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# Integration of the Actual and the Digital: Folding Modeling into Beginning Design Learning

by David Matthews

*Our nervous systems are "...grown to the way in which they have been exercised, just as a sheet of paper or a coat, once creased or folded, tends to fall forever afterward into the same identical folds."*

**Philosopher William James**

## Introduction

This article outlines a critical method of introducing processes of making digital and actual models in a beginning design studio. The central objective of the studio is to introduce the students to a method of using material and digital models that reflects the values and practices desired in advanced design practice. Concepts and theories from educational psychology are applied in the beginning design studio to enhance opportunities for practicing cognitive processes required for advanced/higher thinking skills such as analysis, synthesis and evaluation. The ideas presented in this article were developed in a cooperative process with Steve Temple, Associate Professor, University of Texas San Antonio, as an effort to unify concepts learned in the wood shop and computer lab.

## Theory

Robert Leamnson, in *Thinking about Teaching and Learning, Developing Habits of Learning with First Year College and University Students*, discusses the importance of establishing good habits of learning early. "Learning as brain-change, rather than brain use is critical in establishing good habits of learning. Learning is defined as stabilizing, through repeated use, certain appropriate and desirable synapses in the brain," (Leamnson, 1999). The project outlined in this paper provides the first experience with digital technology in the design studio. The processes in which students engage are to serve as an initial model to be repeated in upper-level courses.

The introduction of design processes on the foundation level can have profound and lasting physiological impressions on the brain. Beginning design studies are the first steps in establishing the neuro-pathways that will be used in advanced design practice. It is the objective of the instructor to provide an experience that establishes a conceptual foundation that allows students to build their own understanding of the relationship between the virtual and the physical processes of designing.

Critical thinking with digital and physical model making is the central "brain exercise" of the studio. Bloom notes higher-order thinking as analysis, synthesis, and evaluation (Bloom, 1956). These higher-order thinking skills serve as the basis of what will be employed in the class. Bloom's higher-order skills are brought into greater focus when combined with the work in critical thinking. Halpern states, "Critical thinking is purposeful reasoning involved in formulating inferences, calculating likelihood, and making decisions," (Halpern, 1984). The course is structured to allow students to make decisions on how to create abstractions between the processes of transforming from physical to the digital and just as important the process of making the digital into a physical form.

