MINNEAPOLIS COLLEGE OF ART AND DESIGN
MINNEAPOLIS, MINNESOTA

From Model to Made: Digital Fabrication and the Artist

by Brad P. Jirka

HISTORY:

Computer modeling, and specifically **form•Z**, has been a key component of MCAD's 3D programs in Furniture and Sculpture for over a decade. Originally adopted to aid our students in the professional visualization and presentation of proposed projects, it soon became one of their basic ideation tools. As our programs are about "making", the further addition of a Digital Fabrication Lab with RP and CNC capabilities appropriately extended these skills into studio production.

Within a series of program courses including "Presentation Techniques", "The Object and the Computer", and "Digital Fabrication", the students not only acquire modeling skills, but explore the possibilities and impact of computer modeling on the design and creation of 3D objects and environments. The dialog extends from its direct and current effect on design, its future impact on our explorations, and the implications of personal fabrication.

PREMISE

Art is birthed in concept and realized in execution…

At MCAD the creative process always seeks a balance between concept and execution. As a community of artists we relish the theoretical exploration but have come to expect its physical realization. Neither is viewed as dominant or initial, nor is presented as being more important or imperative; as both merge to define our individual "practice".

The beauty of being an artist is that one is not only the "designer" of their work but usually its fabricator, engineer, material specifier, and installer as well. Within our Sculpture and Furniture programs, this approach results in students that are skilled "makers" creating works that reflect a conceptual understanding of the concerns and needs of the object, space, content, and context.

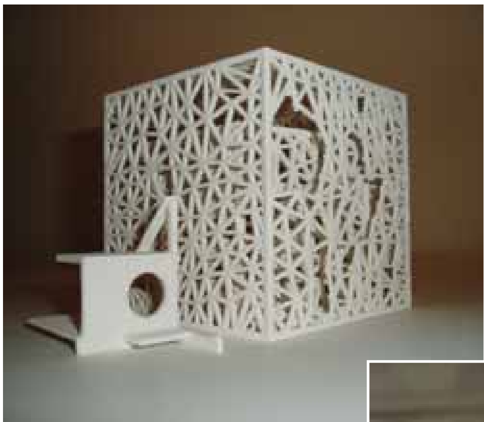


Figure 2: Brian Jorgenson; Drawing Untitled structures; Structural works derived from cut paper drawings. RP Gypsum.

Figure 3: Karl Zinsmaster; Furniture Design "Lines in Space". RP vessel line model "floating" in space. RP Gypsum; mirror.

Figure 1: Karl Zinsmaster; Furniture Design "Phones". The Objects themselves take inspiration from iconic objects, like the radio horn and umbrella, while exploring an almost Seuss-like freedom of form to rejoice in the absurd. RP Gypsum, wood.

Figure 4: Daniel Dreke; Sculpture-Installation "Facades." Installation of modeled facades in situ. Detail. RP Gypsum, photo documentation.

The possible difference between the artist's "practice", and that of other CAD users, may be in this relationship between theory and result. As the "makers" of our creations, the work is most always "ours" striving to eliminate any disconnection between design and fabrication and, to varying degrees, the interpretive loss of the artist's vision. For the artist there can be no compromise in the "reality" of the envisioned work.

Within this premise we introduce 3D modeling as yet another tool to our students' repertoire of techniques. It can take on a number of roles, ranging from presentation and ideation to design and fabrication assistance, but it is not indispensable. It may enable the exploration of new realms, whether it is visual data mining on the Internet or even the ability to visualize the ephemeral nature of smoke trails, but the greater concern is about our ability to see something new and bring it to life.

We explore the realm as it undoubtedly impacts our future, and the nature of form and the object, but not as a creative imperative. How, or if, the digital is ultimately applied to an individuals work is solely their concern, driven by their practice and as appropriate to their individual investigations.

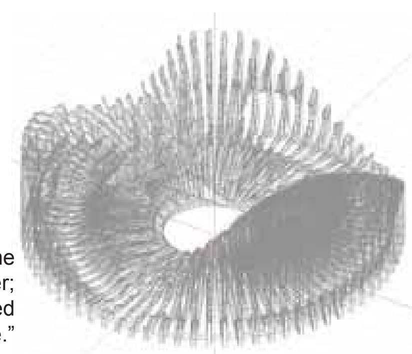


Figure 5: Wireframe by Alex Schroter; Sculpture "Stellated Landscape."

