Amit Zoran, hybrid reassemblage: The masks. Glazed ceramic, spray paint, Objet PolyJet 3D-printed heads and epoxy glue, 2010. (left) a broken helmet. (middle and right) A broken element glued around a 3D-printed head. (© Amit Zoran)

ARTIST'S ARTICLE

Hybrid Reassemblage: An Exploration of Craft, Digital Fabrication and Artifact Uniqueness

Amit Zoran and Leah Buechley

ABSTRACT

Digital fabrication, and especially 3D printing, is an emerging field that is opening up new possibilities for craft, art and design. The process, however, has important limitations; in particular, digitally designed artifacts are intrinsically reproducible. In stark contrast, traditional craft artifacts are individually produced by hand. The authors combine digital fabrication and craft in their work involving object destruction and restoration: an intentionally broken crafted artifact and a 3D printed restoration. The motivation is not to restore the original work but to transform it into a new object in which both the destructive event and the restoration are visible and the re-assembled object functions as a memorial.

Before I (A.Z.) moved to the U.S. in 2007, I picked several artifacts that were important to me and held unique value in my eyes, and brought them with me. One of these objects was a handcrafted ceramic bowl that was made by someone I cared about. This bowl had a unique texture and was not perfectly round; one could easily see it was a handmade object, a unique artifact that would not be confused with another. The bowl embodied my memories of him making it. It represented great emotional value, associated with deep family connections and important events. In 2010, this bowl was accidentally broken by a visitor to my house. The visitor suggested paying for the bowl. Of course I refused; there is no price that can restore a memory. The original meanings embodied by the bowl were irrevocably changed.

The motivation behind the work presented here is twofold: first, to merge digital fabrication with traditional craft, thereby combining two creative processes that rarely overlap; second, to explore a process of restoring artifacts that preserves the form of the original and the history it carries while at the same time acknowledging the trauma of damage. We explore the deeply personal processes of crafting an object, using a combination of traditional and digital tools; destroying the object, letting go of all of the thought and effort that went into the original; and finally carefully restoring (and thereby transforming) the artifact.

We use the destruction of a handcrafted object—not usually a happy moment—as an opportunity for creation. By reassembling a broken object using contemporary fabrication techniques, we construct a unique artifact that retains traces of the original yet is distinctly changed. The Article Frontispiece shows a ceramic vase that was shattered and then digitally restored in this fashion. Broken pieces of the vase are held together by a 3D printed lattice that follows the form of the original. The ceramic pieces that remain suggest what the unbroken vase looked like. The lattice, instead of replicating or replacing the missing pieces, emphasizes their absence. The resulting "restored" vase functions as a memorial—a memorial that, for the maker, retains traces of the object's entire lifecycle: construction, destruction and restoration; a memorial of a beloved object and its breakage. The new one-of-a-kind piece acknowledges the original, the act that destroyed it and the process of restoring it.

Below we present three projects in which archetypical artifacts are created using craft and fabrication tools and then transformed through intentional breakage and digital restoration. We argue that this is a new kind of craft process that provides insight into the relationships among traditional craft, modern technology, art and design.

Amit Zoran (student, designer), MIT Media Lab, 75 Amherst Street, Cambridge, MA 02142, U.S.A. E-mail: <amitz@media.mit.edu>.

Leah Buechley (associate professor), MIT Media Lab, 75 Amherst Street, Cambridge, MA 02142, U.S.A. E-mail: <leah@media.mit.edu>.

See <www.mitpressjournals.org/toc/leon/46/1> for supplemental files associated with this issue.

Article Frontispiece. A digitally restored broken vase, glazed ceramic, SLS nylon element, epoxy glue and black spray paint, 2010. (© Amit Zoran)

Background and Related Work

We turn first to a discussion of the areas that lay the foundation for our work—Craft, Destruction and Restoration. Where relevant, we examine how each of these processes is being transformed by new technologies such as CAD and digital fabrication.

Craft

Our work is fundamentally an exploration of craft—an examination of the relationships between people, handmade artifacts and technology. It is useful then to begin with a definition. There are many different definitions of craft. Some scholars view the quality of an artifact as its significant aspect, while others put emphasis on the nature of small-scale fabrication processes [1,2]. Richard Sennett defines craft broadly as any process in which the practitioner is deeply invested in the outcome and takes care to do excellent work [3]. We find David Pye's definition, which ties craft to risk-taking, especially useful and evocative:

> [Craftsmanship] means simply workmanship using any kind of technique or apparatus, in which the quality of the result is not predetermined, but depends on the judgment, dexterity and care which the maker exercises as he works. The essential idea is that

