Hackerspaces, Fab Labs, and the Democratization of Exhibits

by Tisha Carper Long

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In the mid-1980s, the print publishing industry underwent a tectonic shift as design, font, and layout software, coupled with inexpensive printers, made "desktop publishing" a commonly understood term. Seemingly overnight, every small business, church, political cause or hobby club began to produce its own publications, from multi-columned newsletters and flyers to monographs, instruction manuals, and chapter books.

Thirty years later, manufacturing is undergoing a parallel transformation, and for exhibit designers and fabricators, these changes promise lower costs as well as wider creative parameters. Designing in three dimensions has become affordable and ubiquitous with user-friendly 3D rendering software. Interactive exhibits that once required substantial electronic hardware can now be programmed with relatively simple and user-friendly devices like the Arduino controller, described below. The cost of fabrication machinery is dropping more slowly, but shared fabrication facilities requiring only a membership or drop-in fee (e.g., $100 per month or $25 per visit) have brought computer-controlled manufacturing within the reach of even small institutions. And if you need help programming those tools, you can explore hackerspaces—physical locations where people come together to learn from each other and to work on digital, media, or computer-oriented projects.

The implications of these technological and sociological changes are not limited to how we do our work. In recent years, theorists and practitioners of exhibition design have promoted a more visitor-driven exhibition development process. These democratizing changes in the tools of the trade suggest ways to accomplish this goal, while dramatically driving down costs.

Designing in Three Dimensions

Accessibility of three-dimensional design is the first step in the transformation of exhibit development. Traditionally, three-dimensional objects have been designed in AutoCAD or SolidWorks, which require a learning curve that is not for the faint of heart—or wallet. These software packages cost from $4,000 to $8,000, with annual subscription fees that run as high as $2,000 per year. Today, basic 3D rendering programs like SketchUp and Alibre can be downloaded for free, with "pro" versions available for about $500 and $200, respectively. Leo Knapp, Exhibit Fabricator at the Oakland Museum of California, explains that these new programs have taken the place of "back-of-napkin" sketches for the early and middle stages of idea development. "They are great for developers who want something specific but find CAD too daunting to learn," he says. "You can get your feet wet with SketchUp."

The problem with these newer, cheaper, and easier programs is that, as of this writing, they don't interface well with fabrication or manufacturing machines. Knapp notes that you have to hand your design "over to your CAD jockey" as an intermediary step to fabrication. Software developers are scrambling to fix this gap in the flow, and very soon—perhaps within a year—programs like SketchUp may be able to talk directly to fabrication machinery like the ShopBot, laser cutters, and 3D printers.

Fabrication Machinery for Limited-Number Manufacturing

The second part of this tectonic shift is in the accessibility of fabrication and manufacturing technologies for small-scale projects. Machines that operate by "CNC" (Computer Numeric Control) have existed in large-scale manufacturing for decades, but access to CNC machinery by ordinary people for small-scale projects is still new. The ShopBot, the first CNC router available for under $10,000, came to market in 1996. It offers capabilities for cutting wood, plastics, and other materials that were completely out of reach to the ordinary craftsperson before that time. For example, using CNC input, the ShopBot can carve complex curves and surfaces such as an aerodynamic model helicopter fuselage.

The Sam Noble Museum of the University of Oklahoma has been using its own ShopBot and laser cutter for several years to step up its game in exhibit fabrication. Head of Exhibits Tom Luczycki says that the ShopBot "has been a great time saver in production, and allows us to spend more time in design rather than execution." CNC fabrication allows more bang for the buck. Luczycki explains, "... the bar has been raised in terms of what our department can accomplish with the current funding. Have we...reduced our budget? No, but we are producing more output and of a higher quality than we had previously."

ShopBot projects at the Sam Noble Museum run from repurposing vitrines to kid-friendly game pieces, as Luczycki describes in a blog dedicated to the topic (see http://snomnh-bot-journal.blogspot.com/).

Another timesaving CNC tool used by the Sam Noble Museum is the 3D printer. Because these fabrication machines work by depositing material (plastic, aluminum powder, etc.) layer by layer, as opposed to cutting away material, this technology is often referred to as "additive manufacturing." This technology is developing rapidly, and prices can vary from a few hundred dollars for a do-it-yourself kit to five-figure costs for very high-quality fabrications. Your needs should guide your research before you buy.