Process

In teaching 3D modeling and digital fabrication, however, it is expected that the student engage the media, and explore its possibilities in relationship to their work, regardless of their existing practice. This always starts with learning the modeling software but is expected to end in the "physical" as bringing the object to fruition is our "imperative."

The initial training is based upon the **form•Z**-modeling tutorial to introduce the depth of the interface and the hundreds of tool and modifier combinations. In our semester long courses we work through the entire tutorial which gives the students not only modeling skills, but presents the tutorial as a reference source when they run into a visualization issue that is unfamiliar.

The "creative" process begins at this same time with ideation and exploration via simple "visualization", or a definition of form. This simple process allows them to explore the compelling forms that can be rapidly realized with digital modeling, while learning the software and adding to their visual vocabulary. Modeling enables them to see new things.

Figure 6: Maquette: The "Stellated Landscape" was developed while working directly in **form•Z**.

Artist's Statement: "There were certain parameters and personal rules afoot when creating this object. Informed from previous work, I wanted to stress experimental process over refined result. The object should work in concert with future objects, in order to chisel out a visual language, which bridges and makes oneself aware of the space between visual language to mathematics. Escaping the conception that mathematics is cold and sterile, and understanding it is a government within the poetry of visual language. RP Gypsum, found figure, wood.

Figure 7: **form•Z** model, Nathan Meagher; Sculpture “Mining.”

Figure 8: maquette,reflective of direct ideation in **form•Z** “Mining” was developed as a manipulated post “unfolded” form. RP Gypsum, wood.

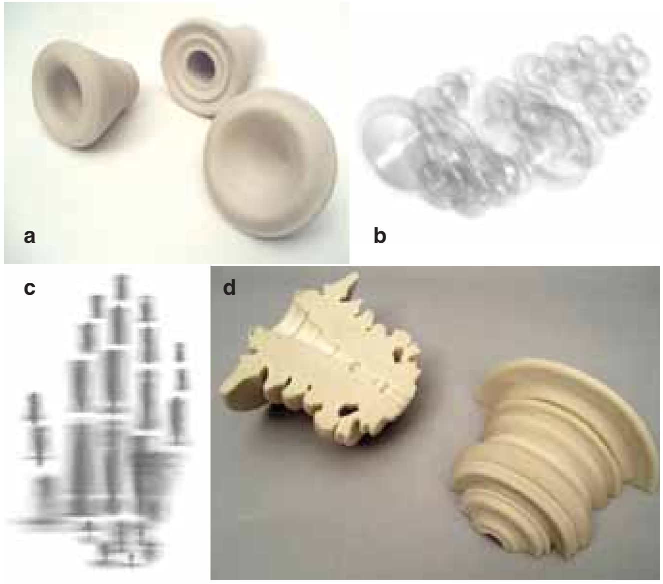
Predetermined Visualization

This typically leads to the illustration of objects that already exist or have been sketched out in some detail. This applies the techniques learned in the tutorial instruction while requiring the students to seek out the best tools and process to represent their objects. They soon realize there are probably a half dozen ways to create each element of an object and how their determination of the best approach will effect later steps in the modeling process. Part of this learning process includes many starts, stops, and “re-do’s.”

This requires the student to exercise their manipulation of the application and seek solutions to modeling problems rather than letting the modeling tools dictate form.

Exploratory Projects and Ideation

Finally there is pure exploration within the software. Essentially “direct ideation” or trying to work the digital like a plastic material. This amounts to “messing around” within **form•Z**, based upon the understanding acquired in the earlier training, while often incorporating “digital found objects” and 3D scanned elements. This extracts them from the designed intent of the tools and application to explore beyond these “planned” limits. To explore without constraint.



Figures 10: Furniture Designs by Claire Moyle.
(a), (b), and (c) “Phalanges Rotations”
This work shows the development of form that would probably not happen outside of the computer. Claire generated rotated forms based on x-ray images of her hand.
Z Renders and RP objects.
(d) “Cervical Organ”
Rotated sections of Claire’s cervical vertebrae from x-rays.

Figure 11: Rubber Stool by Steven Mullenbach; Stool modeled as “built” in **form•Z,** including all joinery, then CNC cut on the Techno router. The cushion was cast of urethane rubber in a mold modeled in **Z** and machined on the router.

