Personal Fabrication and the Future of Industrial Design

Jason A. Morris, Western Washington University

A revolution in manufacturing may be coming sooner than we expect, and it could change the role of industrial design dramatically. Eventually, personal fabrication will allow one to be able to fabricate a product in the home, just as one can print out a color document today. If this prediction becomes reality, how will this affect the profession of industrial design? Does it empower industrial designers or does it make every person a designer? With the creative insights and experimental projects of design students, this paper explores the possibilities and implications of this coming paradigm shift.

Personal Fabrication

Personal fabrication is the manufacturing of a product using a personal computer, digital data, and a printer that can produce three-dimensional solid objects. Also called digital fabrication or desktop manufacturing, it uses methods based on rapid prototyping technology. Rapid prototyping technology has been in use since the early 1990s. Through additive or subtractive processes these machines can make highly precise parts of polymers and metals. Once the designer or engineer creates a digital three-dimensional file, it can be sent to one of these machines to be produced in a matter of hours.

Professor Neil Gershenfeld and the Center for Bits and Atoms at MIT have combined various technologies together in a fabrication laboratory or “Fab Lab.” This lab is contained within a small room with equipment that costs under $20,000 and can make a wide variety of products out of sheet metal, plastic, and printed circuit boards. (Gershenfeld, 2005). As technology becomes less expensive and more compact, it’s not hard to imagine a future where there is a desktop manufacturing machine in each home. And if anyone can manufacture products one at a time in their own homes, then how will that change the role of the industrial designer? How does it change the possibilities for what a product can be?

The Project

These questions were the starting point for a design project given to third-year industrial design students. Students were asked to investigate the various methods of rapid prototyping. They studied the constraints, advantages, and disadvantages of each type. They were also asked a series of open-ended questions that required them to imagine the future of personal fabrication. Following are some of these questions and the discussion that followed.

What are the advantages to using personal fabrication as a production process?

On-demand manufacturing

This method could completely reorder the sequence of product development and manufacturing. The common method of product development is to mass manufacture a product in great quantities and then attempt to sell each one. Now one can design a product, then promote and sell it, then manufacture as orders come in. Since there are no tooling-costs to absorb and each product can be quickly made one at a time, one only then needs to make just enough to satisfy demand. This means less waste, less overstock, and less overproduction.

More work for industrial designers

A business could offer multiple products and present the choices to the customer. The customers then choose, purchase and only make the ones that they desire. This could mean more work for industrial designers and product developers.

Mass customization

Each design could be made unique for each individual. A design could be modified through variables given by the customer; much like a tailor makes clothes to fit the body shape. This may be most

appropriate for design that closely relate to various body types and proportions, such as handles, or prosthetics. One could justify the higher cost because of its inimitable quality and personalization. Mass customization is currently being done in a limited way with some products. Nike enables customers to choose color variations of a shoe design for instance. However, personal fabrication would allow for more than just color choices—it could vary shape and proportion of *every element* of a product.

Revitalizing old products
If one person in a remote area needs a replacement part for an outdated and unsupported device, with personal fabrication, they could re-create the part digitally and then fabricate it themselves. A manufacturer could also provide downloadable replacement parts instead of stocking and shipping them.

Serving the ignored market
Many market segments are ignored, they are usually too small and don't have enough profit potential to get the attention of corporations. Whether they are people with disabilities, people in microniche groups or in those in developing countries, their needs are exceptional and specific to their culture and situation. Designers could work with them to design and fabricate products that serve these ignored microgroups.

Extreme complexity
Additive prototyping techniques allow for geometry that is not possible with injection molding or other mass production methods. Undercuts, internal features, varying wall thickness, zero draft, and other complex geometries are not a problem for most rapid prototyping machines.
For example, the Belgian company Materialise MGX specializes in designed objects that are made by rapid manufacturing. Their work has been shown at design exhibitions around the world since 2003. They work with designers to create unique and extremely complex lamps and lighting. The forms of these lamps are only possible through digital modeling and rapid prototyping machines (Khemsurov, 2006).

The Disadvantages

Abuse
People could use desktop manufacturing to make weapons or other harmful products. As with any tool, it could be used for malevolent purposes. This capability, combined with the ease of Internet file transfer could mean the simple creation and proliferation of destructive devices.

Intellectual property protection
A product design could be easily copied just as a music file can be copied today. This will require that the 3D data files are copy-protected or allowed to be fabricated only a limited number of times. It may devalue the work of the designer and create a black market of pirated designed objects. Coordination with software developers and programmers will be necessary.

