Function Follows Form: 10 Sticks (and a Bench)

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Abstract

While the introduction of digital media in the design studio often emphasizes virtual realms, the effect of new fabrication technology on the architect brings the architect back to the realm of master-builder rather than distancing the architect from reality. While purely digital projects have pushed the development of form, they have also placed an emphasis on form over material. However, with the intention to physically build a project, the connections between process, form, and material become intertwined.

The inception of this project also served as a clear reminder that the tools we use affect the way we think. This project began as a simple idea: how a column becomes animated to form an arch over time. The digitization of this idea took literally minutes in Maya. It was exported and further modeled in AutoCAD, and then rendered and reanimated in 3D Studio-Viz.

This was a very brief, two-week introductory project, in a class on drafting and wood light-frame construction. It served to make a greater connection between digital media, the design process, analog drawing, and the role of craft and material.

“The idea becomes a machine that makes the art.”
-Sol Lewitt

“There is a growing appreciation of new abstractions. Increasingly, computers let us treat abstract relations as visible, working things.”
-Malcolm McCullough
1 Introduction
While the introduction of digital media in the design studio often emphasizes virtual realms, the affect of new fabrication technology on the architect brings the architect back to the realm of master-builder rather than distancing the architect from reality. While purely digital projects have pushed the development of form, they have also placed an emphasis on form over material. However, with the intention to physically build a project, the connections between process, form, and material become intertwined. As schools scramble to dedicate massive funding for specialized equipment for 3D Printers and CNC milling machines, this project presents an alternative. This project was a very brief, two-week introductory project, in a class on architectural practice dealing with drafting and wood light frame construction. While the class was typically based on an average suburban house, this project served to make a greater connection between digital media, the design process, analog drawing, and the role of craft and material.

The inception of this project also served as a clear reminder that the tools we use affect the way we think. Taking a clue from Sol Lewitt’s statement that “the idea becomes a machine that makes the art,” (Lewitt 369), this project began as a simple idea: how a column becomes animated to form an arch over time. Though simple, the conceptual idea took the longest to germinate, and would have been inconceivable to me without my prior experience with Maya. The digitization of this idea took literally minutes in Maya, was exported and further modeled in AutoCAD, and then rendered and reanimated in 3D Studio Viz. The decision to build at full scale only emphasized that the design process and the fabrication process are inseparable, a conclusion that would not have been reached without actually building. The following account describes the connection between process, form, and material in the development of this simple project, and concludes with several significant, yet unexpected outcomes of this process.

2 Design Process – Digital Tools & Transferability
While the plausibility of such a simple idea came from Sol Lewitt, the potential value of the idea came from Malcolm McCullough: “computers let us treat abstract relations as visible, working things” (McCullough 28). In this case, the relationship is between the visible transformation from column to arch over time. In addition, the computer allows this visible relation to develop as a flexible system. Rather than approaching the computer as tool for production of a preexisting idea, digital media in this case can test an idea and develop a working system to fabricate that idea.

While AutoCAD was used to translate the conceptual line to a solid model of a stud, Maya was essential in laying the conceptual groundwork and exporting these results into AutoCAD. Due to the simplicity of this example, 3DS Viz was used only for rendering and reanimation. Without my basic understanding of Maya, I would neither have conceived nor been able to test the conceptual idea that this project was based on only emphasizing that the software we use affects our thinking.
A rough draft was quickly developed testing the idea in Maya and then the process of transferability between Maya and AutoCAD. The idea was first tested with the most basic of animations—the first key frame with a vertical line and the last key frame with the modulation of that line into an arch (Figures 1 and 2).

An animated snapshot was created to fill the gaps between the first and last keyframe—a process commonly referred to as “tweening.” While I could have continued to bring form to these lines in Maya, it was more efficient and accurate to export them into AutoCAD and give them volume there.

