

3D Printing Processes Applied to the Creation of Glass Art

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It should be noted at the beginning of this paper that the motivations behind making the works detailed herein might not be readily apparent. The purpose of this article, however, is to present a few of the innovative techniques used in the execution of my sculptural work, not on the content of the work itself. In the works presented below, my interest has been in merging the methodologies and precise output control of 3D printing with finished objects in non-printable materials as required by the conceptual structure of my sculpture. Without devoting the requisite space to fully explain the ideation of the work, I will attempt to provide the reader with enough of the idea that the object is not an enigma.

I have been interested for some time in making funerary art. In early 2013, I produced a life-size cast glass replica of the headstone commemorating the lives of the common ancestors I share with my matrilineal family members still living in rural Wales (Figure 1).



Gelly Gwrogaeth
ladle-cast glass
2013

The summer after creating that cast glass piece, the Department of Art + Art History at UTA purchased a Makerbot and invited me to experiment with it.

A short while thereafter, I was offered some access to the School of Architecture's Digital Fabrication Facilities, and later the UTA FabLab opened in the Central Library, both greatly expanding my access to sophisticated equipment and technical assistance.

I had no previous experience with 3D modeling software, so I started by printing some simple pre-prepared files downloaded from the Internet. During this initial exploratory phase, I was reminded of the tradition in Welsh culture of carving love spoons (*llewy garu*) as a demonstration of craft, material sensibility, and a display of one's creativity. Reflecting on my role as an artist and craftsman in the modern era, I figured it would be interesting to make a love spoon using a process that almost completely removes my hand from its production. Using an open-source file downloaded from Thingiverse¹, I was able to generate a fairly complex *llewy garu* with only a few mouse clicks of physical effort. I then began to understand something that is not part of the marketing schema built around 3D printers: complex shapes require a fair amount of support material (Figure 2) which must be removed carefully, and the remaining object filed & sanded in order to become a presentable finished piece (Figure 3). This reintroduction of the methods of traditional craftsmanship, however minimal, made the process far more interesting to me than if it truly was push-button sculpture.



Figure 2



Figure 3

I knew that in order to truly explore my creative aspirations in 3D printing, I was going to have to learn to 3D model and operate within the world of Computer Assisted Design. While I was familiar with the Adobe Creative Suite, I found very little crossover in the skillsets. I spent more hours than I'd care to count learning relatively advanced software – primarily Maya.

During this time, I studied Buddhist Art History with Dr. Melia Belliⁱⁱ, becoming fascinated by the traditions surrounding the form of the *stupa* (Figure 4), a form of funerary architecture thought to have developed as a tradition to entomb the dispersed remains of the historical *Shakyamuni* after his deathⁱⁱⁱ.

In my design process, I simplified and aestheticized the *stupa* (as conceived of as a three-dimensionalized mandala) by reducing it to the most basic geometric components: a sphere bisected by a cube.



Figure 4: Stupa 3 at Sanchi
Image Courtesy of Crystal Graphics

Extruded ABS 3D Printed Object as Mold:

The 3D printing process provides the precision necessary to create exact geometries at specifically determined sizes, resulting in the ability to create inter-fitting parts. I designed compression molds to control the form of orange peels in a process in which they are cured into a leather-like material (Figure 5). By controlling the exact exterior and interior dimensions of the 3D printed object, I was able to experimentally determine the proper width between the outer and inner *stupas* to allow the processed orange peel to fit between the two parts of the compression mold without tearing. This is a process I've modified from a Mediterranean technique of making self-flavoring snuffboxes from a variety of locally available citrus rinds, though neither historical nor contemporary examples I could find had any rectilinear features. The precision of the 3D printing process also allowed me to create a nested system for processing multiple rinds of different sizes simultaneously (Figure 6), making my time in the drying kiln considerably more efficient.