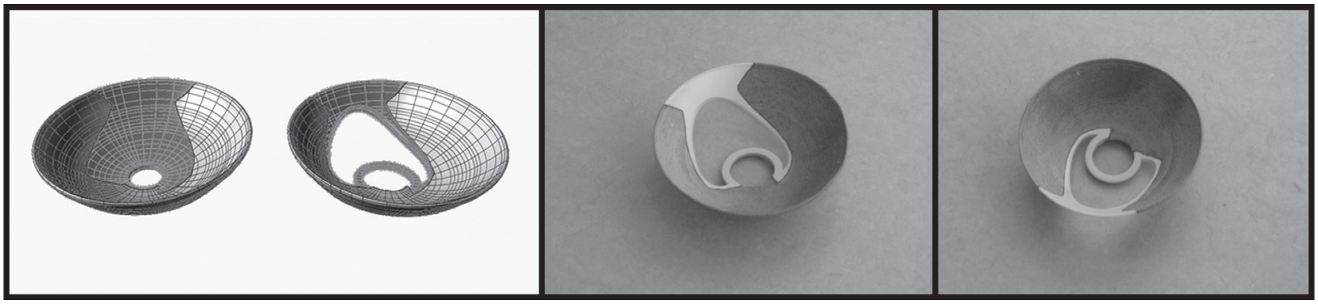


Fig. 1. A digitally restored bowl, 2010. The three biggest broken elements were glued and 3D scanned using a Konica Minolta VIVID 910, while the small elements were not used. (left) The virtual model of a 3D scanned bowl showing two restoration options, designed in the CAD software (Rhino). (right) The restored bowl, using 3D-printed SLS element, epoxy glue and spray paint. (© Amit Zoran)

> the quality of the result is continually at risk during the process of making; and so I shall call this kind of workmanship "the workmanship of risk" [4].

The results of a craft process are unique artifacts, each subject to the judgment, dexterity and care of the craftsperson. A craftsperson makes a series of personal and subjective decisions that define the object. The traditional craftsperson, working with "analog" materials, has no digital history of these decisions that she or he can refer back to or retrace. At the end of the process, the object itself is the only documentation of the effort.

Prior to the Industrial Revolution, everything was made more or less by hand. With the rise of repeatable, machine-driven production, artifacts became cheaper and were of a consistent quality but also became less personal and unique. Along with this change came a change in society's view of the craftsperson. Since machines could replicate the work of the hands, the manual dexterity and expertise required to construct objects lost value. Meanwhile, the work of the mind—the ability to envision and plan for the construction of objects, to design—was elevated. This movement away from craft and toward design arguably reached its apex in the United States in 2002, when the American Craft Museum changed its name to the Museum of Art and Design [5].

It might seem that craft is thus becoming less and less relevant to our modern society. Yet craft is experiencing a renaissance. Today, craft techniques and approaches are increasingly employed in contemporary art, fashion and design [6,7]. Craft practices are also infiltrating other disciplines. For example, a growing community of technology and design researchers is investigating how to blend craft with electrical engineering and computer science [8–10]. Our work explores a new integration in a similar spirit. We examine how craft practices can be combined with digital fabrication.

By digital fabrication we mean a process whereby an object design is created on a computer, and the object is then automatically produced by a machine. Digital fabrication machines can be roughly sorted into two categories: subtractive and additive [11]. Subtractive approaches use drill bits, blades or lasers to remove material from an original material source, thus shaping the three-dimensional object. Additive processes deposit progressive layers of a material until a desired shape is achieved.

Digital fabricators are becoming smaller, cheaper and more pervasive every day. Machines such as laser cutters and 3D printers—once found only in large factories—are increasingly present in universities, high schools, community workspaces and even garages [12]. As these machines and fabrication techniques become commonplace, they will alter the types and quantities of objects we own, reshaping our relationships to things. In the last several years, digital fabrication technologies have impacted the materials (such as ceramics) and techniques of many new fields, including arts and crafts [13]. In previous work, I (A.Z.) explored the transformative potential of fabrication. In an especially relevant project, I designed and 3D-printed a fully functioning concert flute [14]. The flute, which encompasses all the mechanical complexity of a handmade instrument, was 3D-printed as a single device that required no human assembly.

As personal digital fabrication becomes accessible to individuals, it reveals itself as a technology that seems in many ways supportive of craft. In particular, it enables small-scale production and design. Yet the two approaches are also in tension.

Digitally produced artifacts, like handcrafted artifacts, are the result of the subjective decisions of their creators. Digital artifacts also reflect the skills, perspectives and values of their makers [15]. In this sense, digital work is continually at risk in the same way that handcrafted work is. Yet digital craftspeople have access to a rich history of their efforts in the form of digital files, edit histories and—in the case of digitally fabricated pieces—physical objects. This means that there is considerably less risk in digital design than in handcraft.

Furthermore, there is—by definition—no risk in automatic fabrication. A digital design file specifies exactly what a machine should produce; the result is predetermined by the file. Once a design file is created, the object it specifies is infinitely reproducible.