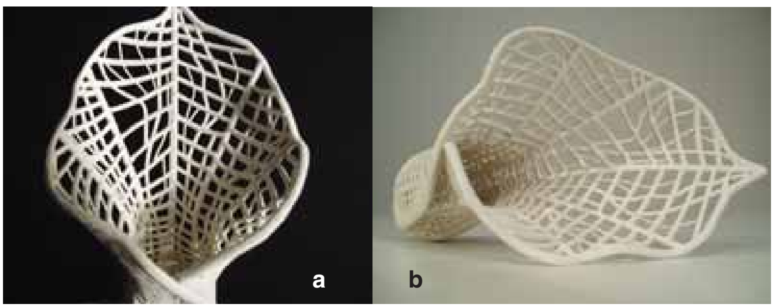


Figure 9: Matthew Hayes: Interpretation of an Iris’ vein structure. RP Gypsum.

By this time the students are confident enough to act intuitively and "mis-mix" tools exploring what can actually "happen" in a "virtual" 3D world and what can become "real". The ultimate and simple functional test of these explorations is generating a physical object using one of our RP or CNC machines. A machine, after all, can only accept proper file formats and "real" objects.

Building in form•Z

As our students are already experienced makers, we can teach them to model as they would "build". Simply meaning that they are taught to "fabricate" in 3D rather than simply "visualize"; they are "making" a virtual object not "representing" it. This seems like a natural translation from the studio process and incorporates the needed information to realize the work into the modeling stage.

"Building" or "fabricating" in 3D implies the application of their understanding of materials and process gained from studio practice, while exploring the enhanced forms made possible through 3D modeling. For example, it is not considered adequate to simply model a sphere, but that they ultimately define its fabrication in their modeled work. What material or process they define, from sheet metal to composite construction, is of little consequence as long as they specify the true material and reflect process in their final design stage. This includes issues like material thickness, consideration of structural capability, assembly systems, etc.

Modeling in **form•Z**, as similar as it is to actual fabrication, then becomes a "planning" tool in the processes of fabrication that translate directly to the objects creation in either the traditional studio or in our Digital Fabrication lab.

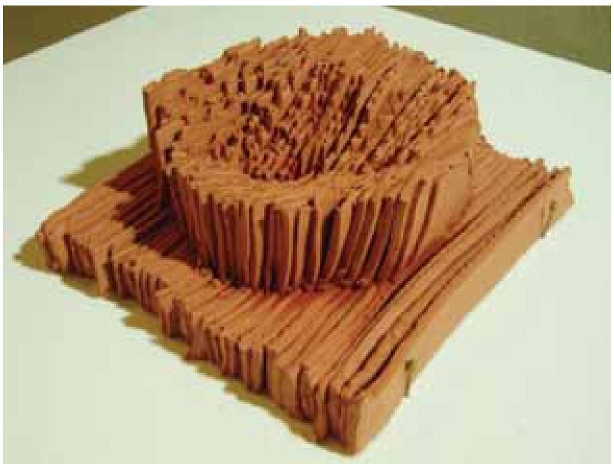


Figure 12: Sculpture by Caleb Coppock: "A View From Above." Mining Data: One of the objects from a series. It was generated by the displacement of data "found" on the Internet. The object itself was formed of layers of laminated clay sections cut from contour slice patterns of the model.

Figures 13: Furniture Design: "Wally's Chair" by Nate Moren. (a) **form•Z** rendering of the chair model. (b) OSB panel on the CNC router after cutting the sections for one chair. (c) Stack lamination: OSB components assembled on the laminating jig. (d) Two of the finished chairs.

"Wally's Chair" was modeled and rendered in **form•Z** including the steel rod legs and mounting system. Contour slices from the model were extracted as cutting lines for the CNC router to make the OSB stack laminated sections. These were then laminated on a forming jig, hand finished, and assembled with the integrated steel legs.

They are challenged to search for form possibilities that might be tedious, difficult, or even impossible utilizing traditional studio processes, while maintaining a focus on the conceptual issues of the work.

