Open Source Maker Movement: Opportunities for the Engineering Design Classroom

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Abstract

The proliferation of open source 3D CAD and 3D printing software, coupled with the growing community of the Open Source Maker Movement, has created opportunities for anyone to participate in engineering-related activities. What does the Open Source Maker Movement mean for education, especially for engineering graphics? The Open Source Maker Movement offers students and instructors free 3D CAD software, the ability to design and redesign artifacts, and access to hundreds of thousands of open source CAD projects. The Open Source Maker Movement has expanded opportunities to engage a larger population in engineering design, especially for those who thrive to innovate and exercise creativity (Lewis, 2008). Educators who teach their students how to engage with the Open Source Maker Movement will not only provide their students with more avenues to engage in engineering design activities, but build a foundation for life-long learning.
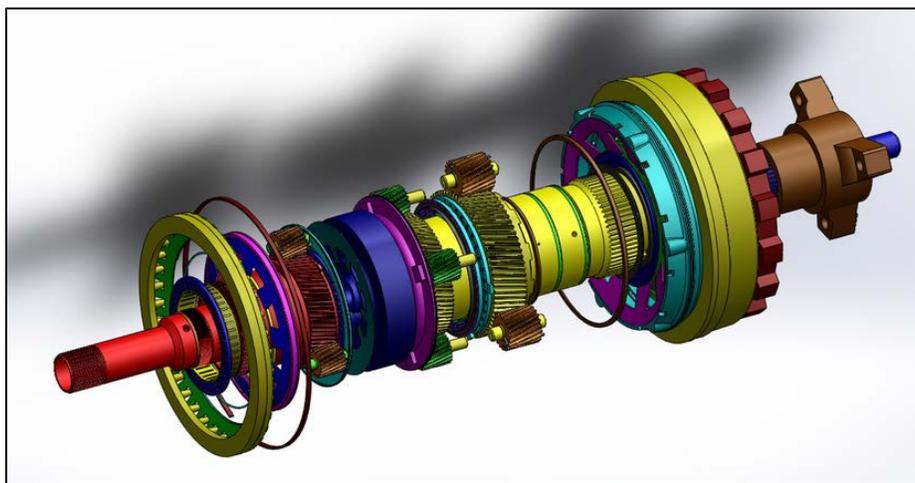
Introduction

While 3D printers and fuse deposition modeling are familiar to engineering graphics and engineering-related disciplines, 3D printers have started to saturate through all disciplines of career and technical education (Murray, 2013). While most educators are well aware of 3D printing trends, they may not be familiar with the Open Source Maker Movement and the surge of open source CAD models that are freely accessible on the Internet; this flourishing community of "makers" has published hundreds of thousands open source 3D CAD models of innovative ideas from a variety of open source websites. Established models can be downloaded to fabricate on 3D printers, laser cutters, and CNC machines. As a result, many software developers have released a number of free and open source 3D CAD modeling programs to increase CAD design opportunities for all types of designers (Autodesk Corporation, 2014; Blender Foundation, 2014; FreeCAD, 2014; OpenSCAD, 2014).

Traditional CAD or engineering graphics education focuses on the utilization of commercial-grade CAD modeling software to prepare students for careers in engineering product design, e.g., Autodesk, NX, Solidworks. The authors of this digest strongly support the use of industry-

standard software, but also believe the proliferation of open source 3D printers provides students opportunities to use application software (apps) that complement industry-standard software to design and prototype product designs affordably. Further, having access to completed designs may help engineering-related student's better design features of their own models (Cross, 2002). Introducing open source 3D CAD modeling software in conjunction with avenues to engage in the Open Source Maker Movement may provide students opportunities to sustain lifelong learning in engineering design, regardless of their career paths.

Implicit Benefits for Students

Teaching students to be creative while designing, especially when designing under constraints, may be difficult for educators to include in their classes. Educators and industry professionals tend to expect students to learn creative skills while demonstrating a defined understanding of 3D CAD software functionalities (Giloi & Toit, 2013). The difficulty lies with the ability to accurately grade or measure creativity because it is more about the process that occurs when solving design problems utilizing CAD software, rather than the finished CAD model. Creativity includes, but is not limited to, experimentation of features, reflecting on past modeling experiences, synthesizing information when completing design revisions, communicating with others to access solutions, and the time it takes the student to arrive at the final product or solution (Giloi & Toit, 2013). Students who navigate open source 3D CAD model website libraries have more opportunities to see different types of part features and digital assemblies. Figure 1 shows an Automatic Transmission Model for Mercedes that has been posted on GrabCAD.com; this can be beneficial when students are trying to think creatively.

Figure 1. Mercedes Automatic Transmission Assembly Model

Some educators may be hesitant to introduce free 3D modeling software programs or open source repositories of 3D CAD models due to the lack of confidence in the utilization of open

source resources. The reality is free CAD modeling programs and open source 3D model websites do exist and provide an extreme wealth of intrinsic knowledge about engineering graphics. Currently there are free 3D CAD programs to serve almost every type of engineering design-based discipline currently taught in career and technical education, and each has developed its own online community of users; students can interact with these communities at their own pace.

