3-D Printing of Optical Supplies

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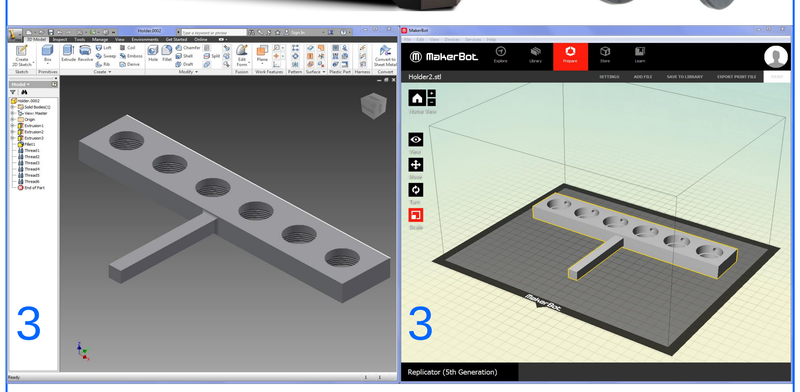
1. Introduction

3-D printing, the process of making parts using computer-driven layering of materials (such as plastic), is poised to revolutionize the industry of manufacturing. In order to benefit from this exciting new technology, research must be done in its early stages to determine how it will affect various aspects of the industries it can serve, such as the optical supply industry. In this study, it is hypothesized that 3-D printing technology can produce optical supplies that are of equal quality to their traditionally manufactured counterparts, but are significantly cheaper and better for the environment. Optical supplies are the focus of this study because the retail prices for these products are exorbitant and it is more practical to build custom supplies for the optics department. The money saved by 3-D printing could be allocated for other lab equipment. In the process, we are also calculating the structural integrity of the 3-D printed parts and how they have an ecologically positive impact on the world around us.

2. Materials & Methods



[1]**Hardware-** The machine used to print the optical supplies is the MakerBot® Replicator® Desktop 3D Printer. It can stack layers of the printing material to a height of just 100 microns thick. It includes a xy-plane movable extruder that layers the material and a z-plane movable build plate.

[2]**Material-** Supplies are built using a biodegradable plastic called Polylactic Acid (PLA). It is derived from corn and produces zero greenhouse gas emissions when heated. A spool of PLA is fed to the printer and acts similarly to a cartridge of ink in a paper printer.

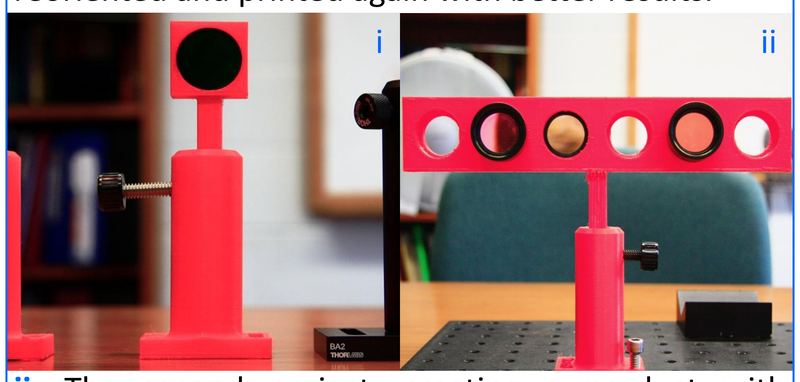
[3]**Software-** The supplies are created using a program called Autodesk® Inventor® then sent to MakerBot® Desktop® where they are rendered and exported as a print file. MakerBot adds rafts and infill to give the product structural support.

3. Experiment

The cost of the PLA material was determined first in order to compare the cost of 3-D printed supplies to that of retail optical supplies. The following chart shows the constants used for determining the value of a 3-D printed part based on its mass:

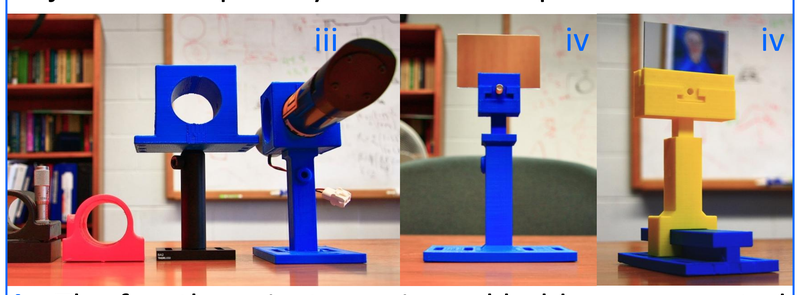
PLA Color	Price	Weight	Price Per Gram
B, Y, R	$48.00 /	900g =	$0.0533

i. The first project, creating a holder for a filter, was staged in two trials. The base piece and holder piece were printed, but the base did not print very well due to mechanical errors of the printer. It was reoriented and printed again with better results.



ii. The second project, creating a product with multiple filter holders, also ran into some mechanical issues initially. The printer was not programmed to put supports under certain areas, which led to the stem of the filter holder being malformed. The holder turned out ideally the second time.

iii. The third project, a laser holder for the lab, went through multiple designs before an effective final product was made. The first and second designs were meant to be directly bolted to the base plate, but the final design with a stem and y-axis adjustment capability seemed most practical.



