Digital Design and Making
30 Years After

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Abstract

Current design studio pedagogy is undergoing significant change as the means and methods of ideation, representation and making evolve with digital tools; Computer-Aided-Design-Computer-Aided-Manufacturing (CADCAM) remains a contentious topic among many studio instructors and faculty in the academy. Computing is now nearing ubiquity; many processes and products have seen significant evolutionary trends, if not revolutionary transformations; this is no less the case in the academic and firm design studio. The impact of “digital” media and CADCAM, in the design-make process, remains obscure and formally unknown.

In this paper, we will review our research and findings from the work of three students; two current students who were in our Digital Design II (DDII) spring 2006 course and the third student, the writer, will reflect on “design and making” from a “pre-architecture” and pre-studio/pre-computer (CADCAM) perspective of ‘making’ thirty-three years ago.

The research findings provide universal precepts pertinent to current thinking about emerging studio pedagogy. Our findings suggest that computing technology should be introduced at the outset of design education for the beginning student in basic design studio; and moreover, advanced designers can partner with “digital” tools to ideate and realize their, heretofore unrepresentable and unconstructable, ideas in the early stages of design using CADCAM.

Introduction

A brief overview of our forthcoming journey is as follows; in section two we will briefly look at recent context of CADCAM and studio pedagogy. In section three, we will outline the research problem and methodology as well as our hypothesis. In section four we will provide a comparative overview of the design-make work. In section five, we will conclude by providing an analysis of our evidence and observations; with a recap of the key-points of our findings and review the evidence that substantiates our claim. Now let’s review the context of design and making in architecture.

Background and Context

In ancient architecture, design and building were typically a seamless process where the master-builder was usually on site and worked directly with 1:1 layout and his fellow craft-persons who “made” the building. Two-dimensional drawings and three-dimensional physical models were used minimally and the act of design was interwoven with the act of constructing. It was not until the 15th century that we begin to see the slow breakdown of the master-builder and craftsman guild system
(Kostoff 1978); resultantly, the designer was slowly isolated from the act of crafting and making the physical artifact (i.e. the building). Hence, during the Renaissance, conceptual thinking and representation began to be seen as something separate from the construction of buildings, consequently, perspective drawing and representational techniques evolved as a means of design exploration and communication of design “intent” to the remote “builders”.

Visualization and Representation Phenomena

In the mid 1990’s, we have seen the computer impact the process of architecture in the area of 3D modeling and “visualization;” however, this 3D phenomena, until very recently, has generally been confined to “marketing” presentations in the form of renderings and animations.

In architecture, most design studios have remained isolated from the computer, typically using 2D free-hand drawings on traditional paper-based media. In practice, we now see many firms embracing 3D modeling and Building-Information-Modeling (BIM); however, generally, the adoption of these emerging 3D modeling tools, in the early phases of design, are not transformative of form; Rather the emerging 3D tools are being used to replicate the earlier forms and techniques used in past design processes via traditional 2D physical media. So, one can say, as we saw in the mid 1980’s to 90’s, where we saw 2D digital graphics simply replace paper graphics as a means of production and efficiency, we are now seeing 3D digital models simply replace the former 2D paper processes in the studio.

In fact, in the emerging context of digital adoption of 3D modeling tools, many claim the computer is a hindrance to creativity and sensitivity to space and place (Gehry 1999 and McCann 2004). However, some have claimed the computer as not only a visualization and making “tool,” but rather, also a design “partner” in form ideation and conceptualization (Lynn 1999; Barrow & Mathew 2005).

Dimensional “Thinking” – 0D to 10D

In our recent pedagogy and research, we have developed a language for the communication of representational “thinking” relative to technology and “Dimensions” (D). The following diagram depicts our earlier representation of
the interrelationship of the “D’s” and design thinking (see Figure 1 - Barrow and Mathew 2005).

For the purposes of this paper, we would like to frame the topic to focus on “design” ideation, exploration, and communication as related to the early stages of design.

