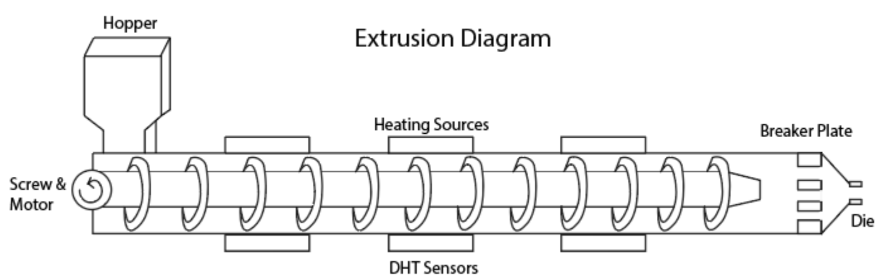
3D printing allows users to create multiple design iterations quickly and at low costs. Therefore, 3D printing has become a major component in rapid prototyping for both engineering disciplines and technology and engineering classroom use. The two main filament types used are Acrylonitrile Butadiene Styrene (ABS) and Polylactic Acid (PLA). Both examples are thermoplastics meaning they can be reformed with minor chemical degradation. In the prototyping process, large quantities of waste is produced from failed designs and support material. One makerspace reported fifteen pounds of filament waste in one semester.[1] Although PLA is biodegradable and made from renewable resources, such as corn, only industrial composting facilities can degrade the material into water, carbon dioxide, and organic material.[2] Additionally, PLA is not accepted at all recycling facilities due to its dissimilar melting temperature. As the patents of 3D printers continue to expire and prices decrease, more and more people will buy 3D printers for personal use; yet, there is still not an affordable and sustainable model to recycle the plastic waste. Therefore, PLA waste will continue to enter landfills at alarming rates.

My proposed solution is a system that melts and extrudes PLA filament waste into reusable 3D printing filament. In developing my design I have taken inspiration from *Filabot*'s industrial scale filament recyclers.[3] The first component of my system is a reclaimer that turns the waste into uniform sized pieces. Next, the PLA pellets enter a hopper that feeds the PLA into the extruder consisting of a long horizontal barrel and rotating screw powered by a motor and Arduino. Within the extruder are three temperature zones, monitored and controlled by temperature sensors, an Arduino, and a LCD screen, with visual output of temperatures. At the end of the barrel is a breaker plate serving as a filter for larger chunks and reducing the rotational current of the PLA before extrusion. The PLA then emerges through a die opening corresponding to the desired size filament. The extruded filament will then pass through an airpath of fans that will cool it. A sensor or caliper will be used to monitor a uniform thickness of the filament within an acceptable tolerance and it will then be autonomously spun onto a spool.



One of TCNJ's Strategic Plan Priorities is to "Build, operate, and maintain a safe, sustainable, and accessible physical and technological infrastructure that supports high-caliber learning"[4]. As prototyping is a vital component in Technology Engineering Education and Engineering, an in-house recycling program would allow the college to carry out these important learning opportunities in a more sustainable capacity. Currently PLA waste, in TCNJ's School of Engineering prototyping facilities, is discarded into the trash. If there are twenty students in a class, each student may discard at least one

[1] *Sustainability at the Makerspace*. NYU MakerSpace. (n.d.). Retrieved October 25, 2021, from https://makerspace.engineering.nyu.edu/sustainability/.
[2] *Balkcom, M., Welt, B., & Berger, K. (2002). Notes from the Packaging Laboratory: Polylactic acid -- an exciting new packaging material.* University of Florida IFAS Extension.
[3] *Filament maker - recycle filament for any 3D printer*. Filabot. (n.d.). Retrieved October 25, 2021, from http://www.Filabot.com/.
[4] *TCNJ 2021: Bolder, Better, Brighter*. TCNJ. (2021). Retrieved October 25, 2021, from https://academicaffairs.tcnj.edu/strategic-plan-2021/.

preliminary prototype per project totaling large quantities of waste. Therefore, recycling the filament could reduce the amount of PLA filament entering landfills. Additionally, this project would serve as a sustainable solution to any makerspace (educational, commercial, or residential) that utilizes 3D printers for rapid prototyping. Thus, presenting a solution to a large target audience.

The project will be assessed on its ability to create usable filament from PLA waste. The recycled filament should retain similar mechanical properties to that of the original filament which can be tested for a tensile strength of approximately 45MPa. Additionally, the filament should have a round diameter and uniform thickness of 1.75mm with an ideal tolerance of $\pm$.05mm so that it may be successfully printed again. The final design should also be a safe and low budget system that would be able to be developed for in-classroom use in Technology and Engineering programs and abundant makerspaces.

I, Kayla Devosa, a senior Technology and Engineering Education major in the School of Engineering will lead the project. I will be mentored by Dr. Matthew Cathell, associate professor in the Department of Integrative STEM Education, with a background in Chemistry and Materials Science. I will also be recruiting another student in the School of Engineering as part of my team.

Fall Semester: Research and Preliminary Design	
Survey development for Qualitative Research	November 3, 2021
Solution Subsystems	November 17, 2021
Develop Gantt Chart for Future Work	December 15, 2021
Literature Review	January 31, 2021
Spring Semester: Prototyping, Testing, and Redesign	
Develop Preliminary Prototype	March 1, 2021
Test and Redesign	Ongoing
Final Prototype	May 6, 2022

As a School of Engineering student I will be receiving $100 towards my senior design project. Based on my research and planning, I am seeking an additional $1,000 to develop my prototype. The subsystems for my project are the reclaimer, extruder, air path, and winder which will each consist of individualized mechanical and electrical components. The reclaimer will use a motor and blades to pulverize PLA waste into uniform chunks. A bulk of prototyping will go into developing the extruder which is the most intricate subsystem. Components of this subsystem will include a chamber, screw, motor, hopper, three DHT sensors, three heating elements, two Arduinos, two LCD screens, breaker plate, and die. Additionally, an air path will be designed from a series of fans and an Arduino. Lastly, the spooler will include an Arduino and motor. I estimate the electrical components of the project to total approximately $300. The mechanical and construction materials will be approximately $400. Due to the intricacies of this system, particularly developing a safe and effective extruder, extensive trial and error in designing and manufacturing these components is expected. Therefore, these values will likely increase with the need to replace and test new materials and components.