increasing equipment reliability and safety, this proposal aims to significantly enhance student involvement and learning through increased course use and expanded research activities. With reduced downtime and usage, the new extrusion equipment will allow students to rapidly produce 3D printing filaments for everyday use in the STC and E&D department. Also, novel printing filament materials will be developed, manufactured, and
subsequently characterized to determine material properties (such as viscosity, mechanical characteristics, and biodegradability) and “ease-of-use”/manufacturability within campus 3D printers. Due to the capabilities of the volumetric feeder, printed parts and filaments can be ground back into the original starting materials and subsequently fed and manufactured into recycled 3D printing filaments. This cradle-to-cradle process of filament manufacturing, 3D printing, regrinding, and re-manufacturing shows students the sustainable aspects of plastics and composites engineering, and it is currently not possible with the existing equipment.

2. Is similar equipment or technology available elsewhere on campus—such as the Student Technology Center, Classroom Services, Video Services, Western Libraries, a college lab?

No ☐ Yes ☒ If yes, describe why the existing equipment does not meet the needs outlined in this proposal.

Currently, the only equipment on campus that is capable of creating custom 3D printing filament is the E&D department’s twin-screw extruder. Attempts to manufacture filament using the twin-screw extruder have been challenging due to the size and complexity of this extruder.

3. If this project involves the replacement of equipment, including computers:

a. Describe the “before and after” configuration changes. (A spreadsheet reflecting these changes may be attached.) Or, write “N/A.”

If this project is funded, the current 1970’s extruder will be removed from use permanently and the new extruder will be installed in the Plastics and Composites (PCE) lab.

b. Describe the costs and benefits of replacing vs. upgrading. Or, write “N/A.”

Due to the age and condition of the current extruder, upgrading the extruder to adequately address the safety and dimensional control issues is not possible. And replacement is necessary.

4. Would this equipment be available to students outside of your department?

No ☐ Yes ☒ If the proposed technology would be used by students outside of your department, describe how they would gain access, how equipment availability would be publicized, the hours/week when equipment would be available, and any costs that would apply.

Whenever requested, the Engineering and Design department offers use of equipment to other departments in the College of Science and Engineering. Some examples of STF funded equipment that is shared with faculty and students in CSE include the universal test stand and the laser cutter. Faculty and students from Chemistry who are developing custom materials of polymer additives could utilize the extruder to create 3D printed parts to evaluate the custom material’s performance. Students wishing to access the new filament extrusion equipment would require approval from the E&D department and the PCE program. After approval, safety and engineering lab-use trainings would be required before extrusion use. The extrusion equipment availability and reservation would be performed using the Facilities Online Management (FOM) system, which would ensure proper tracking and data-collection of extruder use-time and student users. Extrusion costs will be dependent on the materials being manufactured.
5. Does this project involve the check-out of equipment to students?

No ☒ Yes ☐ If yes, discuss whether or not the Student Technology Center/ATUS Loan Pool could be assigned this task.

6. Does the department have adequate operating funds to provide ongoing maintenance and support?

No ☐ Yes ☒ If yes, describe.

The department does have adequate funding to support the extruder’s maintenance and support. In addition to operating funds specified for the support of equipment used in the curriculum, the department collects lab fees for consumable costs associated with equipment used in classes.

7. Does the department have adequate personnel funds to provide ongoing staff support for the project?

No ☐ Yes ☒ If yes, describe.

The Engineering and Design department currently has five instructional technicians dedicated to the instruction and supervision of students working in the labs. One of these technicians is dedicated to the PCE labs where the extruder would be located. Additionally, the department has an additional senior technician who is responsible for all maintenance and repair of equipment.

VI. Space and Site Information

This section addresses any space alteration or site preparation necessary for the proposed project. Site alterations include painting, holes in walls, security systems, carpeting, construction, lighting changes, or conversion of a lab or office.

Special Note: If this project would require any site preparation, or if this project would use any space not currently under your department’s control:

a. You must submit a draft proposal to Space Administration by March 28, 2016.

b. Space Administration and Facilities Management will then conduct a site survey and respond to you by April 4, 2016 about project feasibility, cost, and schedule.

c. You must include the site survey response with your final proposal.

1. Location for installation of equipment or technology:

   ET 113 Plastics Processing Lab

2. Would site modification be required?

No ☒ Yes ☐ If yes, describe the modifications (e.g., electrical, air, painting, lighting, security, network access, etc.).

3. Would this project use space not currently assigned to your department or area?

No ☒ Yes ☐ If yes, describe.
VII. Project Schedule

Describe your overall implementation schedule. (Remember that project awards are announced during spring quarter, and that projects are to be substantially completed by the end of the calendar year.) If any site preparation is involved (see section VI above), align your project schedule with the schedule provided by Space Administration and Facilities Management.

The extruder and auxiliary equipment would be purchased during Spring 2016. The anticipated lead time is 4-6 months, allowing for installation during late Summer or Fall 2016. Installation time upon arrival will be minimal, allowing for incorporation of the extruder into coursework and research during academic year 2016-17. It is predicted that student manufactured filaments will be implemented into campus 3D printers during late Fall quarter or early Winter quarter of 2016-17.

VIII. Constraints

List or describe any external or internal factors/constraints that could affect your project schedule, project objectives, or the project budget (e.g., if external approval is required for curricular changes, or if funding must be received by a certain date).

The only foreseeable constraint is the manufacturing, shipping, and set-up lead time of the single screw extruder (quoted at 4-6 months from time of purchase). However, previous purchases with this equipment manufacturer has shown that their quoted lead times are accurate, and therefore should not be any issue.

IX. Submitting the Proposal

1. Make sure your proposal does not exceed 12 pages (not including Tech Initiatives Summary Sheet).

2. Complete top portion of a 2016 Tech Initiatives Proposal Summary Sheet for the front of the proposal.

3. (for proposal submitters) Electronically submit Word versions only of the proposal and summary sheet for prioritizing:
   a. Faculty and staff: Submit by internal due date, per your unit’s process, which must be before proposal due date of April 11.
   b. Students: Submit by April 8 to AS VP for Academic Affairs at ASVPforAcademicAffairs@wwu.edu.

4. Submit prioritized proposals:
   a. (faculty and staff proposals)
      College Dean/unit head: Ensure appropriate approvals and priority are on Summary Sheet, then email proposal (Word version) and summary sheet (PDF version) to diane.bateman@wwu.edu (the STF Committee secretary) no later than April 11.
   b. (student proposals)
      AS VP for Academic Affairs: Ensure AS President approval and priority are on Summary Sheet, then email proposal (Word version only) and summary sheet (PDF version only) to diane.bateman@wwu.edu (the STF Committee secretary) no later than April 11.

Note: Paper copies of proposals are no longer required; please do not send.