The following chart attempts to expand on our earlier thoughts and writing (see Figure 1 above and Table 1 below). Please note that we have expanded the number of “D’s” from 8 to 11 to now include “operation” and “recycling;” we feel it is important to begin to map the comprehensive spectrum of the “virtual 3D model” and “holistic-life-cycle-management” now being purported by BIM (Building-Information-Modeling).

We see the emerging integrative holistic architecture process model that is Design-Build-Operate, and Green Architecture to be a natural evolution of technology impact in architecture (Barrow 2000). The use of BIG “D” and little “d” design nomenclature is a spin off of a paper by the writer (Barrow 2005). As we all know, the design process is incredibly complex, so much more so with the introduction of digital media, so there are admittedly holes in the above chart; but hopefully, it is an aid to our discussion and findings.

As part of our analysis, we mapped a non-CADCAM traditional media design process. Note the number of “design-process” steps not available (see Table 3).

Further discussion of animation, simulation, fabrication, construction and operation (i.e. BIM - Building-Information-Modeling), while a rich and significant area of emerging “D” design process, is well beyond the scope of this paper. In the following section we will review our research premise and methodology.

The Research Methodology

This section provides the framework for our research and findings.

The Problem

Thus far, most agree the computer has been a hindrance to creativity, sensitivity, tactility and experiential phenomenology (McCann 2004). Criticism of the computer in the design process has typically been in the following areas:

Hardware Barrier
Key-board + mouse interface – lack of digital dexterity
Software Constraints
Non-intuitive user interface – lack of
creative synergy
Unoriginal forms - Algorithmic bias
toward planar or primitive forms

Representational Bias
Undeveloped surfaces/spaces
with “realistic” material and texture
mapping

3D Virtual Model / Non-Tactile Output
Confinement of design ideas to
monitors - virtual images
Often confined to 2D plot media
(3D viz data reverted back to 2D)
Lack of 3D model physical feedback

Desensitization of designer from space
phenomenology
Separation of designer from
experience of Form / Space

Focus on Technology and not on IDEAS
Typically has not allowed ideation
fluidity in the early states of design
Memorization of students with
technology and not their design
solutions

Based on the above noted constraints
of technology in the design process, it
is not surprising that most schools of
architecture do NOT introduce students
to CADCAM in first (1st) year design
education. Further, many studio instructors
feel the introduction of the computer
is a hindrance to creativity, at any stage
of education and practice; other design
instructors more receptive to technology,
remain at best, open to the use of digital
design strategies in the mid to later years
of design education.

The Hypothesis

Our premise was that emerging digital
media, as a result of evolving hardware and
software (i.e. CADCAM), now provides
new possibilities for design pedagogy
and form-finding, both at the basic and
advanced design student levels.

The Methodology

We wanted to observe the means by
which designers, both at the formative
“fundamental” and “advanced” design
education levels, could engage emerging
digital design-make processes. The research
question of pursuit was, “Can design
students leverage digital tools for a fluidic
and iterative means of conceptual ideation
via CADCAM technology?”

Our Graduate Program Design and
Technology Emphasis Area, by conscious
choice of curriculum, is highly multi-
disciplinary; and we have students at all
levels of design and computing capability.
Digital Design I (DDI) is a prerequisite
for the DDII course; these courses, while
complimentary, are quite different. In
the first semester DDI class, all students
are required to do the same projects
for the development of fundamental
design principles and learning within a
digital framework. The DDI course is
driven by small incremental design and
technology assignments. These assignments
(typically weekly projects) interweave the
concept of “creativity, analytical thinking,
diagramming, 2D, 3D, and 4D digital
visualization as well as 6D fabrication
projects.

Contrastingly, the DDII course requires
each student to develop an independent
research problem, as well as congruent
learning goals relative to their design
discipline, current assessment of design
and technology weaknesses, and their
personal digital design aspirations. We find
this methodology provides a rich interface
of research, pedagogy, creativity and learning.

