Department of Fine Arts: Sculpture and Funiture
MINNEAPOLIS COLLEGE OF ART AND DESIGN
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Digital Modeling for Fabrication

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At MCAD the creative process always seeks a balance between concept and execution. Within the Sculpture and Furniture programs this approach results in students that are skilled makers creating works that reflect a conceptual understanding of the concerns of the object, space, content, and context.

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.

Modeling in **form·Z**, as similar as it is to actual fabrication, eases the transitions between the digital and the real. As the student works more within **form·Z**, it becomes a learning tool in the processes of fabrication translating directly to an object's realization in the traditional studio. Five years ago we added computer aided digital fabrication as the next natural step.

This past year our primary fabrication focus was within the course "Objects and the Computer". This class is designed to explore the possibilities and impact of computer modeling on the design and creation of 3D objects and environments.

In conjunction with MCAD's rapid prototypers, the students are challenged to search for form possibilities that might be difficult, or even impossible, utilizing standard studio processes while maintaining a focus on the conceptual issues of the work. This encompasses not only the creation of objects with our Rapid Prototype (RP) equipment but the access to other production processes through "job-shops" enabled by computer design.

PROCESS

Our training in computer modeling is threefold: Visualization and presentation skills, computer aided design, and computer enhanced creativity with output ranging from patterns through 2D renders to physical output and animation.

Tutorial: The first step is instruction 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 to look back upon when they run into a visualization issue that is unfamiliar. In workshops, or intensive short courses, we present a similar process to the tutorial but limited to key techniques and the major modeling tools.

Predetermined Visualization: Our second step is to illustrate 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 "redo's".

Exploratory Projects and Ideation: The third step is pure exploration within the software; essentially ideation directly with the computer, utilizing the special capabilities of **form·Z**, to generate un-thought of forms or non-predetermined objects. The students are urged to create works that are too tedious to manufacture by hand, or simply cannot exist outside of the computer or be realized without "building" with a rapid prototyper. This amounts to "messing around" within **form·Z** based upon the understanding acquired in the earlier training steps.

By this time the students are confident enough to act intuitively and "mis-mix" tools just to see what will happen. The ultimate functional test of these explorations is generating a physical object using one of our RP machines. A machine, after all, can only accept proper file formats and "real" objects.

HONORABLE MENTION IN FABRICATION

Shanty Town by JESSE GANTENBEIN, Furniture Design
Infiltrated and assembled RP gypsum.

ALSO SEE PAGE #14.

Modern 3D Printers (Additive Rapid Prototype systems) are not much more complicated than a typical flat printer from the user's standpoint. Equipment maintenance can be an issue but even this has been greatly simplified in recent years and similar to a complex copying machine. Subtractive Rapid Prototype machines (SRP; routers and machining centers) require more experienced "setup" and operation including bit selection, material mounting, and cutting parameters simply due to their machining process. Even so many of these machines are approaching the simplicity of a 3D printer.

AWARD OF DISTINCTION IN FABRICATION

Teseneossils by DAN TESENE
Sculpture / Fine Arts Studio
Infiltrated RP gypsum.

ALSO SEE PAGE #14.

This work is about the "building" of complexity; understanding how complex systems come to exist. While algorithmic in nature, Dan develops the objects using a visual and intuitive process in form•Z. He creates an initial modular form that is then multiplied and stacked using form•Z transformation tools. A section of the model is then "deformed" as a group of elements. The groups are then copied, mirrored, transposed, and composed, resulting in the objects that are generated in our 3D Printer.

Most algorithmic artists assume that the works are generated via programming code rather than a direct manipulation by the artist. While this direct manipulation may not be possible without the "invisible" algorithms within form•Z, it demonstrates the artist's use of "computer as tool" rather than primary programming. The artist's focus is on the creation and composition of the object rather than the technical aspects of its generation.

Additive Rapid Prototype Modeling Concerns: Most 3D printers use an .STL (Stereolithography) format file. This format is a list of triangular surfaces that describe the solid model. As a result, all objects must be "closed" or "capped" so as to be solids and "watertight" STL files. This also precludes the use of surface modeling.

It should also be noted that, as STL files triangulate facets, they interpret "smooth objects" as facetted, hence a smooth object will revert to a facet setting based upon its "resolution". As a result, we usually model as "facetted objects" of higher resolution to begin with.

Viewing models in "surface render" will give you a better idea of what they will look like from a RP machine.

Hollow forms: We hollow out all of the more massive areas of our objects to reduce solid volumes that cost us more (our in-house RP "build" cost is based upon weight while job shops generally base cost on time. Elimination of unnecessary bulk reduces both). This is accomplished by "Boolean differencing" smaller copies of the individual elements from their original objects or removing geometric solids. For our machine we try and maintain a 0.125" wall thickness.

Negative molds: Hollowing also enables the students to generate molds directly from our Z-Corp Rapid Prototyper in gypsum. We have successfully cast everything from plastics and low temperature metals to bronze into un-infiltrated molds. The molds are created by differencing the object from a solid block then adding needed sprues, vents, pour cups and lightening holes. We let the mold dry thoroughly then cast using standard practices. (Z-Corp also produces a refractory gypsum material for casting.)

