



Aligning "making" with Manufacturing Technology Education

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The Emerging Technology and Technician Workshop

Introduction

In January 2014, the Digital Fab Lab Learning Community (DFLC) and the Florida Advanced Technological Education Center of Excellence (FLATE) designed and developed a 3 day workshop “The Emerging Technologies and Technicians” (ETT) Workshop. St. Petersburg College (SPC) in their Collaborative Center for Emerging Technologies, or CCET, hosted the workshop, located on the Clearwater Campus in Clearwater, Florida. The goals of the workshop were to give participants an exposure to and experiences with Next Generation Manufacturing and Digital Fabrication (“Fab Lab”) environments as well as defining high-level alignments to their colleges’ academic programs, entrepreneurial programs, industry training, and regional economic development.

Methods

Participants from around the country shared their experiences with existing Fab Labs or their interest in starting one in their community. In a nutshell, a Fab Lab is a facility that has a number of tools and equipment set to carry out design and fabrication processes by individual “makers”. Fab Labs can be found in colleges where the primary audience is students working on class projects in a variety of disciplines; and also in libraries, museums, or other community facilities where the community members might be the largest group of users. They are also found in small business start up centers where members of the organization would be the main users. No matter where they are housed, “Fab Labs” require a business model that supports equipment repair and maintenance, skilled equipment technician expertise, instructor time and facility management.

During the workshop activities, participants learned to apply manufacturing processes and procedures for design of subassemblies that make up a final product. Attendees participated in hands-on activities. SPC students and instructors used the following methods for the hands-on rapid prototyping activities:

- Fabrication processes (additive manufacturing/machining)
- Product Design (3-D modeling)
- Quantity assurance (metrology/measurements)
- Reverse engineering (laser scanning)
- Fit and form (metrology/measurements)

Between the hands-on sessions, attendees gathered for facilitated discussions and mini-workshops to brainstorm ideas for aligning these “Fab Lab” manufacturing processes to economic development, academic program and industry training. Attendees also visited TSE Industries, a local design and fabrication facility that uses many workshop processes for a variety of custom products made of common and specialty plastics and rubber. At TSE workshop participants observed industry professionals using the workshop techniques.

Table 1. Agenda for Emerging Technologies and Technicians Workshop

Wednesday, January 8, 2014

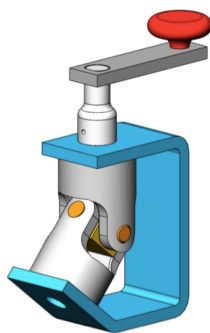
1:00 PM	Welcome: CCET, SPC & FLATE
1:15 PM	DFLC Sponsor & Lifecycle Overview
1:45 PM	Lab & Hands-On Activities Orientation
2:30 – 5:00 PM	Emerging Technologies & Technician Hands-On Project (<i>sessions 1-2</i>)
4:30 – 5:30 PM	Optional: Fab Lab Mentoring & NGM Enterprise & Technician Models

Thursday, January 9, 2014

8:00 AM	Tour of TSE Industry
10:00 AM	Break
10:15 AM	Emerging Technologies & Technician Hands-On Project (<i>session 3</i>)
11:30 AM	Curriculum Alignment Project Session #1 (Lunch provided)
1:00 PM	Emerging Technologies & Technician Hands-On Project (<i>session 4</i>)
2:45 PM	Break
3:30– 5:00 PM	Employer Alignment- Leveraging Emerging Technologies for Economic Dev

Friday, January 10, 2014

8:30 AM	NextGen Mfg. Best Practices & Resources
9:00 AM	FINAL- Emerging Technologies & Technician Hands-On Project
10:30 AM	Curriculum Alignment Project Session #2
11:45AM	Project summary
12:15 PM	Lunch (provided)
1:00 – 2:00 PM	Workshop Summary; Evaluation; Attendee Experience; Wrap Up



The Project: CRANK POWER TRANSFER ASSEMBLY

In the workshop the manufacture of the crank power transfer assembly (unit) was broken into 4 modules with small groups of participants starting at different stations. The workshop activities were constrained by time and resources (equipment) of the Collaborative lab at SPC such that the production of the entire crank power transfer assembly would have taken more than the three days for all participants to complete in typical order. Therefore, the workshop staff pre-prepared drawing files as well as pre-fabricated some parts and sub assemblies for the use of the participants.