Our Digital Design II (DDII) course, in spring semester 2006, was used as the research venue. This work included collaboration with a high-technology automotive engineering research center (MSU Center for Advanced Vehicular Systems – CAVS, http://www.cavs.msstate.edu, Co-PI – Neil Littell) where a 30+ year old handcrafted wooden sculpture, made by the writer, was digitally scanned for “reverse engineering” of the object. For me, the instructor/writer, this provided a means of revisiting the past to gain greater understanding of what new technology means to the designer in the current context of digital design possibilities.

For the “beginning” pre-architecture student, the existing handcrafted wooden sculpture offered tangibility to the discussion of digital design and “Dimensional Thinking” as a means of engaging pedagogy. For the “advanced” design student, synergy of ideas occurred relative to studio presentations of all students work and pursuant discussions regarding “ideation” and “form-finding.” The following section reviews the digital design and CADCAM process for each of the three students; first, the two “pre-architecture” students, and last, the “post-professional” architecture student.

Making and CADCAM

In this section, we will review three student’s projects, 1) Larry Barrow, 2) James Johnson, and 3) Bo Zhao.

Basic Design – Brushes and Birds – Handcraft and Form Finding

The first student (the writer), was a first-year undergraduate student who had no art or studio training at the time of the project. The project was assigned in a freshman level Art & Humanities course as the semester final project. The design program, as provided by the instructor, asked the student to “build a model of a toothbrush.” On the final day of classes, of her 60 students, 59 showed up with various scaled “realistic” models of a toothbrush. The writer chose to abstract the idea of the toothbrush, with the intent of immolating and abstracting a bird form. The instructor loved it, gave a congruent grade of an A for the course, and said I would be a “good” architect .... one day.

I almost threw the much maligned, beat-up bird away several times. However, when faced with the pedagogical challenge of how to engage digital design with my student, with NO architectural training and NO design background, other than our prior DDI course in Fall 2005, I was very glad I had retained the “brush-bird”. I revisited what it was like for me, in a
similar position, to THINK about design (see Figure 2).

The above artifact was cut from the trunk of a juniper tree from my father’s farm, felled and hand-hewed, by the writer. Tools utilized were an axe, handsaw, machete, pocket knife, wood file, sandpaper, paint and paintbrush (i.e. archaic?). Hence, an all hands-on design-make process with no representation of form, or distance from the process of making. Rather, as in classical sculpting, the essence of the form lay with the block of material. The essence of the process was the “subtraction” of material, in an iterative design-make-design process to discover the already existing form. Thus, the interwoven partnership of man and matter, in a transformative process of the maker and material, revealed the form in a creative act of exploratory odyssey of the unknown.

The following uses the earlier discussed “D” dimensional digital design thinking framework to analyze and map the design-make process for the “hand-crafted” wooden sculpture.

Using our “D” dimensional design thinking framework as discussed in section 2 (see Table 1 & 2); we have attempted to map each of the three student projects for the derivation of design pedagogy principles. First, the “Brush-Bird” is shown; note the mapping shows the minimal levels of design-make process steps; similar to traditional artisan work – the act of “subtracting” the wood from the tree trunk exposed the final form; the “maker” was able to receive direct tactile and visual feedback from the hands-on making of the artifact (see Table 3 and Figure 3).

Basic Design – Shadows and CADCAM Form Finding

As mentioned, the primary focus of the DDII course is the pursuit of digital ideation and making in architecture using emerging technology. The second student, James Johnson (JJ), holds a Bachelor of Science undergraduate degree in Architectural Technology. This “technical” program offered the student a basic understanding of 2D AutoCAD and construction fundamentals. Hence, this pre-architecture student, prior to our program and DDI where we briefly introduced free-form modeling in a two week project, had no prior experience with free-form modeling or CADCAM physical automated output. Hence, James

![Table 3. Design Dimensions – Larry Barrow “Bird Sculpture”](image1)

![Figure 3. Design Dimensions Chart – Larry Barrow “Bird Sculpture”](image2)
does not understand the rules of design, how to do them, or break them (Eisenman 2006). Hence, this provided a rare opportunity to do “research” in the area of digital technology in the early formative phases of a new architecture/design student’s development.

