Digital Design Pedagogy. Basic Design – CADCAM Space Box Exploration.

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This paper presents an overview of emerging potential for digital design pedagogy in the early formative years of studio instruction. As a vehicle, we have used a "pre-architecture" graduate student's work produced in our Digital Design II course in Spring 06. This student has a bachelor's degree in Architectural Technologies and hopes to attend a "professional" degree program in architecture after completing our "pre-post architecture" Master of Science in Architecture degree. 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.

Emerging digital design tools are now infusing the design process; thus changing the design process and form. Hence, we are now seeing unprecedented design-make creativity in architecture. However, many argue the emerging digital design-make paradigm, in the academic setting, is detrimental to development of student's design sensitivity and the learning of the art of ideation and making. Based on our research analysis, we will review our findings regarding the pros and cons of digital design tools, and reflect on the interface of technology implementation in the early formative years of studio pedagogy.

Introduction

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 the emerging 3D modeling tools are not transformative of form; rather the emerging 3D tools are used to replicate the earlier forms and techniques used in past design processes (i.e. 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 drafting as a means of production and efficiency, we are now seeing 3D digital models replace the former 2D paper processes in the studio, typically without transformative impact.

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 is not only a visualization and making "tool," but rather, also a design "partner" in form ideation and conceptualization (Lynn, 1999, Barrow & Mathew 2005).

The Methodology

Our Graduate Program Design +Technology Emphasis Area, by conscious choice of curriculum, is highly multi-disciplinary; 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 one-two week projects) interweave creativity, analytical thinking, diagramming, 2D, 3D, and 4D digital visualization as well as 6D fabrication processes. Contrastingly, the DDII course requires each student to develop an independent research problem, as well as congruent learning goals relative to their design discipline. The student is asked to assess their design and technology weaknesses, and pursue a project with learning goals according to their personal design aspirations while leveraging digital tools.

Basic Design – Shadows and CADCAM Form Finding

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 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 student chose to study shadows as a means of design inquiry. We chose to setup the primary focus of the work with the study of various "4" cube space boxes." The student was assigned a series of virtual to physical 4" cube exercises; each week the constraints were tweaked and more complexity of "shape" was allowed for a greater level of freedom and form variation. 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 criteria and constraints/opportunities:

Cube 1 = 4" - Exterior - Orthogonal / Interior - Orthogonal - (1/8" gaskets)

Cube 2 = 4" - Exterior - Orthogonal / Interior - Orthogonal - (1/2" gaskets)

Cube 3 = 4" - Exterior - Orthogonal / Interior - Obtuse - (any thickness gaskets)

Cube 4 = 4" - Exterior - Orthogonal / Interior - Amorphous

Cube 5 = 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. Excerpted images of the results of the cube exploration are shown in the following images (see Figures 1 and 2).

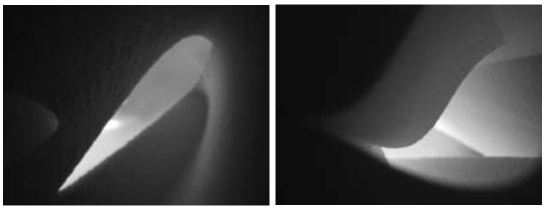

Figure 1: Cube 5 - CADCAM output and student observation.

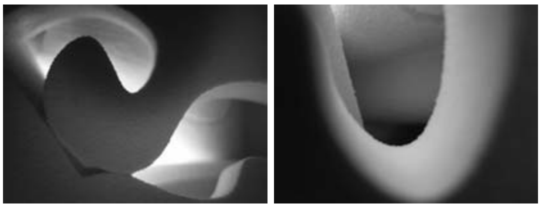

Figure 2: Cube 5 - CADCAM output and student observation.

The CADCAM tools proved to be empowering for the student's exploration and learning.

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.

- 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 CADCAM 3D printed models were from Rhino STL files.

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

James used Rhino software primarily; this was introduced in our DDI class in Fall 2005. There were no shape constraints – in fact, technology was a design "partner" in form finding.

- Representational Bias - Undeveloped surfaces/ spaces with "realistic" material and texture mapping.

James used Rhino software primarily as a "low viz" output, not as 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 was required to produce virtual 3D models with digital camera sets to explore virtual space; additionally he was required to produce a 3D printed model for instructional review and self analysis of his work. The 3D printer is a huge benefit to tactility and form exploration.

• Desensitization of designer from space phenomenology - Separation of designer from experience of Form / Space.

James was encouraged to use both the virtual and physical camera as his 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 – Computer typically has not allowed ideation fluidity in the early states of design - Memorization of students with technology and not their design solutions.

James work was consistently criticized (weekly) regarding his design ideas and form pursuit progress; the media was discussed in terms of it's opportunities to assist the design process, not the media technique. 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." 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 that is impossible to do with traditional hand hard-media making methods.

The "free-form" spaces" and were only feasible 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, not the media. 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 Thinking – Digital tools make the complex design process even more so; however, with careful pedagogy and dialog, we feel 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. Just as in traditional media, keep the digital tool representation at a conceptual or schematic level of representation.

• 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. 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 5-7 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.

• CADCAM – costs $, not only for Hardware and Software, but for output as well (especially for 3D printing). This is a very important issue; we need to more research in this area. Please note, the instructor did not charge James for the 3D printed models, to remove the COST factor. This needs more attention for future analysis of CADCAM pedagogy.

• CADCAM – At its best, in later years of studio, offers the student the thinking environment of "parts and assemblage" whereby manufacturing can be immolated.

• CADCAM – As most skills, requires basic ability and comfort prior to being leveraged for creativity (hence, see last point).

• CADCAM – 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.

CADCAM 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. Architectural form concepts, heretofore, impossible to model and represent, are now possible due to CADCAM.

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