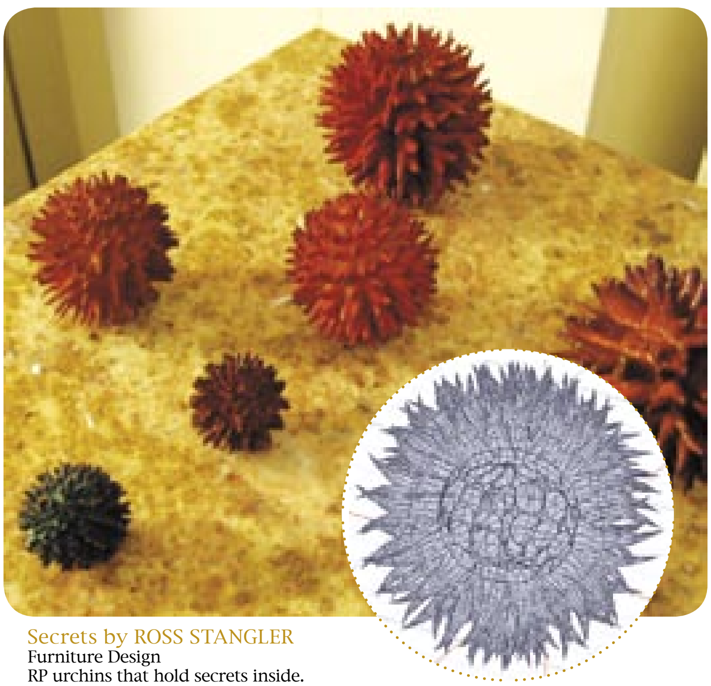
"Testing" the STL "build": We initially use the "Query" tool to check that objects are "facetted", "solid", and "well formed". We then export the models as a STL file and reopen the STL file in **form·Z** to check for lost elements (but do not "re-save" the file to leave the exported file intact). We also check the preview in the STL format "options" dialog but have found that some things visible there are not always visible in the final file.

Modeling for Subtractive Rapid Prototype (SRP): Many SRP machines come with software for translating DXF or other file formats to machine code to create tool paths. Other translation software is readily available and the translation has always seemed effortless and reliable. In house we use software that was packaged with our three axis Modela machine while we generally send DXF files to job shops.

ANDREW JUNG
Fine Arts Studio
A typical RP mold (whose base is its casting).
RP gypsum and plastic.

Structure and Decay by TONY SUNDER
3D Foundations
Painted infiltrated RP gypsum.

Chair by BRANDIS CONROY
Furniture Design
Cast from an RP gypsum mold. Crown pewter.

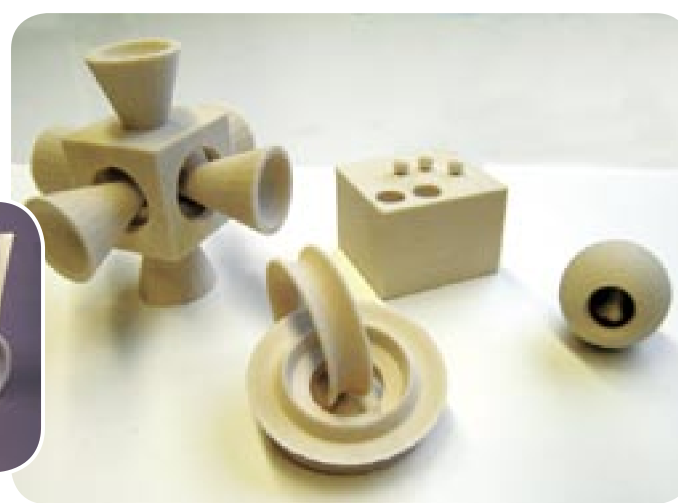


Secrets by ROSS STANGLER
Furniture Design
RP urchins that hold secrets inside.
Surface finished infiltrated RP gypsum.

Cutting file formats: When sending work to job shops for 2D router, laser, plasma, or waterjet cutting, the typical format is a vector line drawing. The shop will be able to tell you their preference as to software. We typically use Adobe Illustrator files, 2D drafting programs, or **form•Z** draft files saved to vector or Illustrator formats.

Digital Patterns: Low cost and machine free! Other fabrication techniques that we find entertaining, simple in **form•Z**, and "machine free" are: "unfolding" of facetted models, generating "sections", and generating "contours". These are then scaled to size and printed on one of our banner printers (or "tiled" in a standard printer) to generate full size sheet metal patterns and traditional "lift" sections for solid objects.

Bench by JESSE GANTENBEIN
Furniture Design
Render and finished full scale from patterns.
Composite fiberglass and wood.



Mystery Objects by JOE LINDEBERG
Furniture Design
Independent but trapped elements inspired by Chinese Mystery or Puzzle Balls.
Infiltrated RP gypsum.