MAKER: Collaborative Iteration in the Evolution of 3-D Models

Ms. Jean L. Bossart, University of Florida

Jean Bossart is an Associate Engineering Librarian at the University of Florida (UF). She has a BS in chemical engineering and MS in environmental engineering from UF, over 20 years of experience in industry and consulting, and is a licensed professional engineer in Florida.
Abstract
Collaborative iteration is an optimization process by which a design is developed, built, tested, and then re-designed based on input from multiple individuals. 3D printing facilitates design evolution by allowing models to be built at a rapid pace. Numerous open-source 3D model designs intended for 3D printing are available through websites such as Thingiverse™. This paper provides an example of such collaborative iteration of the design and functionality of a simple 3D model, a series of interactive gears. The prototype model on Thingiverse™ offered a rough working of the gears. Users who downloaded and printed the model offered subsequent sequential improvements to gear teeth and spacing, iteratively improving the smoothness of the gear operation. Library makerspaces provide 3D printing facilities to a diverse group of students and facilitate their access to these open source model designs, allowing students to build, test, and re-design.

Introduction
Historically, development of a geared machine required a lengthy process of design, build, and testing. Modifications of the design would then be made and the process of re-designing, building, and testing would be repeated. The rapid prototype method of product development has been around for about 30 years.1,2 Rapid prototyping is an additive manufacturing process by which 3-D physical models are fabricated layer-by-layer.2 In this process, 2-D slices are stacked on top of each other to create a 3-D object. Computer aided design (CAD) facilitated the emergence of rapid prototyping by enabling fast and repeated modifications to design drawings. This paradigm was further advanced on March 11, 1986 when Charles Hull received a patent for a solid imaging process known as stereolithography, the precursor to 3D printing.3 With the introduction of 3D printing, the design optimization cycle has been further shortened and the design process is now open to anyone with a computer. With 3D printing now readily available, would-be inventors can manufacture their own designs.4

Gears are versatile mechanical parts which perform many different types of motion control or power transmission. A gear is a wheel with evenly spaced and sized teeth and an external gear has teeth on the outside of the wheel. Gearing is two or more wheels with meshing teeth. When the teeth are cut straight across the edge of the wheel parallel to the axis of rotation, it’s known as a spur gear. These are the simplest types of gears and are used to translate rotating motion.5

Methods
A simple interactive spur gear mechanism in a heart-shaped housing was chosen because it demonstrated the iterations in the evolution of a 3D model. The model is a popular selection for students at the University of Florida and it can be built quickly and easily. The original 3D gear heart was posted on Thingiverse™ on February 1, 2015.6

In the original model, the gears were close together and would barely turn. A subsequent model had the gears printed separately from the heart enclosure and required the model to be snapped
together. By having the gears printed separately from the heart structure, the model could be printed in two colors. The most recent iteration posted on June 2, 2015 has the gear heart printed all as one piece, but with the gear spacing adjusted to allow for a smoother turning of the gears, represents an optimized design. At least five revisions to the model were posted improving the meshing of the gears.

All models were built on a Fusion 3D printer using PLA filament. The extruder temperature was set at 215°C and the bed temperature was 45°C. The infill was 20 percent and printed with no supports or rafts.

**Discussion**

Comments posted on Thingiverse™ demonstrate how collaborative iteration facilitates optimization of a design. A popular design, such as the geared heart, can catalyze individual users into an ad-hoc collaborative community. As individuals print the model and make improvements, they post the revised model design with comments on what improvements they made. Other users pick up the design at that point and insert their own design modifications, reposting their improvements as well in a repeating process. This collaborative approach allows for rapid process improvement. For example, the following are excerpts from the Thingiverse™ website Gear Heart model design.⁶

---

**Geared Heart by UrbanAtWork, published February 1, 2015**

Quick note: I found a very small deformation on the axle of one of the models uploaded. I should be able to add it to the next tweak. Thanks for posting all the Makes and positive feedback!

UPDATE (2015-02-05): I added a version (GearedHeartV1_5-wGearHoles.stl) that has holes in the gears and axels ... as requested by a couple users (to make it easier to turn with a pencil tip or paperclip).

UPDATE (2015-02-08): I added a "new" version that has a larger gap around the axles to try and address the issue some are having (including me) with the first layers fusing (especially with PLA). Let me know how it works, thanks.

UPDATE (2015-06-02): I added a new version of the large gap model that was causing some printers to print usual bridging at the top layer of the model. If your printer isn't perfectly dialed in or this is your first try at printing this model then use this version first: http://www.thingiverse.com/download:1366134

Newest Version has rounded size and bigger hole for the keychain. Make sure you print with the gear faces down.

---
Conclusion
Collaborative iteration allows a design to come to fruition as a final product much faster and more optimized than traditional methods. 3D printing facilitates the design process by allowing models to be built at a rapid pace and then tested and redesigned. Open source 3D printing model design files found on on-line sources such as Thingiverse™ provide a platform/venue for collaborative iteration. Library makerspaces can support collaborative iteration by providing access to a makerspace where 3D printing is available to a diverse group of students.

Bibliography