Ultimately, all participants were able to complete the four workshop modules and perform the fit, form and function testing at the end. The four hands-on workshop modules are described below.

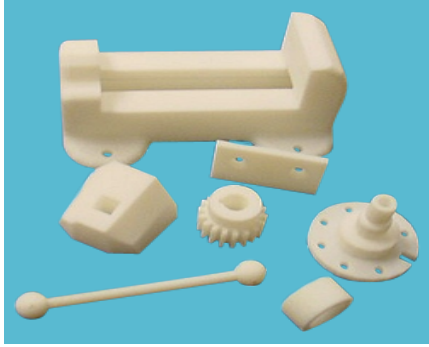
MODULE 1: The manufacturing process begins with the Reverse Engineering of an assembly from which the design is made. The Reverse Engineering module includes working with measuring calipers, micrometers, and scale as well as measuring machines such as Smartscope, Optical Comparator, CMM, and FaroArm Edge Scanner. During the workshop, participants measured one or more of the assembly components using the tools mentioned depending on the time available, but were able to learn the basics of digital scanning, the optical comparator and various micrometers. The manufacturing process begins with the Reverse Engineering of an assembly from which the design is made. The measuring process also includes tests and checks for size and tolerances to be sure all parts will fit together properly when assembled. If a part did not meet the desired specifications, it would require redesign, alterations and/or re-fabrication.



A disassembled crank power transfer assembly to be reversed engineered and reproduced. The crank power transfer module (black components) transfers power to the planetary gear (white) assembly at the top of the photograph.

MODULE 2: The manufacturing process of new products begins with creating the parts the assembly into the desired product. This process can include parametric solid modeling in SolidWorks (or similar modeling software) to identify and create the key shapes and features of the design process of the model. This module demonstrates the use of SolidWorks for designing simple components of the crank power transfer assembly. The 3D modeling files are formatted and become input for the machines used in various fabrication processes. This module could also include reverse engineering tasks using Laser scanners to generate the design/model files.

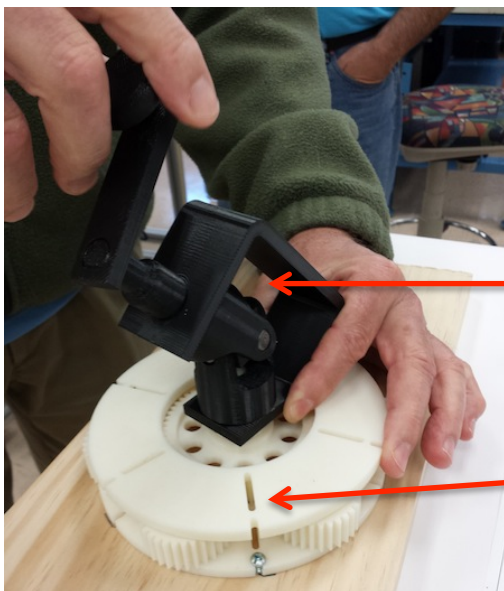
MODULE 3: Module three includes the basic steps of 3D Printing using the Stratasys 1200 Elite and uPrint SE, driven by Fused Deposition Modeling (FDM) Technology. The designed component models are saved as an .STL file in SolidWorks then opened in Catalyst software to build in real ABSplus thermoplastic parts. The products of the 3D printing are functional prototypes that are durable, stable and accurate up to a resolution of .178mm (0.007in.). 3D Printed parts are later evaluated for form, fit and function in everything from ergonomics to manufacturing processes.