Object Translation

While the fabrication or "creation" of an object on a rapid prototyper has become as easy as color printing (all one needs is a "good" STL file that fits in the "build" area of the machine) it does tend toward the glyptic object and is limited in scale and structure. The result tends toward the maquette, "precious" object, or smaller "components" of a work. To expand to "real" materials and larger scales requires either the application of traditional studio skills, access to larger scale CNC equipment or, most often, both. To translate larger projects to traditional studio techniques, while maintaining the accuracy of the design model, we often use the **form•Z** Unfold, Contour and Section tools to generate patterns. These can then be scaled to size and printed on one of our banner printers, or projected to size and traced (even directly onto the materials). These patterns are then used to generate full-size cutting patterns, traditional sheet metal patterns, and traditional "lift" sections for solid objects eliminating a considerable amount of "layout" time.

Figure 14: "A View from Above" sculpture by Caleb Coppock. Four of the **form•Z** displacements from digital images "found" on the Internet. Painted and printed wood, RP Gypsum, machined acrylic.

Mining DATA: From the Artist's statement:

"My works are part of a tiny sculptural series titled, "A View From Above". The elements of the project consist of many small, sushi-size works in wood, plastic, paint, and gypsum. I am exploring our contemporary perspective on the world around us and imagery's influence on how we frame our landscapes.

The process starts with finding imagery on the internet that deals with visual depth and perspective. Examples include color wheels, optical art, elevation data, and satellite imagery. **form•Z**'s image-based displacement tool allows me to quickly map visual information onto the surface of a three-dimensional model. From these literal transformations into real space, forms emerge as part of a strange lexicon of landscape hors d'oeuvres.

The models are created through rapid-prototype printers and desktop CNC machines. They are arranged alongside small paintings and sculptural works that act as parts to a re-mixable whole. The "A View From Above" series seeks to explore the vastness of visual information available in today's world by cropping in tightly to various fragmented bits."

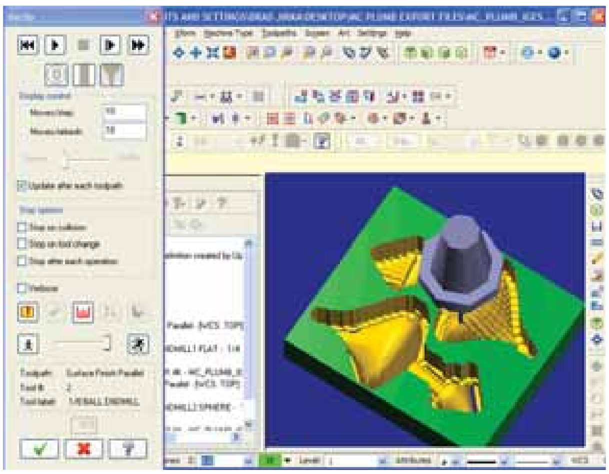


Figure 15: MasterCam toolpath verification showing virtual machining animation.

Of course cutting components, or "carving" 3D forms, on a CNC machine eliminates even that step and facilitates the generation of complex or repetitive forms. The generation of digital forms on a CNC machine requires simply the correct file format if one chooses to use contract shops.

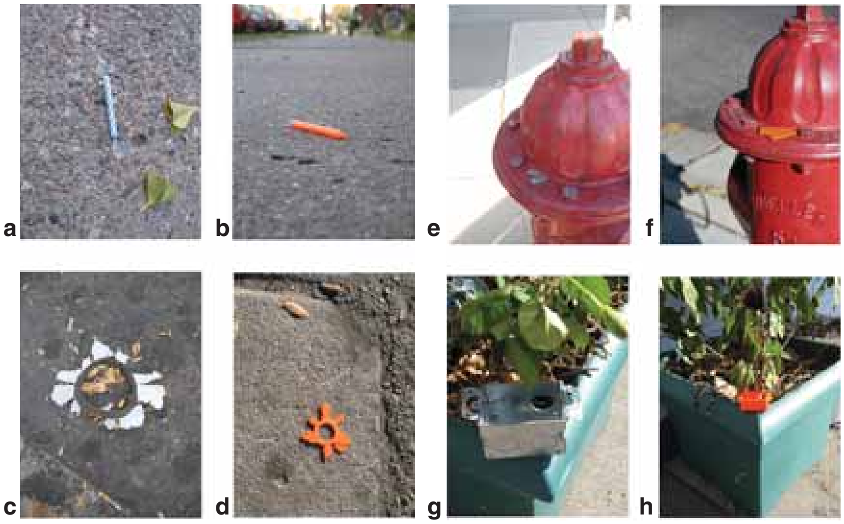
The use of an in-house CNC router does add another layer to the learning process but its complexity is dependent upon the machine and software choices. Within our own digital fabrication lab the machine requirements range from "drop and build" for the Zcorp rapid prototyper, and nearly that with the Roland Modela, to the Techno router that demands some knowledge of computer aided machining techniques and general machining processes including machine set up, bit selection, and feed rates relative to material and spindle speeds.