The instructional challenge was to offer a learning experience that limited the necessity of prior education regarding architectural history and theory, as well as building construction techniques. Thus, our goal was to NOT do a building. The student chose to study “shadows” as a means of design inquiry. The instructor (i.e. the writer) established a design+technology exploration and learning framework sequence as follows:

- Observation of “shadows” in nature
- Observation of “shadows” in the built environment
- Observation of “shadows” in great works of architecture (interior and exterior)
- Digitized “wooden sculpture”
  - Project 1 - reverse engineering
- Diagramming “wooden sculpture”
  - Project 2 - Decomposition – observing the essence
- Virtual 3D model re-interpretation
  - Project 2 – Making JJ’s Bird
- Synergistic series of 5 – 4” Cube studies – virtual to physical output
  - Project 3 – 4” Cube Space Boxes

Figure 4. Project 1 – Digitized wooden sculpture – digital capture - (MSU - CAVS)

Table 4. Design Dimensions – James Johnson – Reverse Engineer Bird Sculpture

Figure 5. Design Dimensions – James Johnson – Reverse Engineer - Bird Sculpture
Figure 4 shows the Project 1 “wooden sculpture” reverse engineering process. Table 4 and figure 5 depict the mapping for Project 1 - reverse engineering of the “bird” sculpture.

The following images show the Project 2 diagramming and understanding of the essence of the “wooden sculpture”. Additionally, JJ’s reinterpretation of the “bird” in digital 3D virtual form is shown.
via his 3D Rhino model (see Figure 6).

3D printed physical CADCAM output from the virtual model were then “observed,” via photography (see Figures 7 & 8).

Table 5 and figure 9 depict the mapping for Project 2 – recreation of the “bird” form (see Table 5 and Figure 9).

The preceding CADCAM transformations were undertaken to provide the student with the understanding of CADCAM possibilities and to facilitate forthcoming creative exploration. As means of further exploration, the student was assigned a series of virtual to physical 4” cube exercises, each week offered a greater level of freedom and form variation, moving from “planar” to “curvaceous” shape & spaces (i.e. form) with a synergistic series of five - 4” cube explorations.

The student was given various “design” constraints, and “transformative” operations for the study of positive-negative space relationships, light shadows, and surface as a means of gaining in-sight to space and form. The following is a recap of the design constraints:

**Cube 1 = 4” x 4” x 4” - Exterior - Orthogonal / Interior - Orthogonal**

- (1/8” gaskets)
- Cube 2 = 4” x 4” x 4” - Exterior - Orthogonal / Interior - Orthogonal - (1/2” gaskets)
- Cube 3 = 4” x 4” x 4” - Exterior - Orthogonal / Interior - Obtuse - (any thickness gaskets)
- Cube 4 = 4” x 4” x 4” - Exterior - Orthogonal / Interior - Amorphous
- Cube 5 = 4” x 4” x 4” – Negative space of Cube 4 – transformed to positive form

Upon completion of Cube 5, the student was then requested to select an area of Cube 5 that might suggest an urban sculpture or architecture. The results of the cube exploration are shown in the following images (see Figures 10 through 16).

See Table 6 and Figure 17 mapping James’ 4” cube Space Box exploration. Notice the design exploration begins in 3D.

This concludes the overview of the “pre” architecture student’s project; in the next section, we will overview the digital design work of the “post” architecture student.

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**Table 5.** Design Dimensions – James Johnson – Recreated Bird Sculpture

**Figure 9.** Design Dimensions – James Johnson – Recreated Bird Sculpture
The third student, Bo Zhao, holds a professional degree in architecture and has worked for approximately two years in an architectural firm. Hence, this student entered the program with a solid understanding of AutoCAD as both a 2D and 3D design tool, as well as being proficient in Photoshop. However, other than the brief free-form modeling project in DDI, previously mentioned, Bo had no

Figure 10. Cube 1 - CADCAM output and student observation

Figure 11. Cube 2 & 3 - CADCAM output and student observation

Figure 12. Cube 4 - CADCAM output and student observation
prior experience with free-form modeling or CADCAM physical automated output. This section will analyze the advanced "digital design" process used by the writer’s student in a graduate level Digital Design II course. The student, Bo Zhao, entered our “post-professional” graduate program as a means of learning more about design, technology and architecture. This provided an opportunity to do “research” in the area of digitally driven form concepts. For the proposed inquiry, the student chose to use the “skyscraper”

Figure 13. Cube 5 - CADCAM output and student observation

Figure 14. Post Cube 5 – Bisected Sculpture + Space Form - student observation

Figure 15. Post Cube 5 – Bisected Sculpture + Space Form - student observation
as a means of exploration of digital form generation.