This paper explores multiple dimensions of risk. As craftspeople, we create handmade objects that embody Pye's ideas in an orthodox sense. In destroying these objects, we embrace a clear and dramatic risk. We sacrifice the objects we have carefully crafted in order to explore new design and building practices. Finally, we work as digital craftspeople in the restoration and transformation of the broken originals. We explore how digital design and 3D printers can be used to produce unique artifacts, subverting one of the essential characteristics of digital fabrication.

Destruction

The marriage of craft and digital fabrication that we explore is made possible by destruction. It is the act of breaking a handcrafted object that gives us the opportunity to restore it with 3D printing. In a simple and primal way, destruction is the ultimate risk a creator takes on when embarking on a project—fabrics can stain or tear, wood can be cut and ceramics can shatter. By accepting destruction, the craftsperson comes to terms with one of the essences of the workmanship of risk.

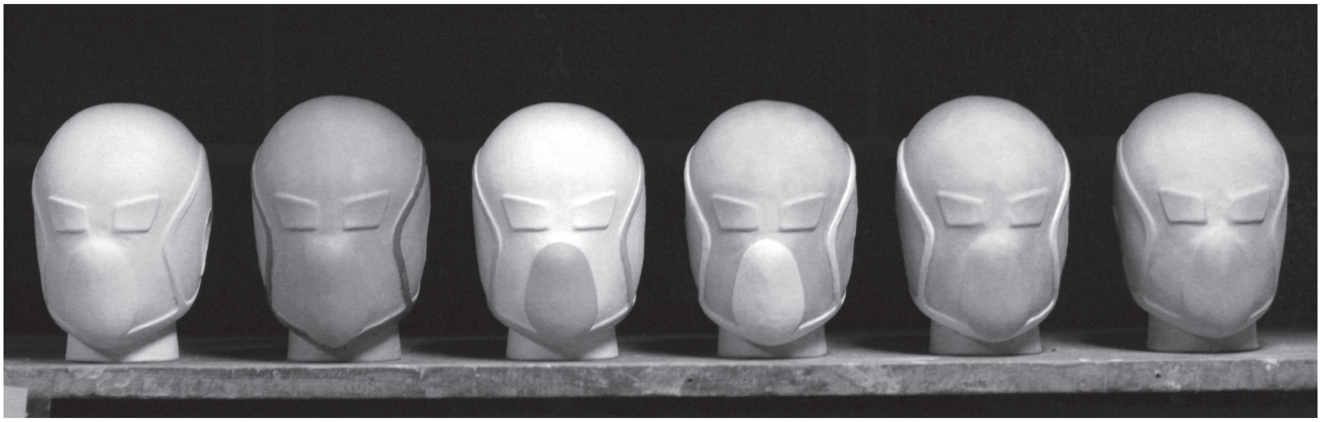


Fig. 2. Six cast masks on a shelf, using three different clay colors, before being fired, 2010. (© Amit Zoran)

The use of destruction as a creative tool has long provided fertile ground for artists exploring issues like impermanence, loss of control and fragility. Gordon Matta Clark's carved buildings [16]—abandoned homes and warehouses that are cut up into new forms—are one striking example of work in this tradition. Cornelia Parker's *30 pieces of silver* [17]—a collection of silver utensils that have been flattened by a steamroller—exemplifies a more lighthearted exploration of (cartoon-inspired) annihilation. Both of these works—while by no means entirely representative of the way this topic has been addressed in art—illustrate some of the enduring appeal of including destruction in creation. The reshaped buildings and the pressed pieces of silver retain the history accrued in their making and use while functioning both as documentation of the destructive/creative performance and as new beautiful and expressive objects in their own right.

Creative destruction has also been investigated in myriad ways in design. Particularly relevant to our work are designers who have experimented with broken ceramic. In *Vase of Phase*, Dror Benshetrit made vases from porcelain, broke them and put the broken pieces back together [18]. In *Shock Proof Vases,* Tjep attached polyurethane rubber to the interior of a set of vases. Each rubberized vase was then broken, resulting in a semi-soft surface of shattered pieces held in place by the rubber [19]. As in our work, these forms retain qualities of the original vases while recording and displaying the destructive act. Daniel Hulsbergen, in *CenterPIECE,* uses an alternative technique, restoring broken ceramic vases using Dutch basketry [20]. This technique of mixing two different craft traditions demonstrates how breakage can be used as an opportunity to join different materials, techniques and aesthetic qualities.

In our work, we exploit this opportunity in a similar fashion to bring together craft and digital fabrication. We use fabrication as a restorative process, a means of acknowledging and coming to terms with the risks inherent in craft.