High cost
Part cost for personal fabrication is much higher than a mass-produced part, so the value of the product must be justified. This is not a process for everyday commodity objects. It only is feasible for applications that utilize its inherent advantages. However, the lack of tooling costs, assembly inventory management, packaging and shipping costs will offset this high part cost to some degree. Also, part cost will decrease with time as the technology advances.

Material limitations
The materials available for rapid prototyping are limited in diversity, surface quality, and structural properties. For example, SLA parts tend to warp over time and FDM parts are limited to ABS thermoplastics of a single color. The texture of these parts is rough compared to injection-molded parts, which limits its application potential. Any product made with these materials would have to be designed specifically to meet these challenges and exploit their positive attributes.

The Potential

Remixed industrial design
Just as musicians can upload tracks of their music files for the public to download and remix, the same could happen for industrial design. In fact, it already happens today in the form of modifications to cars. Customers buy variations of wheels, bumpers, lights, and other car parts to suit their own style. Another example is “case-mods,” where people modify or redesign the housing for an electronic device, such as video gaming consoles. A future example might be a software program from Motorola that allows one to create a unique mobile phone design. It could provide options for shape, configuration, button layout, size, graphics and color. These options would be displayed as three-dimensional rendering on-screen before one decides to press “print.”

Open-source industrial design
Open-source software, such as the Firefox browser, makes the source-code available to the public. This allows the program to be constantly revised and updated by various software coders around the world. These changes are then shared with all for mutual benefit. Personal fabrication would make open-source industrial design possible. A design could be available for download as a parametric solid model file. This file could then be modified and revised by industrial designers as they desire, adjusting functionality, changing shapes, or structure. Then, these revisions could be shared with all for the evolution of the design.

Directly from designer to the user
Personal fabrication potentially allows the industrial designer to directly serve the end-user. An entrepreneurial designer could design a product, promote it directly to a microniche market, and manufacture it as orders come in. This would allow designers to bypass the entire traditional corporate system of marketing, sales, distribution, and mass manufacturing. The designer could even offer multiple designs for sale, without additional tooling investment costs. The relatively high fabrication costs per unit could be offset by the elimination of the overhead costs of a typical mass manufactured product.

User Designed: Who Needs Industrial Designers?
Users could define their own need, design it, create it through computer modeling and then fabricate it themselves. High school students can learn 3D modeling with Rhinoceros within a few weeks, and many casual computer users can learn Google’s Sketch-Up 3D software. So, if anyone can create their designs virtually, then all they will have to do it press “print.” This is user-defined, user-designed, and user-fabricated design.

Student Work

After this research and exploration, the students were asked to conceptualize applications that best utilize personal fabrication. The students created some inspired designs that wouldn’t be possible with another process.

Tyler Swain's Pendant Lamp

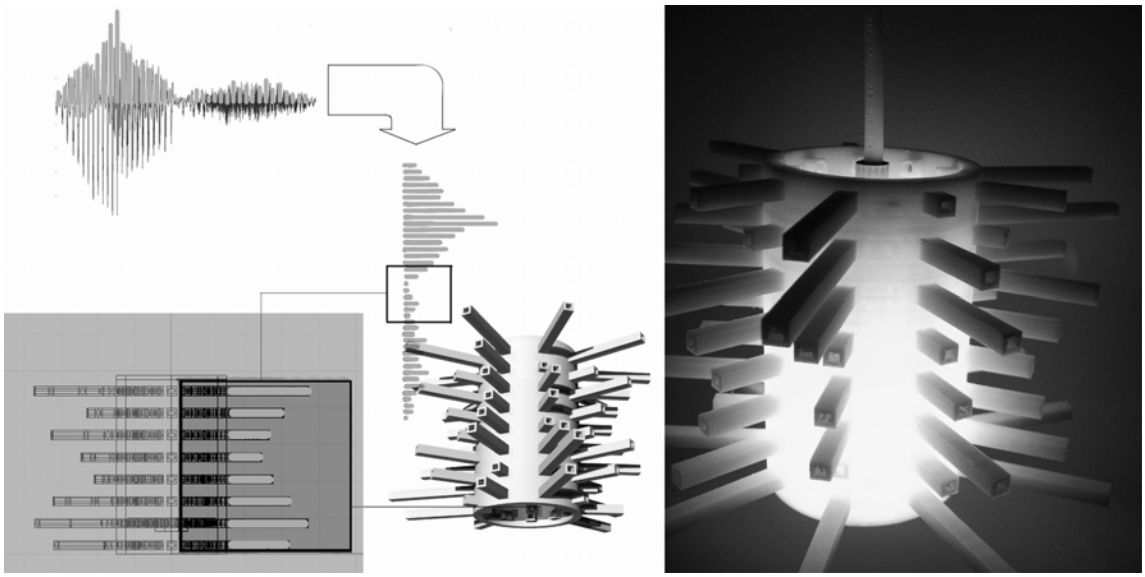

Figure 1. Transforming a sound wave pattern into a lamp form.