Figure 16: "Chickens" sculpture/installation by Nathan Meagher. The "Chickens" spoke to Nathan's impressions of flocking and consumption. Modeled in **form•Z**, the original model was halved, carved on the CNC router, laminated with a steel base, and used as a vacuum form mold to produce the "flock."

To translate a file from **form•Z** to a CNC machine, whether you do it or it is part of the out-sourcing of the work, also requires "deconstructing" larger forms to fit the machine parameters and the use of a CAM software package to generate the machine control toolpaths.

Deconstruction and Preparation

There are physical constraints and process limitations that must be considered in the preparation of a "model" for fabrication, preferably during our digital "building." The machine constraints primarily include envelope size including "depth of cut" and, therefore, overall depth of the object; while the process on a three axis machine is limited to 3D machining in a "relief" like mode (i.e. from one side) or 2D "cutting." To fit the machine constraints, larger objects must be sliced into contoured "lifts" while multisided objects are often divided in half (or a "flip" fixture employed).



Figures 17: Sculpture/installation "Found Object Displacements" by Anna Kaiser.

(a, b, c, and d) Displacements 1: Candle and crushed plastic form; original objects and RP placements (orange)

(e, f, gt, and h) Displacements 2: Plastic scrap and electrical box; original objects and RP placements (orange)

Anna recreated found objects in **form•Z** and fabricated them with MCAD's Zcorp Rapid Prototyper. These objects were then placed in their original environment. Objects are painted RP Gypsum; Images are digital prints.

Machine Files

While there are again choices in software, even allowing a "drop and build" approach, at MCAD we adopted Mastercam to generate machine code. We chose Mastercam as it is an industry standard and would run any machine we elected to add to the lab in the future. Aside from importing a number of file formats, it allows us to generate "virtual machining" animations to "proof" and ensure the student generated toolpaths while generating the required toolpath files for our specific router. (Mastercam also includes full model building capabilities which we rarely use as we are avowed Mac and **form•Z** users.)

Once the students have an understanding of **form•Z**, the use of Mastercam has proven to be a simple step for them within structured guidelines. There are a considerable number of variables that we have yet to fully explore but our students have been able to explore these themselves.

The Product

The students apply their modeling and fabrication skills to such diverse ends as commission and competition proposals, product rendering, maquettes, idea development, studio and production furniture, sculpture and installations. While our goal is to impart to them the processes and techniques of modeling and digital fabrication, our expectation is that they absorb them into their production vocabulary and the creation of their individual work as they might any other process or technique, and be conversant in the media.

Our program is not about imagined results but real results. The students' digital fabrication experience offers additional options to realize their vision and, indeed, reflects a new ability to "see."

But it always comes back to the balance of concept and execution…not letting the process limit the idea nor let the idea succumb to the process. Our goal is to produce what we envision, what we see, and expand upon the nature of our work as artists. For us, digital modeling and fabrication is not an end but, rather, simply a means. It is its application as a tool, in research and fabrication, that entices us the most.

It is also our hope that our students continue to realize some things are better made by hand…

References

[1]. Digital modeling for Fabrication; Brad Jirka; **form•Z** Joint Study; 2004.

[2]. **form•Z** Joint Study Student Awards, Fabrication; Dan Tesene; 2005.

Brad P. Jirka is an Associate Professor of Fine Arts at the Minneapolis College of Art and Design focusing in Sculpture, 3D Computer fabrication, and Foundation Studies. In addition to 30 years of teaching studio arts, Jirka's professional history includes working with the collaborative group "Midwest Electric Art"; co-founding the American School of Neon; and VP of Design for St. Elmo's Inc., an internationally recognized producer of creative lighting. His current studio works focus on the tradition of the Philosophical Instrument while becoming objects of "modern mysticism". These works "explore and discover" the phenomenology of our environment while his Public Art Works, with collaborative partner Katherine Jones, strive for the creation of an "event" often incorporating light, motion, and technology. Recent public works include "Lax Communica" for UW LaCrosse and "Geometrica Kinesic" for UW Parkside. Studio: Bohemiawerks.com