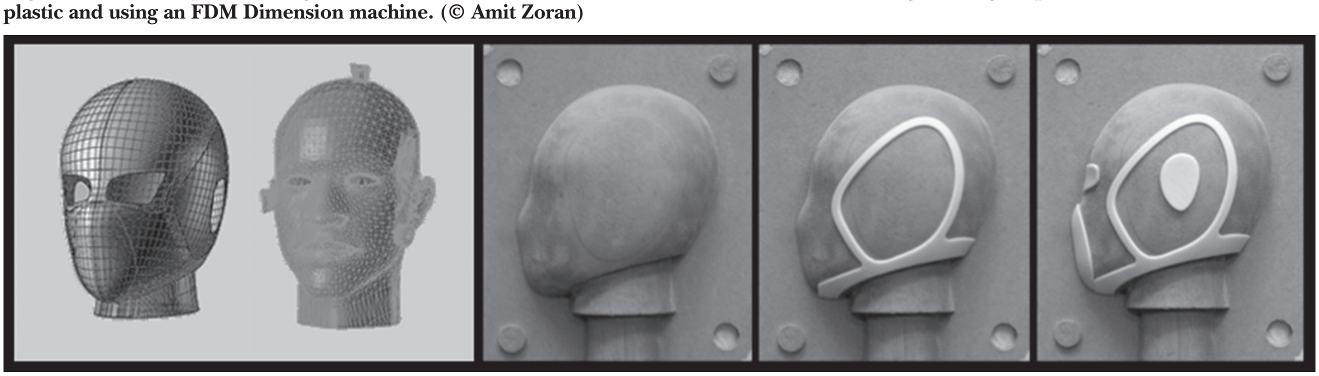
Restoration

In the restoration of art, the restorer's goal is to preserve the original properties of the work [21] and hide any external interferences. The motivation is to be as true as possible to the artist's creation. Preservation and conservation, as in archaeology, have a slightly different focus [22], emphasizing instead the slowing-down of aging. A principle consistent across restoration and preservation is that the craft of the restorer or the archaeologist should be hidden. The stage should be left to the original object.

In architecture, things operate a bit differently. In addition to traditional restoration and conservation, we see modern extensions added to old buildings. In these instances, the hand of the "restorer" is quite visible—the architect builds on top of an old building (or the remains of one) a construction of a distinctly modern nature, thus emphasizing contrasts and relationships between the old and the new.

While the traditional tools of the art restorer, archaeologist and architect differ from one another, in the last 30 years each of these fields has started to adopt digital technologies in similar ways. Increasingly, these disciplines are using design software and computer simulation to create virtual representations of environments and objects, and

Fig. 3. (left) The design of a mask-helmet and model of a head (including pins for the broken elements) in CAD software (Rhino), 2010. (right) The three steps of making the mold, from the milled MDF form (left) to the final mold (right) using 3D-printed details from ABS plastic and using an FDM Dimension machine. (© Amit Zoran)



digital scanners to capture and analyze information about three-dimensional artifacts [23–26]. Digital fabrication—and especially 3D printing—is providing new opportunities for restoration by enabling the relatively easy construction of replicas of broken pieces of original works or entire objects. Using 3D scanners and printers, modern-day restorers can precisely capture and reproduce the exact form of existing objects.

We argue that the use of these tools and processes can benefit craft by facilitating new creative approaches. The accessibility of CAD software, 3D printing and scanning has enabled us to use restoration as an integral part of the craft process. We believe that these new tools can allow restorers, designers, craftspeople and artists to create works that preserve important features of craft while at the same time providing new aesthetic possibilities. In particular, we can capture the form of an original artifact and create new restorations of and extensions to it.

Hybrid Reassemblage

In three projects below we demonstrate our approach to using digital fabrication to restore broken ceramic objects, a process we term *hybrid reassemblage*.

The Bowl

We began this paper by discussing how a personal object—a bowl rich with history and meaning—was accidentally broken. Our exploration of hybrid reassemblage was sparked by the desire to restore the bowl, to preserve some of the history and meaning it held. A traditional restoration—gluing all of the pieces back together—did not seem appropriate. Instead, we selected the three largest broken elements, 3D-scanned them, glued them together and then 3D-printed the remaining missing parts. Instead of attempting to re-create the original bowl, we created a restoration that emphasized its destruction. As can be seen in Fig. 1, the "restored" bowl no longer functions as a bowl—it can no longer hold salad, cake batter or fruit. Instead, it functions as a complete, stable form that memorializes the original while acknowledging the event of breakage and the subsequent loss of functionality.

In the restored bowl, the contrasts between new parts and old are emphasized by different surfaces, forms, textures and colors. The 3D-printed surface is smooth and white, while the original bowl's surface is rough and earthy in color. The new bowl respects both the qualities of the handcrafted object and those of the digitally fabricated restoration; in its new incarnation as a purely decorative memorial, it documents the history of the original bowl, its breaking and its restoration.