Figure 5

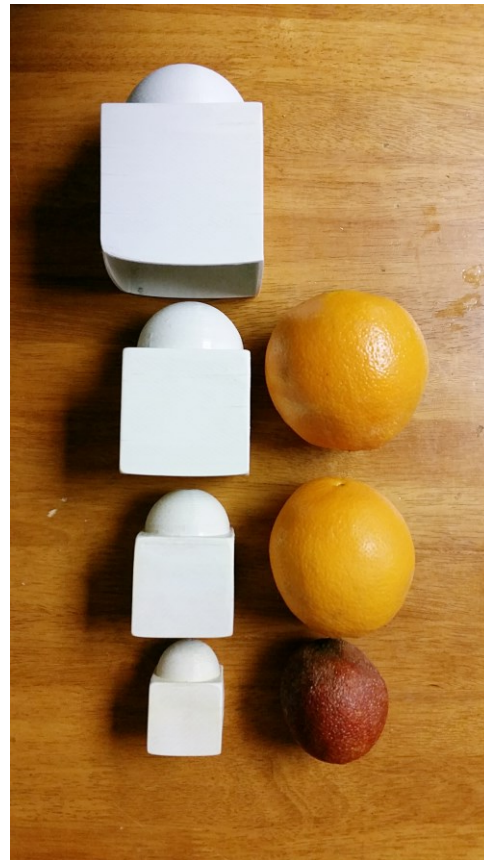


Figure 6

Sintered Plaster 3D Printed Object as Mold for Glass:

A uniformly thin layer of plaster media is spread from the feed bed onto the build bed and a print head deposits a liquid binder onto the desired areas to cure the plaster object layer by layer. This method results in a built-in support structure of uncured plaster that simply dusts off to reveal the printed object. These plaster objects are generally considered the finished object in architectural and/or industrial prototyping processes^{iv}, though I have developed methodologies which combine this 3D printing process with traditional plaster-silica glass casting techniques.



Figure 7

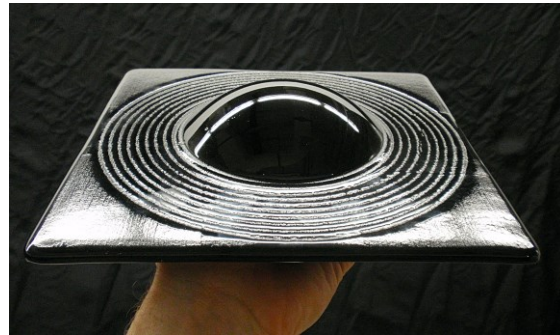


Figure 8

Using a modified setup on a sintered plaster printer, I designed and printed a “slump” mold (Figure 7), which I used to manipulate a 6mm plate of opaque black glass into a form that references, among others things, the top face of a *stupa* (Figure 8). By carefully grinding out the *axis mundi* and mounting the plate in a specially designed light-tight frame, I created a pinhole camera. Pinhole photography can be referred to as “glassless photography” for its ability to capture an image without use of a lens; this is a pinhole camera made of glass. This piece explores a variety of paradoxes between historical cultural approaches to observation and the mirror in the East and in the West (Figure 9).



Figure 9

Everything Is As Nothing Seems
glass, mirror, oak, steel, magnet, photosensitive paper
2014

Extruded ABS 3D Printed Object as Reusable Model for Mold for Glass:

I designed a *stupa* without undercuts and carefully filed away the surface of the 3D printed object to eliminate the striations created in the layer-by-layer printing process. This yielded a smooth ABS model, which was covered with a plaster and silica slurry. Once the plaster cured, the 3D printed object was removed and cleaned for repeated use.

I used this process to create a “blow” mold to control the form of a bubble of hot glass, resulting in an optical surface with the desired shape (Figure 10).



Figure 7

Figure 10

A hot glass bubble is lowered into the prepared mold during the blow-molding process.

Image Credit:
Nathalie Houghton

Misconceptions in the Popular Culture:

3D printing is often marketed as push-button object creation; at my experimental outset into this field, I was guilty of believing this myth. As I have progressed from printing open-source files with only internal support structures to printing custom-designed 3D models which require extensive post-processing to be of use with the mold-making techniques required to translate the printed object into glass, I have been happy to discover that 3D printing methodologies are not a techno-magical solution; one simply trades a set of benefits for another set of problems to be solved.