The Open Source Maker Movement and Free 3D CAD Software

The Open Source Maker Movement operates on a few basic principles, the first being the definition of open source. "In production and development, open source as a development model promotes universal access via free license to a product's design or blueprint; and universal redistribution of that design or blueprint, including subsequent improvements to it by anyone" (Wikipedia, 2014). The second principle is that the Open Source Maker Movement consists of individuals from all over the world who create and publish innovative CAD models freely on the Internet, which has been growing exponentially in recent years as presented in Figure 2. What this growth means for students who are learning 3D CAD design skills is that they have the ability to browse through thousands of CAD models that may help their CAD-based knowledge and skills.
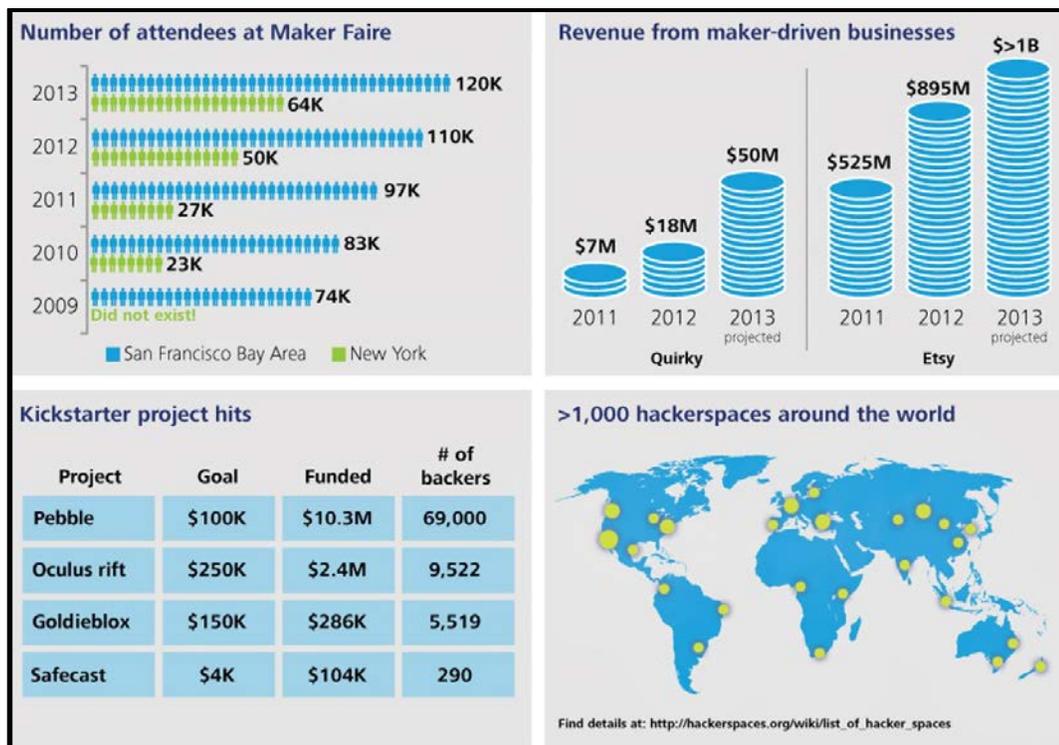

Figure 2. Growth in the Maker Movement

There are a number of free CAD modeling software programs that have become available on the Internet. Some of the popular programs include OpenSCAD, FreeCAD, SketchUp, 123D Design, Meshmixer, TinkerCAD, and Blender. Each of these free CAD modeling software programs have large communities of people using the software. The online networks of people using free CAD software have published instructional and troubleshooting videos where users can learn about specific functions of the programs and/or troubleshoot problems. In addition, there are websites which host the open source 3D CAD model libraries for the public to access. Some of the sites include Thingiverse, GrabCAD, 3D Warehouse, BlendSwap, and SketchFab. Educators, as well as students, have the ability to join these online communities and begin creating their own portfolios of various types of 3D CAD modeling artifacts. The increased availability of CAD models and decreasing cost of technology are the main driving forces behind the Open Source Maker Movement (Hagel, Brown, & Kulasooriva, 2014). Students who are engaged in learning about CAD design software tools should be introduced to CAD modeling programs and open source websites to expand their knowledge of current 3D CAD modeling trends, and provide avenues for social collaboration on innovative product developments.

Exploring the Possibilities of Free 3D CAD Modeling Software

SketchUp is one of the earliest 3D modeling programs that was freely available to the public and focused on the development of 3D architectural models (Hong & Chun-Xia, 2013). During the time when Google owned SketchUp, they created Google Warehouse, one of the earliest repositories providing free access to 3D models. Google also incorporated the ability to insert SketchUp models into Google Earth, so users could create a visual representation of how an architectural model might look if it was constructed.