It is important to note that when 3D printing is used in this way—to restore a unique, handmade artifact—reproductions of the digital restoration are meaningless. The fabricated element gains specific relevance and context by adopting the form of the broken ceramic. After a restorative element is 3D-printed and joined to the broken bowl, there is no sense in re-printing it, because there is no duplicate bowl that matches the restorative part.

The Masks

The bowl project arose from an effort to restore an accidentally broken artifact. The process of repairing the bowl suggested other opportunities for exploring the relationships between craft—and ceramics in particular—and digital fabrication and led us to our second set of experiments: the masks.

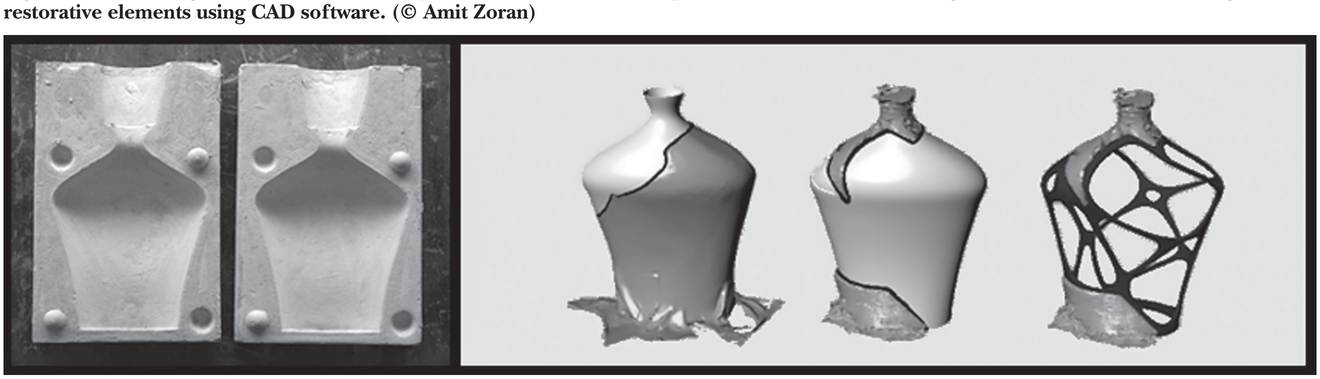
In the mask project, we began to create objects with the express intent of breaking them and restoring them using digital fabrication. We also began to examine other relationships between technology and traditional craft. Here we integrated and juxtaposed different aesthetic styles as well as processes and materials. In particular, we appropriated the "high-tech" aesthetics of robotic comic-book heroes and applied these to traditional ceramic masks (Fig. 2). We also began selectively to apply digital fabrication techniques in our creation of the original craft object.

We began by using CAD software to design a model for the mask. We designed the masks to fit around a digitally designed model of a human head that we purchased from TurboSquid [27]. Then we fabricated a positive two-part mold of our mask using a computer numerical controlled (CNC) milling machine and a Dimension Fused Deposition Modeling (FDM) 3D printer. This mold, shown in Fig. 3, was then copied into a two-part negative plaster mold, and the masks were cast into this mold by slip (a liquid clay). When the clay was dry, the mold was opened and the model was fired. We fabricated six masks using this process, glazing some areas and painting others with spray paint.

We then broke four of these masks either by using a hammer or by throwing them on the floor. Finally, we reassembled the broken pieces around 3D printed models of the head that guided our original design. Three of these broken masks are shown in Color Plate B.

One could reasonably argue that objects extracted from digitally fabricated molds are essentially identical, that they do not have the critical *aura* of a crafted artifact [28], that they are not unique. However, the ceramic pieces were also created by hand—each mask was individually cast, glazed and fired. While partially digitally fabricated, each ceramic was subtly but significantly different from all the others and, during the casting, glazing and firing process, each

Fig. 4. (left) Two negative parts of the vases' plaster mold, based on the positive MDF-milled mold. (right) The evolution of the design of the restorative elements using CAD software. (© Amit Zoran)



was subject to the judgment, impulses, state of mind and care of its maker.

The aggressive and random process of deliberately breaking a crafted object forces the craftsperson to acknowledge and accept risk. The craftsperson confronts the fragility and impermanence of his or her creations and labor. It is an experience of hope, regret, surrender and perverse glee.

In the reassembled masks, we highlight this process. Here, missing pieces are not replaced. Instead, a partial reconstruction of the original mask floats around a 3D printed head. The support structure that holds the broken pieces in place is almost hidden. As with the bowl, the final artifacts serve as memorials, but the emphasis in this case is less on the original objects and more on the documentation and preservation of the demolition.

Fig. 5. Three vases—the digitally restored vases (left and middle) and a complete one (right), 2010. Glazed ceramic, SLS nylon element, epoxy glue and black spray paint. (© Amit Zoran)

The Vases

In the bowl project, we created a restorative 3D printed part by carefully tracking the contour of a broken surface. In the masks project, the breakage was intentional, an integral part of the fabrication process. In the third project, The Vases, we merged these two approaches, deliberately creating and breaking vases and then 3D scanning and tracking broken surfaces to create restorative elements.