The Design Problem

For this inquiry, the student chose to use the “skyscraper” as a means of exploration of digital form generation. Each student was required to do research in their topic area of choice, this being done to gain insights from history as well as evolution into the contemporary context. The student was particularly attentive to architectural designers who are currently regarded as leaders in area of technology and “skyscraper” design (see Figure 18).

The Design Process

The student developed an understanding of the urban context and the issue of world population demographic shifts as we see a shift from agrarian to urban societies. The “skyscraper” was proposed, not unlike earlier “modernist” architects, as a response to transportation and the need for density for amenities offered in the urban context. Thus, the student initiated their representational strategies first in reading, thinking and writing in both numeric and text to generate 3D output. Thereafter, the student began a series of diagrams and sketches that depicted their progressive understanding of the “problem” and the “skyscraper” as an elemental system of core, floor, and skin (see Figure 19).

Please note that the student used marker or pencil on paper (i.e. traditional...
media); this particular student has a laptop computer and has tried an external “wacom” tablet; however, the student prefers the direct contact of hand-eye motor interaction of traditional media. About 50% of our students have PC tablets and are finding significant “comfort” with the digital “free-hand” drawing tools. This area of Human-Computer-Interface (HCI) is very important and will continue to have increasing impact in early ideation representation; however, this is beyond the scope of this paper. Most important to this discussion, we do not dictate any media to the student in the course; we offer a plethora of media, both traditional and digital strategies, for both 2D and 3D output. We feel this pedagogical position of using the advantages of “all” media to be empowering to the student. Additionally, from a research standpoint, we feel we must be open to all design and media strategies to be unbiased in our scholarly pursuit of digital design methodology. The student’s concept evolved into the abstraction of a “female-human figure” (see Figure 20). Pursuant to the 2D paper based media sketches, the student then
moved into the digital realm and generated a 2D “free-form” digital reinterpretation of the concept using Photoshop (see Figure 21).

The student then began another series of digital 2D diagrammatic studies using both line and colour as visualization aids in AutoCAD. Thereafter, the student began a series of 3D digital models to analyse the form (see Figure 22). An additional series of 3D digital models were generated to study the form proportions in the “virtual” environment using Rhino. Following this analysis, the student then began a series of small “physical” models studies, using the Rhino digital models and a ZCorp 3D printer (See Figure 23).

Following this series of shape and proportion studies, the student then began analysis of structure and skin options. This led the student to a series of digital model studies, with subsequent 3D printed “physical” models to study the scale of a tubular “diamond braced” skin system (See Figures 24 & 25).

The ability to migrate between virtual and physical models was invaluable for the development of the form (see Figure 26).

The representational physical 3D printed study models varied in scale from 1:2000 to 1:500. The use of CADCAM allowed accelerated learning of representational strategies to the student; the act of “making” with the “machine” allowed iterative small “test” 3D models to be quickly generated for the student to analyze the appropriate amount of detail and information to be included in various scale physical models. Additionally, part of the challenge for the later developed larger 1:500 scale 3D printed models was the size constraints...
for output of our ZCorp 310 3D printer. Thus, part of the learning experience for the student was the challenge of how to CAD/CAM the elements of the skyscraper as a “kit-of-parts.” This required “parts and assemblages” thinking by the student, which we teach and feel to be relevant in the emerging paradigm shift in the “making” and “manufacturing” of architecture (Kieran, 2004) (see Figure 27).

A site concept was generated as well and a physical model was milled using a “DaVinci” Techno-Issel CNC router (see Figure 28).