From this first draft of the process, two concerns came up: first, how many pieces are necessary to complete this idea, and second, what material would be used to fabricate this? In regard to the first concern, I knew I would have between 15-20 students, so I simply ran the animated snapshot twice, once with each student having his or her own stick, and once with one stick to two students. The number of sticks, about 10 or 20, did not affect the clarity of the idea, and therefore I decided that it was more appropriate to have each stick fabricated by a team of two as this would reduce cost and facilitate the fabrication process with one student on each end of the stick. As this was tested in a class on drafting and wood light frame construction, wood was the obvious material. The literal transcription of the idea from column to arch resulted in a series of free form curves that could have easily been fabricated in plywood with a CNC milling machine or full size template. However, there would have been a significant cost and waste of material associated with this literal transcription, nor did I have access to a CNC machine. Using a 2x4 would be far more cost effective and form a stronger tie to light frame construction, challenging the accepted uses of the ubiquitous 2x4 stud or “stick” found on every wood light frame construction site. With this choice to use a 2x4, the project took on added value in expressing how material affects the choice of form, but can still maintain the conceptual idea. In my view, this made the project more interesting, not less. It was at this point that I decided that this idea was worth pursuing as not simply an exercise in building form, but in how process, form and material can be manipulated to test an idea in full scale.

Following from the rough draft, the above process was then recreated with the introduction of scale into Maya. This was achieved simply in AutoCAD by drawing a 7'-6" line for the first stick, and an approximately 30'-0" line for the animated path, and then imported into Maya. The animation was re-created as above, including the animated snapshots. The next significant step in the design process was to manipulate these free form curves to be fabricated from a 2x4 (Figures 3 and 4).

One of the significant features of Maya is its ability to “rebuild” a curve or surface. Each animated snapshot could be rebuilt in Maya as a system of segmented lines, but what criteria would I use to rebuild this line? As I had decided above that a team of two would fabricate each stick, it became natural to then evenly distribute the pieces between each student. I tried a few variations between 4-8 pieces. However, once seeing these
results, I realized it was not the pieces themselves that were difficult to fabricate, but the connections between the pieces that were significant. Therefore, I decided that each stick would be composed of five pieces, with a total of four joints (two joints for each team member). While in word this may seem cumbersome, in actuality this was a five minute process with the conceptual model in Maya and only reiterated the connection between design material and fabrication. These rebuilt lines in Maya were again exported to AutoCAD and then scaled so that each stick was precisely 2'-0" on center. The lines were then offset, joined, and extruded to the precise dimension of a stud.

Concurrent with this digital process, a full size mock-up of the joint was developed to create a seamless connection to maintain the continuous appearance of a single stick. With the help of a tenoning-jig, a simple glued spline joint was able to make the connection without exposed fasteners and was unaffected by the multiple angles of each piece.

At this point, despite my emphasis on testing ideas, form, and material, I must admit I was aware of one major limitation but had not yet tested it: how would this thing stand? Concerned with deviating too far from the intentions of the class syllabus, I considered simply anchoring these pieces to the grass quad via foundation form spikes. (Figure 5).

Yet, the reliance on another surface for stability seemed to weaken the simplicity of the idea, to say nothing of a statically problematic structure on public display. Naturally I was trying to find some integrated element that would make this structurally static and freestanding. The introduction of function, a bench, solved this problem and presented another unanticipated outcome: the reversal of the iconoclast belief that form follows function. In this case, literally, the function served to support the form. The bench was then simply and conventionally conceived and modeled in AutoCAD.

This 3D model was then imported into 3D Studio Viz and rendered with simple mapped materials and then imported into Photoshop for photomontages in situ (Figures 6 and 7). A conventional animation was created in Viz to go full circle from conceptual animate form to an animation of the final product. This entire process from animated design concept, development, and final animation was combined as one brief animation and played on the first day of class as an introduction to the project.

### 3  Fabrication Process

On the second class period before the fabrication process began, we met at a local lumberyard. This was an opportunity to present the many different products in wood light frame construction, but moreover an opportunity for the students to select material free of defects and deformations. As their first
The first step was to make drawings for fabrication, it also reminded them of the material that they were representing on paper. Fortunately, it also gave the lumber time to acclimate in the shop.