We started this process by designing a vase in Rhino and fabricating a mold. As with the masks, we then cast the vase with slip. Three cast vases were fired and glazed. From these three, we selected two vases and broke them using a hammer. We then selected several of the larger broken parts, glued them back together and 3D-scanned them.

In the design of the restoration, shown in Fig. 4, we began by making simple solid models of the digitally scanned missing pieces. We then stylized and refined these designs, creating lattice structures to contrast and complement the glazed ceramic of the original vases.

The aesthetic intention of the restoration, shown in Fig. 5, was to respect the shape of the original forms and trace the lines of breakage while exposing the inner volume, the negative space, of the vases. As with the bowl, the original functionality is lost, but new aesthetic, performative and cultural meanings are accrued. The 3D-printed parts combined with the original ceramics creates a hybrid effect, folding several contrasting concepts together: the old and the new; the closed and the open; the hand-made and the machined.

Loss and Acceptance through Craft and Digital Fabrication

Through three projects, we have explored how craft, digital fabrication, destruction and restoration can be integrated into a hybrid creative process. We attempted to preserve the essence of craft while experimenting with techniques that are at odds with this very premise. We now turn to a closer examination of the tensions and juxtapositions that formed the heart of our exploration.

An accidental destruction provoked this body of work. We were inspired by this event to use, control and explore destruction in a series of pieces. The acts of intentional destruction that form the heart of the mask and vase projects served as bridges: The destructions allowed us to transform an object from one kind of artifact into another. They also enabled us to engage in a different style of working. Once an object was broken, our focus shifted from creation to restoration. Moreover, the breakage invited us to examine the role of acceptance and loss in our practice and explore the different relationships we have with objects—as makers and as owners.

We found ourselves thinking about how destruction carries meaning beyond the brief incidence of breakage. The shattering of archetypal artifacts such as bowls, masks and vases—each of which serve as important icons in many cultures [29]—is a symbolic act. The bowl and the vases are containers that, once broken, can no longer hold water or food. The mask—an identity changer—cannot hide the head it covers after it is smashed. And yet no individual act of destruction can abolish an archetype. Although we break a mask, masks still exist and retain meaning. Arguably the act of breaking reinforces their power, emphasizing our inability to fundamentally change these foundational categories. Certain artifacts, tools and processes remain constant, although situations and individuals conspire to destroy them. The human impulse to build and create is robust. As tools, materials and practices change, we mourn our losses while continuing to design and build with whatever is at hand.

Yet the process of destruction is personal and emotional as well as symbolic. The more time, attention and care a craftsperson has invested in constructing an artifact, the greater the loss when it is broken. The process of making a unique object is always loaded with intimacy between the maker and the artifact. The breaking of one's own work is an especially aggressive and traumatic experience. However, coming to terms with loss and destruction is a liberating experience. For a craftsperson, exercising conscious if partial control over this process is almost therapeutic. It allows us to incorporate the entire life cycle of objects into our work. We see the processes we explored almost as a ritual of mourning, with intentional breaking serving a purpose similar to the tearing of a piece of clothing in the Jewish burial and mourning practices. The 3D-printed restorations we introduce to repair this damage are intentionally imperfect. They surrender the original meaning and functionality of the object and transform it into a memorial. In our eyes, the destruction and reassemblage is a *rite of passage* for the maker, who is forced to accept the reality of change.

Acceptance is an integral aspect of risk. This work illustrates that modern fabrication technology can be used as an element of compassion and compensation in a ritual of mourning. Esther Leslie, in "Walter Benjamin: Traces of Craft" [30], mentions that for Benjamin, the work of craft is similar to storytelling, embodying time and meaning through practice. Here, the time is the digital age, and the meaning is one of transformed identity—an identity that, while profoundly changed, preserves its most essential qualities.

Acknowledgments

We would like to acknowledge Joe Paradiso, Sherry Turkle, Tamar Rucham, Hannah Perner-Wilson, Ifaat Shoshan, Pamela Siska, Susanne Seitinger and Marcelo Coelho for their guidance and support. This work was funded in part by the Council for the Arts at MIT and Objet Geometries, Inc., and could not have happened without them. Special thanks to Darrell Finnegan and friends in the MIT ceramics studio and the Student Art Association (SAA), who shared their knowledge and assistance.

This work is in memory of William J. Mitchell, who was Zoran's advisor when this project began to evolve, and Avihai Haklay, Zoran's cousin, who crafted the original bowl featured in Fig. 1.

References

Unedited references as provided by the authors.

1. Risatti, Howard. A Theory of Craft: Function and Aesthetic Expression. Illustrated edition. The University of North Carolina Press (2007). Part I, pp. 13–66.