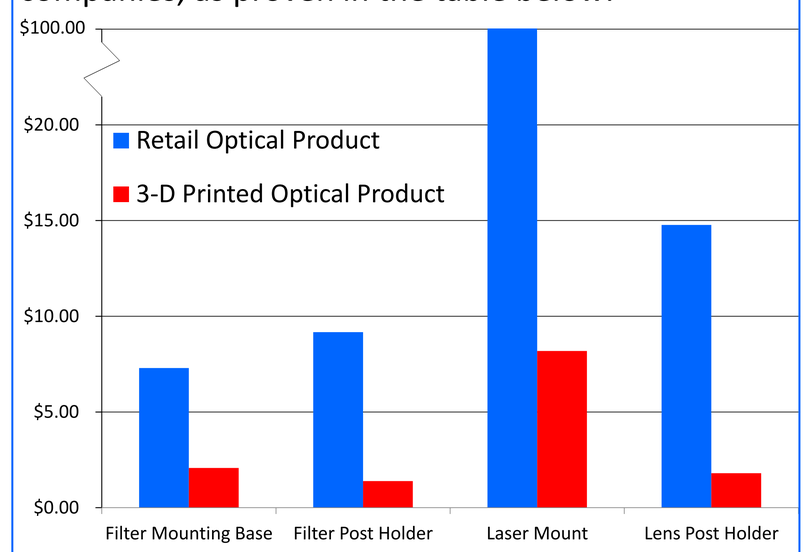
iv. The fourth project, a universal holder, was created in two phases: a holder and an adjustable clamp. The holder was high quality, but the adjustable clamp was too big because the PLA expanded when it solidified. After compensating for the change in size by printing a smaller clamp, it fit perfectly.

5. References

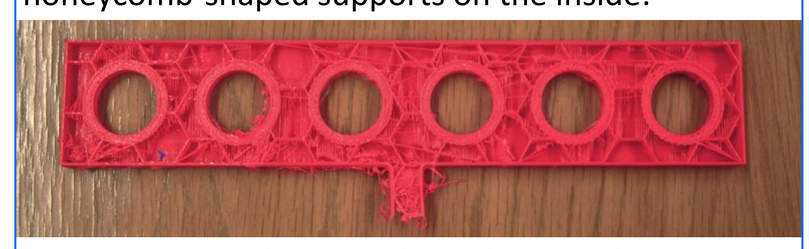
1.) Autodesk® Inventor® 2014 for Education [Software]
2.) MakerBot® Desktop® (Version 3.1.1) [Software]
3.) Brewster, Signe. (2013). *How Does A 3D Printer Work? The Science and Engineering Behind This Emerging Technology.* Retrieved from http://gigaom.com/2013/08/26/how-does-a-3d-printer-work-the-science-and-engineering-behind-this-emerging-technology/
4.) Filton. (2011). *The Printed World.* Retrieved from http://economist.com/node/18114221
5.) West, Larry. (2014). *Pros and Cons of Corn-Based Plastic PLA.* Retrieved from http://environment.about.com/od/greenlivingdesign/a/pla.htm

4. Results

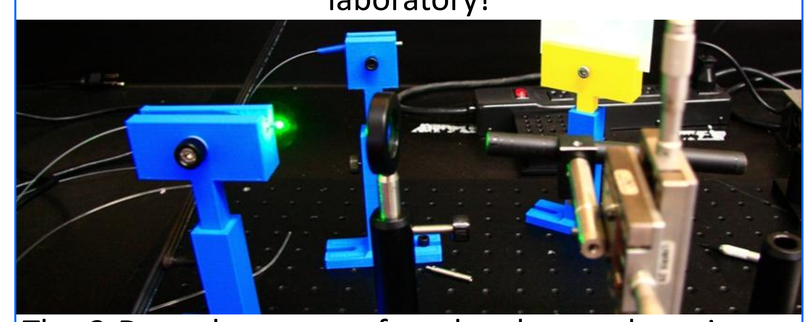
After conducting several experiments, it was evident that the supplies which were 3-D printed are significantly more cost-efficient than supplies which were purchased from optical specialization companies, as proven in the table below:



The 3-D printed optical products are sturdy and completely capable of holding the various lasers, filters, and other pieces that they're designed for. The structural soundness can be accredited to the honeycomb-shaped supports on the inside:



Here are the optical supplies being used in the optics laboratory!



The 3-D products were found to be much easier on the environment because very little PLA was wasted, and very little power was needed for production compared to retail products.

In conclusion, the impact that 3-D printing has on the optical supply industry is reflective of the effect that it will have on all kinds of manufacturing industries. The unparalleled cost and ecological benefits ensure that 3-D printing will have a bright future.

6. Acknowledgements

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