Selected 3D printed parts of the crank power transfer assembly

MODULE 4: The final workshop module covers the basic steps of assembling the nine parts of the Crank Power Transfer Assembly. The nine parts are: support bracket, long dowel pin, short dowel pin, spider, female yoke, male yoke, crank shaft part, crank arm, and crank knob. The 3D printed ABSplus thermoplastic printed parts are assembled as a functional prototype that is durable, stable and accurate in size. As in previous modules, all aspects of the final assembly are evaluated for form, fit and function.

The crank power transfer assembly ultimately drives a planetary gear assembly. Participants did not build any of this assembly during the workshop. However, several were available for participants to test form and fit and functionality of their crank power transfer assemblies.



Crank power transfer assembly

Planetary gear assembly

ETT Workshop Outcomes

The workshop followed a strict schedule over the three days to complete activities and the associated focused discussions sessions. There were 24 participants, a majority of which were community college and university faculty from around the USA. Non-academic participants were economic development and workforce professionals and facilitators/technicians of Fab Labs. In the exit survey, over 85% of the participants said that they would use workshop

materials, particularly the hands-on design / build activities at their institution or facility. Most commented on the project as being an emulation of real product development processes. Overall, the workshop created a unique and comprehensive “hands-on, minds-on experience” that emphasized deeper and enriched learning of design principles and fabrication processes. The workshop also reinforced the need for an emerging new breed of technician with niche and horizontal skills more closely aligned with emerging industry technologies and needs. Finally, the workshop initiated a vehicle for the Digital Fab Lab and NSF ATE (National Science Foundation Advanced Technological Education Program) communities to integrate selected content into their offerings and those from MIT’s research on Science of Digital Fabrication at their website: (<http://cba.mit.edu/events/13.03.scifab/>)

Discussion

The Emerging Technologies and Technicians (ETT) Workshop allows the participants to become familiar with design and manufacturing processes through an advanced project based learning (“hands-on”) activity. To ensure successful production, it is necessary to plan the production process prior to manufacturing or making modifications to the product before production. The activities started with product design and ended with a fit, form and function exercise as a final quality check. The four workshop modules were designed to mimic the first/front-end of a “product life cycle” which include initial product design stages including material selection, making a prototype, redesign, and production process development and finally, production. Quality, functionality, size tests and checks are done during and between all the phases of the process. A full life cycle would also include labeling, packaging, distributing and ultimate recycling after the fabrication steps, but these were not addressed.

Since the first offering of this workshop, participants have reported using the crank power transfer assembly in classes across the country and also have reported improvements on the design for better fit. The DFLE community supports this sharing network to enhance learning of FabLab technologies within academic programs or classes. Additional offerings of this workshop are being planned at other colleges around the country.

Resources for this project, including instructional sheets for each modules, Solid Works files of the components, photos and a video of the assembly and final fit and function testing are available on the [FLATE wiki](#) under the Additive Manufacturing on Advanced ET (engineering technology) Modules as well as the [DFLE website](#). Additionally, a **Crank Power Transfer Device Assembly Video** can be accessed from either of the above websites.

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P1-1 THRU P1-9 POWER CRANK TRANSFER ASSEMBLY

CREATE THE INDIVIDUAL PARTS USING THE SKETCH AND EXTRUDE COMMANDS. CREATE THE ASSEMBLY USING THE COMPONENTS WITH THE MATE CONSTRAINTS. CREATE A DRAWING ON AN A1 TITLE SHEET. PLACE FOUR VIEWS AND ARRANGE AS SHOWN. EVALUATE THE SIZE OF THE MODEL AND SCALE ALL PROFILE VIEWS TO THE APPROPRIATE SIZE. INSERT A PART LIST AND BALLOONS AS SHOWN.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	MALE YOKE REV 3	P1-6	1
2	SPIDER REV 3	P1-4	1
3	SHORT PIN DOWEL REV 3	P1-3	2
4	LONG DOWEL PINS	P1-2	1
5	FEMALE YOKE REV 3	P1-5	1
6	CRANK-ARM REV 3	P1-8	1
7	CRANK KNOB REV 3	P1-9	1
8	CRANK-SHAFT REV 3	P1-7	1
9	BRACKET	P1-1	1