2. Adamson, Glenn. The Craft Reader. Berg Publishers (2010). Introduction, pp. 1–5.

3. Richard Sennett, The Craftsman. Yale University Press; 1st edition (2008). Prologue, pp. 1–15.

4. Pye, David. "The Nature and Art of Workmanship." The Craft Reader, by Adamson, Glenn. Berg Publishers (2010) pp. 341–353; p. 342.

5. Risatti, Howard. A Theory of Craft: Function and Aesthetic Expression. Illustrated edition. The University of North Carolina Press (2007). Parts II & III, pp. 67–206.

6. Hung, Shu and Magliaro, Joseph. By Hand—The Use of Craft in Contemporary Art. Princeton Architecture Press, New York. 2007.

7. Levine, Faythe and Heimerl, Cortney. Handmade Nation: The Rise of DIY, Art, Craft, and Design. 1st Ed., Princeton Architectural Press. 2008.

8. Blauvelt, G., Wrensch, T. and Eisenberg, M. "Integrating Craft Materials and Computation." In Proceedings of the 3rd conference on Creativity & Cognition. 1999. Loughborough, United Kingdom: ACM, pp. 50–56.

9. Buechley, L. and Eisenberg, M. (2009) Fabric PCBs, Electronic Sequins, and Socket Buttons: Techniques for E-textile Craft. Journal of Personal and Ubiquitous Computing, 13(2), pp. 133–150.

10. Wrensch, T. and Eisenberg, M. "The Programmable Hinge: Toward Computationally Enhanced Crafts." In Proceedings of the 11th annual ACM symposium on User interface software and technology. 1998. San Francisco, California, United States: ACM, pp. 89–96.

11. Kai, Chua Chee, Leong Kah Fai, and Lim Chu-Sing. Rapid Prototyping: Principles and Applications. 2nd Edition, Singapore: World Scientific, 2003.

12. Gershenfeld, Neil. FAB: The Coming Revolution on Your Desktop—From Personal Computers to Personal Fabrication. Basic Books, 2005, pp. 3–27.

13. Huson, D. "Digital fabrication techniques in art/craft and designer/maker ceramics." Digital Fabrication 2006. Society for Imaging Science and Technology, Denver, Colorado, pp. 172–175. ISBN: 0-89208-264-X.

14. Zoran, Amit. "The 3D Printed Flute: Digital Fabrication and the Design of the Musical Instrument." Journal of New Music Research (JNMR) Vol. 40, No. 4, 2011.

15. McCullough, Malcolm. Abstracting Craft: The Practiced Digital Hand. MIT Press (1998).

16. Diserens, Corinne. Gordon Matta-Clark. Phaidon Press. 2006.

17. Parker, Cornelia. Cornelia Parker. Hopefulmonster. 2001.

18. Studio Dror's website. "Dror / Vase-of-Phases." <www.studiodror.com/#/Vase-of-Phases/>, accessed 14 February 2011.

19. Atelier 29's website. "a+.29: Tjep's Shock Proof Vases Collection." Tuesday, 21 April 2009. <http://atelier29.blogspot.com/2009/04/tjeps-shock-proof-vases-collection.html>, accessed 14 February 2011.

20. DeTnk's website. "CenterPIECE | DeTnk." Work by Daniel Hulsbergen. <www.detnk.com/node/3113>, accessed 14 February 2011.

21. Hills, Paul. Preface, in *History of the Restoration and Conservation of Works of Art* by Alessandro Conti and Helen Glanville. Butterworth-Heinemann (2007).

22. Settanni, Joseph A. "Conservation, Preservation, Restoration: Terminology Should Assist Clarity." Archival Products. Spring 1998, Vol. 6, No. 2.

23. Reuter, Patrick, Guillaume Riviere, Nadine Couture, Stephanie Mahut and Loic Espinasse. "ArcheoTUI—Driving virtual reassemblies with tangible 3D interaction." Journal on Computing and Cultural Heritage (JOCCH), Volume 3 Issue 2, September 2010.

24. Leitão, Helena Cristina G. and Jorge Stolfi. "Digital Reconstruction of Fragmented Artifacts." ICHIM 04 Berlin: Digital Culture & Heritage. 31 August–2 September 2004, Berlin, Germany.

25. Bawaya, Michael. "Virtual Archaeologists Recreate Parts of Ancient Worlds." Science, News Focus, 8 January 2010. Vol. 327.

26. BBC News website. "Art Restoration's Hi-Tech Front Line." BBC News; Technology. Friday, 27 August, 2004. <http://news.bbc.co.uk/2/hi/technology/3598936.stm>, accessed 26 December 2010.

27. TurboSquid website. 3D Models, 3D Modeling Textures and Plugins at TurboSquid. <www.turbosquid.com>. Accessed 5 April 2011.

