3D Printing of Low-cost Orthotics and Assistive Devices for Disabled Children

A mini-grant proposal

Presented to

The Center for Undergraduate Research And Creative Activities (CURCA)
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Introduction

3D Printing

3D printing is a process of "printing" a three-dimensional object using a machine that translates a virtual 3D computer model into layers of material (usually some form of plastic) that are built up, layer by layer, until an actual, physical three-dimensional form is produced. The process is not much different from the way an ink-jet printer works, except that in addition to an x and y axis (left and right, up and down), there is also a z axis (outward) that moves away from the flat two-dimensional plane and into the third dimension (space).

3D printing has been used for about twenty years in industrial settings, usually for what is called "rapid prototyping" whereby an engineering drawing can be realized in three dimensions, so that a part or device can be tested before it goes into full-scale production. Large, commercially available 3D printers cost over $30,000, and recently, medium-sized units have been introduced that can be purchased for about $15,000 (still quite expensive).

In 2009, a small company in New York, Makerbot, heralded as the avant-garde of a new industrial revolution, began making and selling a small, desktop 3D printer in kit form (hundreds of pieces) for about $1,000. It was capable of producing small objects (or parts that could be assembled into larger objects) about 3.5 x 3.5 x 3.5 inches in size—thus the Makerbot's name for the printer: "Cupcake." The machine utilizes thermoplastic (primarily ABS) in the form of a thick filament that is drawn into the machine, melted (220° C), and extruded from a print head into a fine thread that, as a platform is moved beneath it (x, y), creates an object layer. Once the layer is complete, the print head moves away from the platform (z) and deposits another object layer on top of the first, and so on (imagine a robotic hot glue gun). Dr. Mehlferber has worked with three generations of Makerbot machines over the past three years.

The latest development from Makerbot, the Replicator 2, which is a fully automated, fully assembled and tested iteration of their early machines is ready to print "right out of the box." It can print larger objects (11.2 L x 6.0 W x 6.1 H in [28.5 x 15.3 x 15.5 cm]). There is, of course, a learning curve to climb, but it is much shorter and less steep than before.

Assistive Devices and Orthotics Used in Physical Therapy

In 2008 15.2% of the children in the United States were diagnosed with a developmental disability. Even the most severely disabled child can participate in typical childhood activities if provided with appropriate support. The reauthorization of IDEA in 2004 has mandated that children be incorporated into all school activities, including extracurricular activities in public schools. As a result many children with disabilities are participating in track, and wheelchair sporting events. Many products are available to assist with performance of daily activities, but adapting "off the shelf" products to meet an individual's special needs is not always possible. Currently, the significant variance in the level of disability makes creating individualized products time consuming and–and very expensive. The outcome of this labor-intensive process is not always successful. Children, who quickly outgrow devices, can be especially challenging to help. Conducting research to develop new and better assistive and orthotic devices for children who could benefit from their use but who don't have the financial means to obtain them is a worthy goal. 3D printing makes it possible to design and produce customized, one-of-a-kind objects at a low cost.

Project Description

Our proposal is to purchase a 3D printer (Replicator 2) and consumables (spools of PLA plastic in various colors) from Makerbot, and train several undergraduate students selected from the Departments of Visual Arts, Biology, and Physics to use the machine. Additional training would be provided in the use of SketchUp, which is a relatively simple, readily available, free program for designing virtual 3D models. Drs. Millard and Mehlferber, along with graduate students in the Physical Therapy program, will offer advice and guidance in regard to the objects students print, but the main focus of this project is to provide students with a tool that enables *them* to think creatively as part of a team. Each student will bring her/his background in his/her individual field of study to bear while working as part of a team to identify and produce assistive devices and orthotics for disabled children (properties of PLA plastic include strength, rigidity, toughness, and impact resistance).

Significance

To our knowledge, there are no other universities that have 3D printers available for undergraduate student use outside the framework of specific courses–mechanical engineering or industrial design classes, for example. This project could set the pace for an open, student-centered exploration of this emerging technology in the design and production of low cost orthotics and assistive devices for a disabled pediatric population on local, regional, and national levels.

It is clear that there is the potential for students to make significant contributions across and among departments not traditionally "associated" with one another. In order for a product to be successful it has to meet functional and/or aesthetic needs (art), be engineered to account for issues of fit/ergonomics, weight, strength and structural integrity (sciences), and be priced at a level that makes it affordable for the target population.

Drs. Millard and Mehlferber will encourage and expect students to present their research at conferences on and off campus, and in certain cases, to produce written papers suitable for submission for publication.

Goals and Products

The goals/products of the project are:

- Students from different departments/schools working as a team, who are trained in the use of a 3D printer
- Creative, student-designed and produced low-cost orthotics and assistive devices for a disabled pediatric population
- Dissemination of the knowledge gained by students through: presentation of their research at conferences on and off campus; producing written papers suitable for submission for peer-reviewed publication; participation in exhibitions

Plan for Involvement of Undergraduates

This project will be entirely student-focused and student driven. Faculty and graduate students will provide initial training and ongoing technical support, as well as advice and guidance in regard to the objects students print; however, the main focus is to provide undergraduate students with a tool that enables *them* to think creatively and solve real problems that will ultimately improve a child's quality of life.

Budget

- One (1) MakerBot Replicator 2 -- $2,199.00
- Six (6) 1kg Spools of Filament PLA plastic (printing medium) -- $283.00
- MakerCare Service Plan (extended support, service and repair) -- $350.00
- Carrera Precision CP8812-T 12-Inch Titanium Digital Caliper Micrometer -- $44.41
- Shipping via FedEx Ground -- $30.79
- Shipping Insurance -- $9.00

Total Budget -- $2,916.20

Timeline

- October 2012 – Order machine, advertise project, recruit and select students to participate
- November 2012 – Train students in use of software and hardware
- December 2012 – Students research possible uses (over break)
- January 2013 – Students begin printing objects
- March 2013 – Students document their research, write papers, enter exhibitions, etc.
- April 2013 – Students begin participation in presentation of their research at conferences on and off campus; submit written papers for peer-reviewed publications; participation in juried exhibitions; these activities may extend into the next academic year
- End of formal project, documentation of results; informally, the project will most probably continue