Luczycki suggests that the best use of the 3D printer at this early stage of development may be as an adjunct to traditional methods, speeding up the fabrication and prototyping process. For example, the Sam Noble Museum decided to create a facsimile of a juvenile *Apatosaurus*, but had only 15% of the fossil bones of the original animal. A team of University of Oklahoma paleontologists, interns, volunteers, and engineering students eager to work on the problem scanned the existing bones plus a full set of cast bones of an adult *Apatosaurus* as well as clay models, using transformations such as mirroring, scaling and distorting (because baby bones are not just scaled-down adult bones) to produce all the missing bones in 3D imaging. The entire set of bones was then 3D printed, many in halves, with registration (alignment) pegs. Flexible molds were then made of each 3D printed piece. Luczycki notes that, "Since we needed multiples [of the full dinosaur], traditional casting was still cost-effective over printing additional copies. Also, we did not know the longevity of the printed plastic versus that of our

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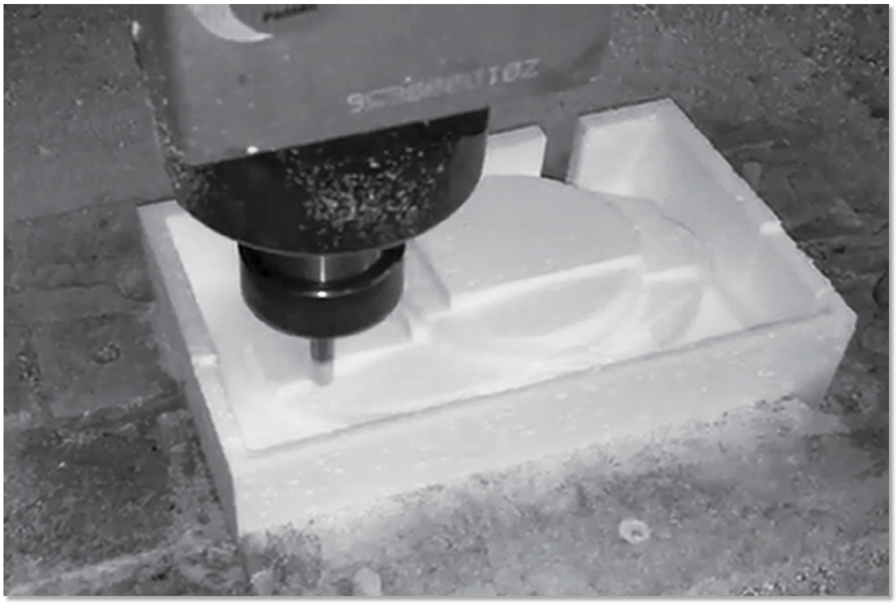

Using CNC input, the ShopBot can carve complex curves and surfaces such as an aerodynamic model helicopter fuselage. The Styrofoam for the oval fuselage was first rough-cut, then finely smoothed (here). The box surrounding the piece will be cut away. Photo by David Long.

(continued from page 41)

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casting compounds." See videos of the *Apatosaurus* project on their YouTube channel: http://www.youtube.com/user/SamNobleMuseum.

Electronic Interactives and the Arduino

Electronic interactives are becoming potentially cheaper by a factor of 10 to 100, thanks to new hardware/software products like the Arduino circuit board. The Arduino was developed at an Italian technical college with the express purpose of enabling students to create software interfaces to the physical world cheaply and quickly. The board itself, which fits into your hand, can be purchased for under $30, and the open-source programming is about as difficult as learning HTML. A single Arduino includes input and output connections to both digital and analog devices, such as motion sensors, motors, or lights. It serves as a "translator" of sorts, allowing digital input to create a real-world response and vice versa. Most interfaces of the past with this kind of capability required substantial electronic hardware.

OpenExhibits, an open-source software development organization and community for museum exhibitions, is in the process of adding Arduino development to its toolbox. Jim Spadaccini of OpenExhibits explains that,

> Arduino adds another dimension to computer-based exhibits. The Open Exhibits framework has lots of software modules that do many things, but exhibit developers were on their own when it came to adding hardware. Building a simple way for museum developers to add sensors and control lights and motors is the logical next step. Exhibit developers can now develop immersive spaces using a combination of multitouch and motion-recognition hardware, software, sensors, and lights. All of this can be done with much less expensive hardware and free and open software.

Stijn Schiffeleers, New Media Producer at the Oakland Museum of California, has worked with local artists to infuse their artwork with an interactivity that relies on the Arduino. For example, artist David Gurman created an art installation at the University of San Francisco, a religious institution. The school's church bell would chime hourly with the number of American soldiers killed in Iraq on the previous day. Schiffeleers used the Arduino as part of an electronic interface that checked the "iraqbodycount.com" website every night and output the number to the physical bell for the next morning's toll.