28. Benjamin, Walter. The Work of Art in the Age of Its Technological Reproducibility, and Other Writings on Media. Belknap Press of Harvard University Press (2008).

29. Jung, Carl G. The Archetypes and the Collective Unconscious. Princeton University Press; 2nd Ed. (1981).

30. Leslie, Esther. "Walter Benjamin: Traces of Craft." The Craft Reader, by Glenn Adamson. Berg Publishers (2010) pp. 386–393.

Manuscript received 9 April 2011.

Amit Zoran is an engineer and a designer focusing on narratives of technology, digital fabrication and craft. Zoran builds and designs tools and artifacts that reflect evocative ethnographic contexts and mixes traditional and state-of-the-art technologies.

Leah Buechley is an assistant professor at the MIT Media Lab, where she directs the High-Low Tech research group. The High-Low Tech group explores the integration of high and low technology from cultural, material and practical perspectives with the goal of engaging diverse groups of people in developing their own technologies. Buechley received Ph.D. and MS degrees in computer science from the University of Colorado at Boulder and a BA in physics from Skidmore College.

Publish in Leonardo!

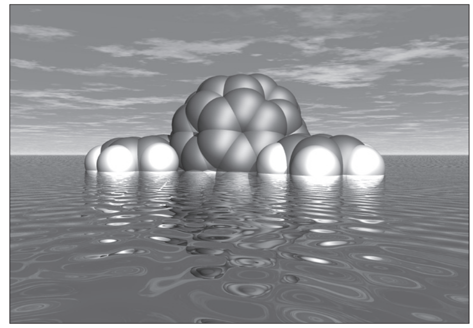
Leonardo seeks articles in the following areas of special interest

Art and Atoms

Guest Editor: Tami I. Spector

The modern world of chemistry is vast and its connection to art strong. From nanocars and extraterrestrial materials to DNA origami and biofuels, chemistry—like art—expresses its transformative, material essence. Chemistry's unique connection to art is the focus of this special section.

Full call for papers: <http://leonardo.info/isast/journal/calls/artandatoms.html>
Author guidelines: <http://leonardo.info/isast/journal/editorial/edguides.html>
Submissions: <leonardomanuscripts@gmail.com>



(© Chris Ewels)

Re-Imagining the Moon

Guest Editor: Sundar Sarukkai

The moon has profoundly influenced the human imagination over the centuries, in the domains of myths, religion, art and science. This special section aims to publish articles from a variety of disciplines exploring various social and cultural aspects related to the moon as well as those that engage with the relation between the moon and the artistic and scientific imaginations.

Full call for papers: <http://leonardo.info/isast/journal/calls/moon-call_2008.html>
Author guidelines: <http://leonardo.info/isast/journal/editorial/edguides.html>
Submissions: <leonardomanuscripts@gmail.com>

(© Danqing Shi)

Environment 2.0: Through Cracks in the Pavement

Guest Editor: Drew Hemment

In urban environments we are separated from the consequences of our actions as surely as the tarmac of the road cuts us off from the earth beneath. But between the cracks in the pavement, another world flourishes—local activism, recycling, environmental collectives, permaculture, urban gardening. Leonardo solicits texts that document the works of artists, researchers, and scholars involved in the exploration of sustainability in urban environments.

Full call for papers: <http://leonardo.info/isast/journal/calls/environment-2.0_call.html>
Author guidelines: <http://leonardo.info/isast/journal/editorial/edguides.html>
Submissions: <leonardomanuscripts@gmail.com>

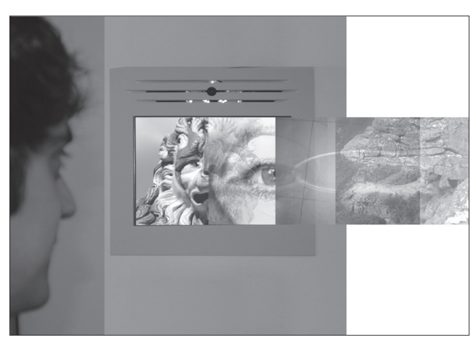
(© Betsy Damon)

ArtScience: The Essential Connection

Guest Editor: Robert Root-Bernstein

What is the value of artistic practices, techniques, inventions, aesthetics and knowledge for the working scientist? What is the value of scientific practices, techniques, inventions, aesthetics and knowledge for the artist? When does art become science and science, art? Or are these categories useless at their boundaries and intersections? Artists, scientists, artist-scientists and researchers of all sorts are invited to explore such questions in the pages of Leonardo.

Full call for papers: <http://leonardo.info/isast/journal/calls/artsciencecall.html>
Author guidelines: <http://leonardo.info/isast/journal/editorial/edguides.html>
Submissions: <leonardomanuscripts@gmail.com>



(© Elisabeth Weissensteiner)