While the design process was purely digital, the fabrication process followed more traditional means. The first step in this process was developing what were effectively shop drawings. For many of these students, the lines drawn for this project were the first “hard lines” they have ever drawn. From an analog view, the fact that these drawings were in essence shop drawings emphasized that the lines we draw have a direct correlation to what gets built. It also addressed the issue of clarity and legibility through density of lines necessary for making multiple reproductions, particularly necessary to keep the original vellums out of the messy shop, all necessary skills to fulfill the drafting requirements of the syllabus.

Each team of two was given a line drawing from AutoCAD, which indicated the angles of each joint and was plotted to 1/4” scale. Considerable effort was placed to ensure a uniformity of appearance, a reproducible legibility, and certainly accuracy in these drawings. While craft in drawing was emphasized, craft in the fabrication of the parts was emphasized with four required “general notes.” The 2x4 had to be planed to 3 3/8”x1 3/8”, joints were to be made from a 3” spline joint sanded smooth, the grain must be continuous along the length of the stick, and finally there was to be no exposed glue on the surface of the stud (Figures 8 and 9).

While these steps may not seem relevant to a digital process, what did surprise me was that through the drawings students took ownership of their stick. Each team of two was very particular about their drawings, and it was very interesting to watch the perceived difficulty of the stick as it became more arch like, even though each stick had exactly the same criteria, only the angle and dimensions changed. Before we went to the shop, all of these drawings were pinned up in studio to see the progression of all the sticks, emphasizing collaboration and coordination.

The equipment used to fabricate this project can be found in any wood shop: a planer, a miter saw, and a table-saw with tenon jig. The planer was used to set the material to the precise dimensions. To ensure uniformity, all materials were planed at the same time to ensure consistency in dimension. There was some general confusion in cutting their first angle in the compound miter saw, but after that, the cuts were made easily (Figure 10).

The table saw was set-up with a dado blade to the precise depth and width of the spline joint, and a tenon jig was set to center the joint (Figure 11).

Finally, each team was given a set of 1/2” plywood splines, which were then glued into the joint, and cut to fit after the glue was dry (Figure 12).

As much as there was a transfer of ownership in the drawing of the stick, there was a much greater pride in the actual craft and fabrication of their stick. The finish criteria in the “general notes”
Figure 10. Miter Saw

Figure 11. Table Saw with Tenon Jig

Figure 12. Spline Joints

Figure 13. Finished Project
an avid surfer, realized that it also had unintentional symbolic form (Figures 13-16).

4 Conclusion
While I am aware of the irony involved in creating shop drawings for a process alluding to digital fabrications, the significance of this project is that in building accurately from the digital environment, the connection between process, form, and material becomes intertwined. The project was conceived to display the connection between digital media and craft. As a built thing, its roll of "display" in the public realm was significant on two fronts. For the students, it made a greater impression about the role of craft, and more broadly, emphasized the
The project also tested the transferability of digital information across several different programs through their ability to test ideas, transpose that idea to scale, and represent the idea before its actualization.

Sol Lewitt has remarked that the work of art can only be perceived after it is completed (Lewitt 372). While I am not suggesting this quick study is a work of art, the beauty of the experiment is in the many unexpected outcomes as a result of building at full scale. As has already been emphasized, this project emphasized the connection between process, form, and material. While in the digital virtual domain there has been an emphasis on form, with the integration of material in the process, an emphasis is placed on structure and connections. Quite by accident, this project questions the iconoclast relationship that form follows function. The result of this unintended polemical response is the necessity of a closer collaboration between form and function—in essence that form and function become one.

Above all, this project has illustrated the effect on the design process as a result of fabrication. While traditionally the use of digital media has emphasized form, the process of fabrication places emphasis on the tectonic qualities of architecture. Instead of fabrication being after the fact, the integration of digital media in design and fabrication develops a possibility for the return of the architect as master builder.
References