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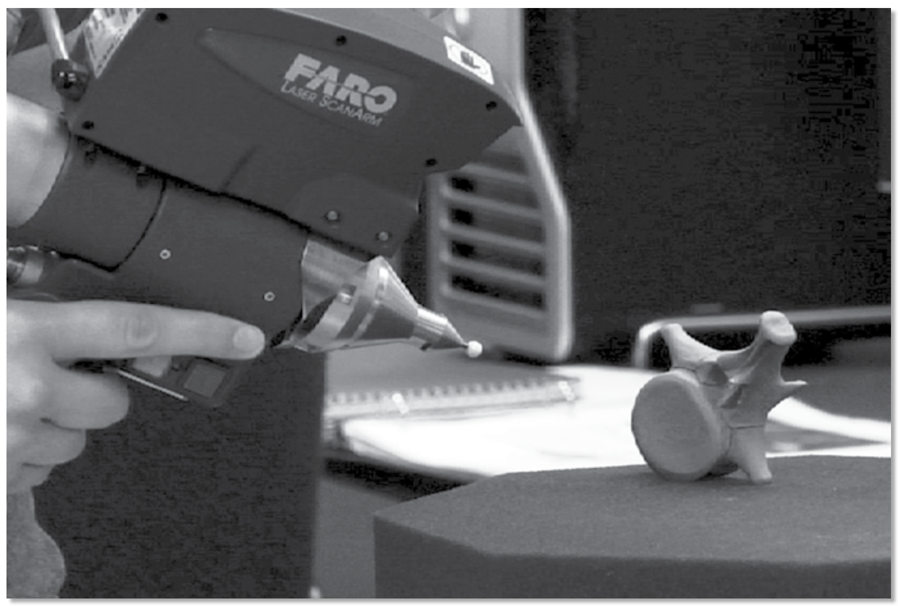
Shared Facilities: Hackerspaces and Fab Labs

The Arduino is within the budget of just about anyone, and is fairly simple to learn for those who enjoy technical exploration. Not all the tools described in this article are so user-friendly or inexpensive: for example, a ShopBot can run from $8,000 to over $15,000. For museums that are not ready to make an investment in software research or manufacturing machines, Hackerspaces and Fab Labs come to the rescue. There is a good deal of crossover between these shared resource facilities. Hackerspaces tend to be more software-focused, while Fab Labs appeal to a broader audience of "makers." Both operate on membership fees and encourage (openly or implicitly) a culture of idea-sharing and cooperative learning. Hackerspaces are probably not a major destination for most museum exhibit professionals, but if the idea of sitting in the same room with a lot of very smart computer-programming types sounds like a relevant learning opportunity, check out the Hackerspaces list in the Resource list accompanying this article.

The first Fab Labs were the brainchild of personal-fabrication visionary Neil Gershonfeld of MIT, and have now spread across the world, both under the Fab Lab name and various others, such as the TechShop. In exchange for a monthly fee of about $100 and enrollment in basic safety classes, these facilities offer the free use of ShopBots, laser cutters, 3D printers, and a variety of other fabrication machines. Computers loaded with the necessary CNC software are also available at these facilities, so you can design on-site as well. Today, these shared-resource "labs" can be found in almost every major American city, and in dozens of international locales. See the Resources listing on p. 44.

Visitor-Driven Exhibit Development

One of the most fascinating questions about the democratization of design and fabrication technology involves the role of the visitor. Many museums are seeking ways to strengthen visitor or community voices in exhibitions through talkback boards or social media. These technologies suggest a potential for visitor empowerment that was inconceivable in the past, such as inviting visitors to alter the form or nature of an exhibit for a truly open-ended experience. What if we allowed our visitors to create Arduino interactions to change the input or output of an electronic interactive based on their own whims? What if we allowed them to design their own 3D forms to be



Existing fossil bones, and clay models like this, were first scanned in 3D. Courtesy of the Sam Noble Museum.

New technologies require plenty of research, and any museum should fully understand its own needs before diving into a purchase.

(continued from page 43)

Resources:
Hackerspaces: http://hackerspaces.org/wiki/List_of_Hacker_Spaces

TechShops: http://techshop.ws/locations.html

Fab Labs (MIT-affiliated): http://fab.cba.mit.edu/about/labs/

Other shared fabrication facilities: http://wiki.fablab.is/wiki/Portal:Labs

fabricated at the museum? Are we ready for the radical democratization that these tools and shared resources suggest is possible?

Conclusion

Tom Luczycki of the Sam Noble Museum remarks that, "We are at a time where 'If you can design it, you can make it' is increasingly true." This begs the question of quality control. The old days of printmaking had a natural bar set for quality thanks to the cost and relative scarcity of printing presses, and a tradition of apprenticeship. Anyone who lived through the desktop publishing revolution remembers the infamous "ransom note" publications, where a dozen different fonts and typefaces peppered the page. While there remains a gradation of design quality in the print world, however, the "ransom note" era has largely passed because desktop publishers began to pay attention to commonsense design rules. We can probably expect similar trends in the evolution of exhibit design and fabrication. The battle for good design is never-ending.

New technologies require plenty of research, and any museum should fully understand its own needs before diving into a purchase. Shared facilities offer the best opportunity for exhibition designers and fabricators to gain the hands-on experience necessary to determine what is worth buying and what is worth "borrowing." Creativity and frugality were never so happily paired.

L to R: Fossil, 3D print, mold, and cast. The prints and the molds of bones like femurs were fabricated in two halves to produce casts that could accommodate structural rods without drilling. Courtesy of the Sam Noble Museum.