The larger scale 3D printed model at 1:500 allowed representation of the skyscraper floor plates as well as the proposed primary “diamond braced” skin support matrix (see Figure 30).

The CAD/CAM generated parts were then assembled to convey the student’s idea in physical form (see Figure 30).

See Table 7 and Figure 31 mapping Bo’s skyscraper Sway Tower design process.

**Finding and Analysis**

This section offers an overview of larger questions and guidelines regarding digital principles and digital media pedagogy.

The following is a review of or findings relative to the frequent criticism of the computer in the design process discussed in section 3 where we discussed “problems.”
Hardware Barrier
Key-board + mouse interface – lack of digital dexterity

JAMES: used a PC Tablet with an internal Wacom tablet and is comfortable with direct sketching of ideas using Alias Sketchbook. Software utilized was primarily Rhino and Photoshop. Virtual images were generated directly in Rhino, most of the output images were photos taken of the 3D printed models. All CAD/CAM 3D printed models were from Rhino STL files.

BO: used a laptop computer with an
external Wacom tablet, as mentioned earlier, he did not like the interface and resorted to his preferred pencil, pen and marker on paper. However, his navigation of the keyboard-mouse and software for 3D digital modeling did not hinder his creativity. Software utilized was primarily Rhino and Photoshop. Some 3D studio Max rendering was done for the final image output. Most images were generated directly in Rhino. All CADCAM 3D printed models were from Rhino STL files. The model base was drawn 2D in Auto CAD and CNC routed on a small format Techno Isel milling machine.

Software Constraints
Non-intuitive user interface – lack of creative synergy
Unoriginal forms - Algorithmic bias toward planar or primitive forms

**JAMES / BO:** both used Rhino software primarily. Both were introduced to the Rhino in our DDI class in Fall 2005. No form constraints – in fact, technology was a design “partner” in form finding.

Representational Bias
Undeveloped surfaces/spaces with “realistic” material and texture mapping

**JAMES / BO:** both used Rhino software primarily, “low viz” output, not a “rendering” tool (Barrow and Mathew, 2005).

3D Virtual Model / Non-Tactile Output
Confinement of design ideas to monitors - virtual images
Often confined to 2D plot media (3D viz data reverted back to 2D data)

Lack of 3D model physical feedback

**JAMES / BO:** weekly image output for studio PowerPoint crit / reviews for self analysis and instructor input. Also, 3D printer is a huge benefit to tactility and form.

Desensitization of designer from space phenomenology
Separation of designer from experience of Form / Space

**JAMES / BO:** Student encouraged (forced) to use camera as their eyes inside and outside the form (3D virtual model) for space analysis and design exploration and photography of physical models.

Focus on Technology and not on IDEAS
Typically not allowed ideation fluidity in the early states of design
Memorization of students with technology and not their design solutions

**JAMES / BO:** Student criticized consistently on their design ideas and form pursuit progress, not the media technique. However, the instructors experience with digital media was consistently offered as a means of digital exploration “possibilities.”

The following conclusive section will provide derived “digital design / CADCAM” key points we have derived from our recent pedagogy.

**Conclusion**

We feel CADCAM output, that is virtual 2D/3D environments as well as 3D automated machine output, now offers a
significant counterpoint to the claim that
the computer desensitizes the designer
from “creativity” and “physicality.”

Our pedagogy and research has shown
the visualization and representational
power of emerging 2D and 3D CADCAM
tools. Architectural form concepts,
heretofore, impossible to model and
represent, much less manufacture and
construct, are now possible due to
CADCAM. CADCAM tools and digital
design strategies proved to be empowering
for the student’s exploration of form and
space.

With the recent emergence of
both more user-friendly hardware and
software, we are seeing a paradigm shift
in design “ideation.” This is attributed to
the evolving human-computer-interface
(HCI), specifically; the use of PC Tablets for
INPUT that now allows a natural hand-to-
eye fluidic means of creative drawing and
diagramming for design ideation. Further,
emerging CADCAM OUTPUT machines
are capable of “making” form impossible
to do why hand and traditional making
methods.