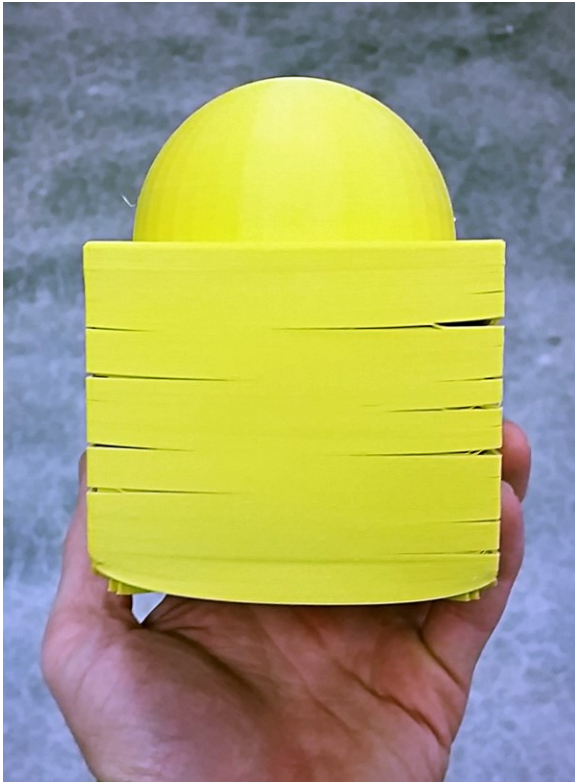


Figure 11

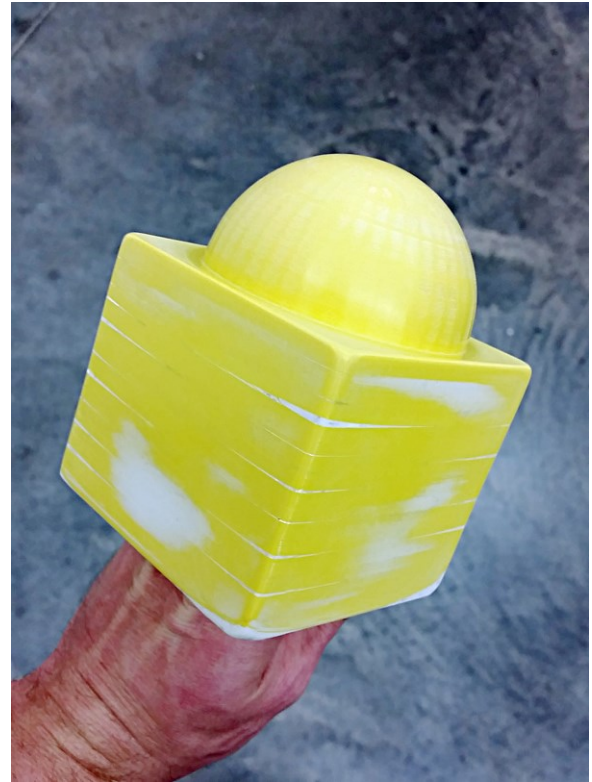


Figure 12

I am interested in working with 3D printing processes, though my output is often not the actual printed object itself. It is, for me, a way to create a precise sized model or mold to integrate into my sculptural practice, which considers the finished material to be an integral component of the content (Figure 13).

My interest in merging 3D printing methodologies with glass-forming techniques is not simply about formal control; my undergraduate training as a historian prompts me to always think about the historical context of any process or material I work with in my art practice. The two techniques at hand – glass forming and 3d printing – are not directly linked, though they share a curious alignment in historical trends. For the dominant majority of the history since their respective developments, both techniques were highly-guarded, proprietary secrets of industry that were impossible for the commoner to access without obtaining a job in a production facility. Due to the associated expenses and controlled nature of the means of production, designs to be executed were almost always highly vetted and were intended to fulfill the desires of a client, whether produced on spec or in a commission situation. Simply put, the ability to produce an object of one's own design was virtually impossible.

About thirty years before 3D printing was in its initial stages of development¹, the world of glass forming was being revolutionized by the radical sharing of information and techniques as instigated by Harvey Littleton¹. This eventually resulted in the current situation where several Universities and publicly rentable facilities have glass programs, allowing anybody to access the means of producing glass objects of their own design for a relatively nominal cost. Within the past few years, the expiration of several important patents in the realm of 3D printing has allowed the production of remarkably inexpensive units, similarly opening the point of access to almost anyone interested.