Tyler's lamp concept begins with a sound wave as given by the customer. It could be a spoken word, a message or a preferred musical sound. That sound wave is digitized into a pattern, which is then reinterpreted to the varying lengths of the rods protruding from the lamp. The rods lengths are adjusted with CAD modeling software and then exported as an STL file. This file is then sliced and produced using an additive rapid prototyping process, in this case FDM. Finally, it is assembled as a lamp with a form that is based on that sound wave pattern.

CJ Fredrickson's Audio Speakers

Figure 2. Personal body pose becomes form for audio speakers.

CJ's audio speakers begin with a bodily pose that the customer captures through a three dimensional scan of themselves. Computer software then translates that pose to the flexible digital figure. It then adjusts the scale to fit the speaker diameter chosen and exports the model as an STL file. Desktop manufacturing creates the figures in plastic, the speaker cone and wiring are installed and the speaker is ready to play.

Sarah Owen's Relief Photograph Display

Figure 3. The process of translating a digital image into a physical relief display.

Sarah's display begins with a digital photograph provided by the customer. This photograph is transformed into a topographical relief surface. The brightest portions of the photo are the thinnest section and the darkest areas are the thickest sections. This 3D data is converted into surfaces and fabricated using an FDM machine. When light is transmitted through the semitranslucent display the photograph appears as areas of dark and light.

Feasibility

In the near future, it's evident that desktop-manufacturing machines will be in the price range of many home consumers in just a few years. Rapid prototyping machines used to cost over $100,000 each, but now, the latest generation is available under $10,000. For example, the 3D Systems V-Flash desktop modeler is priced at $9900 and 3D Systems predicts that they will be able to bring the cost down to under $2000 in five years. The Desktop Factory by IdeaLab will begin selling its first printer for $4995 this year, and this company expects to bring the price down to $1000 within four years. (Hansell, 2007) Even today, high-end hobbyists are using laser-cutter desktop machines costing $4000. Additionally, a group called Fab@Home is promoting the open-source working plans for building your own 3D additive printer (or fabber) for about $3000 in material costs.

Researchers and engineers are developing machines that not only create polymer and metal parts layer by layer, but also print electronic circuitry, and micro electromechanical systems (MEMS). Researchers are also studying how to build structures with nanofactories using proteins as building blocks. The theoretical result will be molecular assemblers that arrange amino acids into proteins to create designed objects (Drexler, 1992).

Conclusion

Personal fabrication empowers the industrial designer by providing the opportunity to bypass the traditional (and expensive) product development infrastructure. But it also empowers the amateur designer to design their own products and bypass industrial designers entirely. The role of the industrial designers may then be to help create software that enables the public to do their own industrial design. Much like a tax accountant who helps create the software TurboTax, they are empowering the public, but conversely taking projects away from the professional.

To imagine the power of a manufacturing facility contained within a small affordable device is an exciting prospect for industrial design. It changes the very nature of product development as it is done today. The profession of industrial design will need to approach design problems differently. Rather than working on single products designed to fit the majority of the population, designers will be creating products that will be modified to suit each individual. Designers will not be creating fixed forms but, rather, forms that can be shifted and transformed. This will require the collaboration between industrial designers, software programmers, and engineers to make this shape shifting possible and intuitive.

References

Drexler, K. E. (1992). Nanosystems: Molecular machinery, manufacturing, and computation. New Jersey: John Wiley & Sons.

Fab at Home website (2007) http://www.fabathome.org/wiki/

Gershenfeld, N. (2005), *FAB: The coming revolution on your desktop—from personal computers to personal fabrication*. New York: Basic Books.

Hansell, S. (2007, May 7). Beam it down from the web, scotty: 3D printers could be in homes much sooner than you think. *The New York Times*, pp. C1, C8.

Khemsurov, M. (2006) Private first class: Four designers use rapid-prototyping technology to invent products inspired by intimacy. *I. D.* 11.

Materialise.MGX (2007) website, http://www.materialise.com/MADE/main_ENG.html

Noorrani, R. (2006), *Rapid prototyping: principals and applications.* New Jersey: John Wiley & Sons, Inc.