Both the “pre” and “post” architecture
student’s (James and Bo) forms and spaces
were only achievable using CADCAM; the
“free-form” spaces’ and “female-human
figure” were only feasible to translate into
architectonic form using digital design
techniques via 3D free-form “virtual”
modeling and 3D printing “physical”
modeling output. CADCAM tools proved
to be empowering for the student’s
exploration, learning and design creativity.

The following is a list of Digital Design
/ CADCAM pedagogy key points:

**Hardware:** Use a Tablet in lieu of a
desktop or laptop.

**Software:** Use Rhino, or another “low
viz” free-form modeling software, to
maximize the student’s opportunity to
explore form with out software bias. Also,
limit the texture mapping and
“realism” options by staying away from
“middle and high viz software” for
conceptual form generation.

**Animation:** Minimize animation work; none
for the beginning student, and only
where assemblage or spatial experience
is augmented, or sun study for energy
analysis is relevant for the “advanced”
design student.

**Out-of-the-Box:** Require weekly reviews,
that is image output into PowerPoint,
this formalizes the design process into
“chunks” that keeps the student and
instructor cognizant of the work that is
in the box .... as the idea evolves get into
3D output as-soon-as-possible.

**Use Traditional Media:** Do NOT
disallow ANY media, always critic the
representation and design intent and
the contribution, or lack thereof, of the
media representation. In our Digital
Design I course, we require handcrafted
physical models at the outset of ideation
as part of the design process. This
sets up a “hands-on” form generation
attitude while engaging the 3D virtual
early concept models.

**Design + Making:** a lot more fun than
30 years ago; however, it is also much
more complex and technology based.
Most now agree, the argument is no
longer be about which media to use,
traditional or digital media; rather, most
Design Thinking: Digital tools make a complex processes even more so, however, with careful pedagogy and dialog, digital tools and congruent representational strategies enriches the student’s intellectual development as a designer.

Technology Offered: The sequence and means of Hardware and Software offered to the student is critical.

Allow Failure: Setup an environment that expects failure and difficulty, in the failure comes success. Expect and welcome problems with the technology.

Abstract Thinking: Diagramming and thinking prior to engagement of technology is critical when doing a “rational” design process (i.e. Bo). However, in the case of James, we are convinced that one can also “chase” and “find” the IDEA in the computer.

Teaching Ratio: At the Graduate Level, we maintain 7-10 grad students per advisor/instructor. Digital exploration demands a lot of “dynamic” attention, weekly, and this requires a reasonable studio teaching load.

Weekly Goals: Setup weekly goals and expectations, review weekly and adjust based on what “actually” did, or did not, happen.

CAD/CAM: costs $, not only for Hardware and Software, but for output as well (especially for 3D printing). This is a very important issue, needs more research and is beyond the scope of this paper). Please note, the instructor did not charge James or Bo for their 3D printed models, to remove the COST factor. This needs more attention for future analysis of CAD/CAM pedagogy.

CAD/CAM: At its best, offers the student the thinking environment of “parts and assemblage” whereby manufacturing can be immolated.

CAD/CAM: As most skills, requires basic ability and comfort prior to being leveraged for creativity (hence, see last point).

CAD/CAM: Introduce tablets and limited “low-viz” 3D modeling software at outset of basic design education – not as a middle or late design education “add-on.”

Emerging designers are integrating “digital thinking” in their fundamental conceptualization of form. These creative free-forms are only feasible for translation to tectonic form using digital design-make techniques. CAD/CAM tools are empowering designers for form exploration and design creativity. Current computing technology is now infusing the creative design process; the computer is becoming a design “partner” with the designer and is changing form and architecture; thus, we are now seeing unprecedented design-make creativity in architecture.

Mississippi State University’s School of Architecture has been a leader in computing in architecture; my colleague and cohort; Professor Michael Berk wrote a paper in 1993 entitled: DIGITAL NOMADS: The Computerization of a School of Architecture where he called for a notepad in every backpack. I would like to end our conversation here by calling for a Tablet.
in every backpack and 3D printer in every studio. Happy computing.

References