Autodesk has recently released a number of free 3D CAD software programs to make it easier for people to engage in the Open Source Maker Movement. 123D Design, Meshmixer, and TinkerCAD are among these software programs, and are already gaining traction within the online community. After joining Autodesk's 123D application community, users have access to free 3D CAD modeling programs that have been released, as well as access to the library of 3D models that have been published using these software programs. Figure 3 illustrates an example of a traffic light model that was created using Autodesk's 123D Design software.
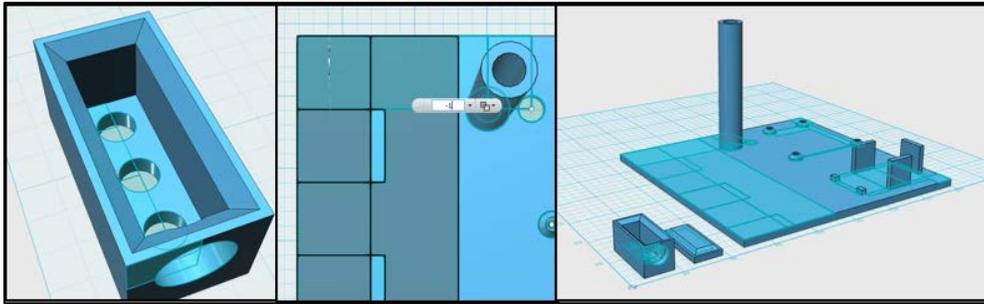
Figure 3. 123D Design – Traffic Light Model

Enhance Creativity and Social Collaboration

While the Open Source Maker Movement continues to expand, so does the availability of open source 3D CAD models. Websites like Thingiverse and GrabCAD are websites where individuals can create user profiles and interact with other individuals around the world who are also active in 3D CAD design activities. Thingiverse is primarily geared around the open source 3D printing community and provides access to over 100,000 free CAD models that can be downloaded for creation with a 3D printer. GrabCAD is an online community of CAD engineering professionals and students where users on the site can either browse and access 3D CAD files or publish their own CAD models to begin creating a portfolio of current and completed projects. Online communities like Thingiverse and GrabCAD provide individuals with opportunities to study open source 3D CAD models and to freely interact with other engineering graphic designers. Figure 4 provides a list of the file types supported by GrabCAD's viewer.

Neutral Formats	Proponents	File Extensions	Geometry Type	Parts in doc	Contains BOM	Colors
IGES	ANSI / ASME	IGS, IGES	Precise	Single	Yes	Yes
JT	Siemens PLM, ISO	JT	Either or Both	Either	Yes	Yes
Parasolid	Siemens PLM	X_B, X_T, XMT, XMT_TXT	Precise	Single	Yes	Yes
PRC	Tech Soft	PRC	Precise	Single	Yes	Yes
STEP	ISO	STP, STEP	Either or Both	Either	Yes	Yes
Stereolithography	3D Printer Vendors	STL	Tessellated	Single	No	No
Universal 3D	ECMA	U3D	Tessellated	Single	No	Yes
VRML	Web3D, ISO	WRL, VRML	Tessellated	Single	Yes	Yes
Proprietary Formats	**Vendor**					
Inventor	Autodesk	IPT, IAM	Both	Multiple	Yes	Yes
CATIA v5 & v6	Dassault Systèmes	CATPART, CATPRODUCT	Both	Multiple	Yes	Yes
CATIA v5 & v6	Dassault Systèmes	3DXML, CGR	Tessellated	Single	Yes	Yes
Pro/ENGINEER / Creo	PTC	ASM, NEU, PRT, XAS, XPR	Both	Multiple	Yes	Yes
I-DEAS	Siemens PLM	MF1, ARC, UNV, PKG	Both	Multiple	Yes	Yes
NX	Siemens PLM	PRT	Both	Multiple	Yes	Yes
Solid Edge	Siemens PLM	ASM, PAR, PWD, PSM	Both	Multiple	Yes	Yes
SolidWorks	DS SolidWorks	SLDASM, SLDPRT	Both	Multiple	Yes	Yes

Figure 4. Accessible GrabCAD File Types

Conclusion

This digest is not suggesting that free and open source 3D CAD software will in anyway replace commercial 3D CAD software for education. However, there is high educational value in introducing students to the existence of these free programs and online communities (Hagel, Brown, & Kulasooriva, 2014). Students will be able to access 3D modeling tools outside of the

classroom, which may open up tremendous opportunities for observing current graphic design trends, spark new ideas, and/or provide channels for communication and collaboration. The Open Source Maker Movement also assists students with the development of creative, innovative, and problem solving capabilities, while engaging in engineering design-related projects. The Open Source Maker Movement may ultimately benefit students' educational experience and provide them with the means to engage in lifelong learning activities relating to engineering design.

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Figures

Figure 1 – Retrieved Sept 6, 2014, from https://grabcad.com/library/mercedes-speed-automatic-

   transmission-by-solidworks

Figure 2 – Retrieved July 13, 2014, from http://dupress.com/articles/a-movement-in-the-making/

Figure 3 – Retrieved July 13, 2014, from Open Source Classroom, LLC

Figure 4 – Retrieved July 13, 2014, from http://blog.grabcad.com/blog/2013/04/22/a-brief-
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