The work presented in this paper is intended to push the development of a bridge between these two methodologies; the possibilities at this nexus are tantalizing, and there is no shortage of exciting work yet to be done.

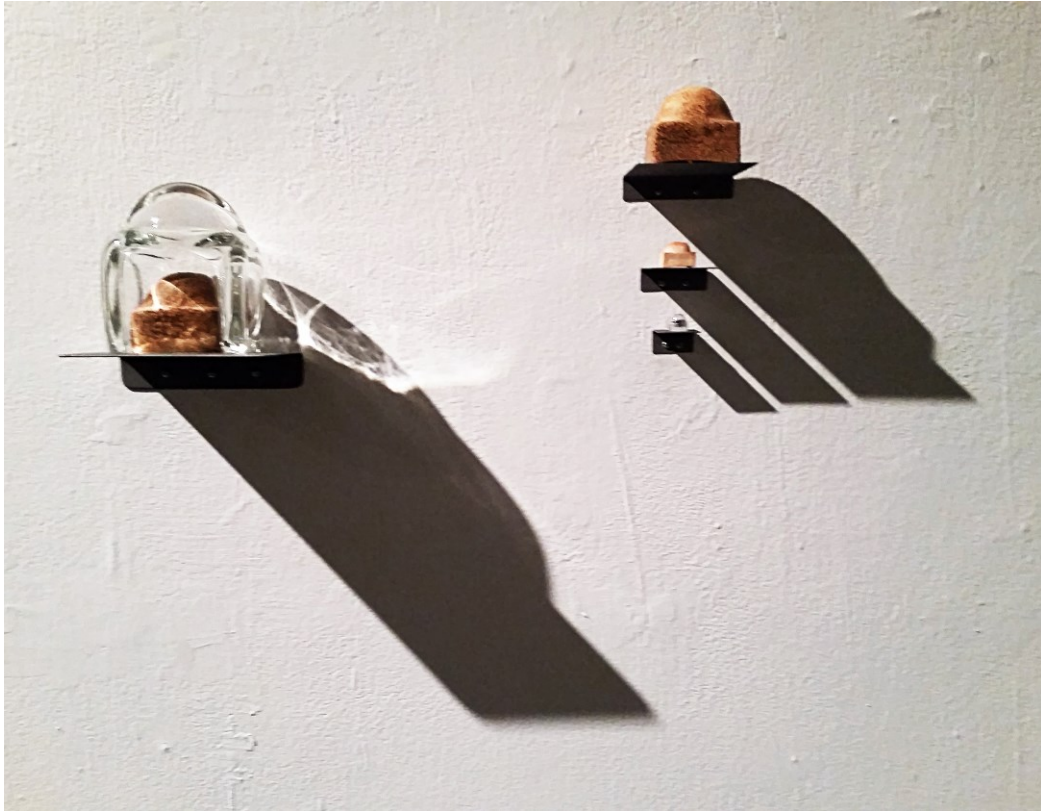


Figure 13

Best Laid Schemes and Banal Frequencies Notwithstanding, a Massacre is a Massacre
Rat remains, regret, mirror, glass, avocado pit, orange peel, oak, steel

2015

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production, designs to be executed were highly vetted and were intended to fulfill the desires of a client, whether produced on spec or in a commission situation. Simply put, the ability to use either of these fascinating processes to produce an object of one's own design was rare.

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Sources

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^v Hull, Charles W. Apparatus for Production of Three-dimensional Objects by Stereolithography. Uvp, Inc., assignee. Patent US4575330 A. 11 Mar. 1986.

^{vi} Byrd, Joan Falconer. *Harvey K. Littleton: A Life in Glass*. Skira/ Rizzoli, New York: 2011.

Biography

Morgan Chivers graduated from San Jose State University in 2011 after spending a full decade earning four simultaneously conferred degrees and five minors: BA History, BA Global Studies, BFA Photography, and BFA Spatial Arts, with minors in Anthropology, Music, Religious Studies, German, and Environmental Studies. He recently earned the MFA in Glass / Intermedia from the University of Texas Arlington (May 2015).

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