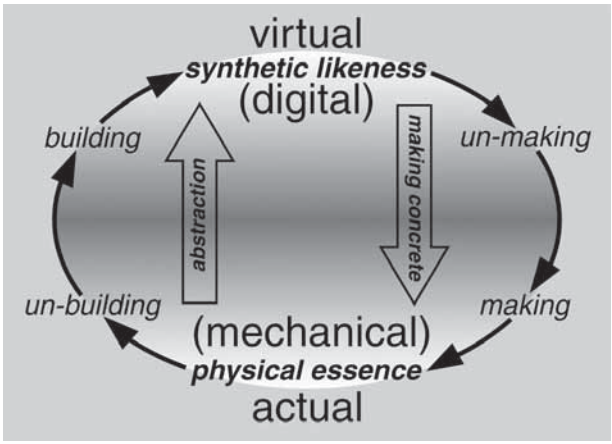


***Figure 1***: Model of digital and physical integration.

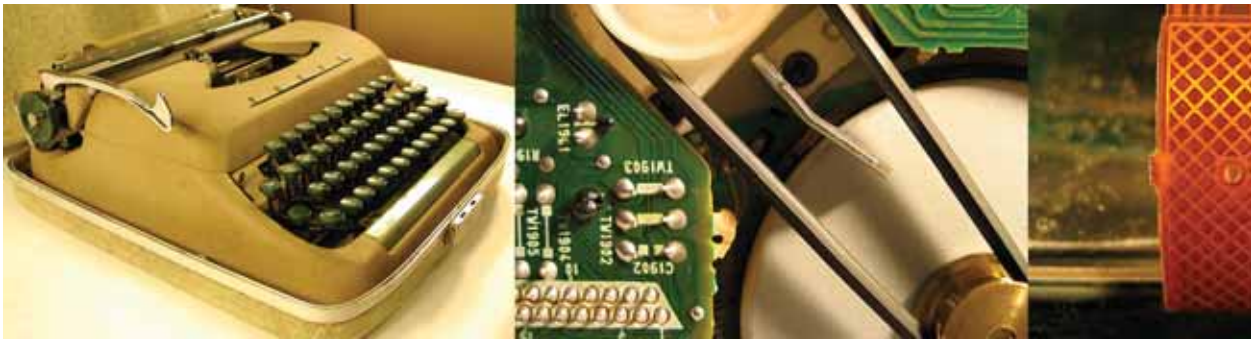

***Figure 2***: Un-building appliances.

**form•Z** represents the central tool integrated into the studio for digital making. Critical thinking occurs when students are able to make cognitive links between the physical and digital realms by using analysis, synthesis, and / or evaluation that employ purposeful reasoning and decision-making. The studio is based on creating a tension between digital representation and physical actualities. The model in Figure 1 illustrates how students move between the digital and physical. Students start with the actual and moving toward the virtual. The student will abstract the physical in a process of un-building and building as they work in the digital realm. The process of transformation from the digital to the physical is one of making concrete. In the process of making concrete, students must un-make the digital and make the physical. The studio presented in this article implements the model illustrated in Figure 1.

## Phase 1 - Physical to Un-building

Students find an existing appliance for the purpose of discovering the physical qualities, they take the objects apart in a systematic manner that results in a pile of singular objects. The process is documented with digital photography. Note Figure 2. Phase One introduces the students to the material qualities of the selected appliance. Due to a general unfamiliarity of how things are constructed, students often struggle with the process of un-building. The methods that are employed to construct the appliance create a physical and cognitive interaction of problem solving. Mechanical processes of joining materials such as set screws, slot and tab, spot welding, and glue challenge the students to interact with construction methods and processes used to make the appliance when they take it apart. Analytical skills are required to systematically disassemble a complex appliance.

The experience of un-building introduces the student to the importance of materials, fabrication, precision, and accuracy needed in the process of making. The exercise is to introduce students to look at objects not only as what they are, but how are they are constructed and what qualities are inherent within the materials and fabrication? The process is to build neuro-pathways that strengthen the relation of systems of materials and fabrication and the creation of objects and environments as beginning designers.

## Phase 2 Abstraction - Un-building to Building

Students use the disassembled components of the appliance and complete a series of formal design fundamentals exercises. The transformation of the appliance into a new set of potential design ideas is a process of abstraction. The project does not require a reference the utility of the original appliance in this phase but rather investigate a new potential for building by being aware of the inherent qualities found in the objects created in Phase One. The process requires higher-order thinking skills such as analysis of shape and form to be successful. Students must search for new opportunities that have logical relationships with elements and principles of design in this phase.

Fundamental design concepts such as radial organization, rhythm, and diagonal transformation are created with existing objects from the appliance. Students are introduced to the idea that the process of abstraction in design is a synthesis of knowledge of the physical reality of the object and the building of new ideas. Using analysis and evalua-

***Figure 3:*** Design Fundamental Investigations.

***Figure 4:*** Design Fundamental Investigations with Photoshop.

tion of existing objects discovered when the appliance was taken apart leads to new design potentials. The process in Phase Two is to reinforce that ideas for design are a relationship of making analysis of the external world (the pile of objects created in Phase One) to abstract ideas such as design fundamental ordering principles. The process exercises the brain in a manner suggesting that design ideas are not purely cognitive, (i.e. the light bulb coming on in the brain,) but rely on analysis and synthesis of the physical world. Note Figure 3.

Students continue the investigation in Phase Two by using the computer as a tool of abstraction. Photographs of the appliance parts are manipulated to enhance design concepts such as color, form, and pattern with Photoshop. Graphic investigations employing computers are introduced as a process that engages analysis and knowledge of the physical world to realize new opportunities through abstraction of physical objects. The computer is introduced as a decision-making tool. This process is to reinforce the relationship of the physical world and the virtual as a symbiotic process. Note Figure 4.

Students analyze the photographs for inherent qualities such as pattern, color, and form and use the tools in Photoshop to intensify the quality. This is a process that requires the student to simultaneously emphasize the quality and de-emphasize visual distractions in the photograph. Tension is created due to the depth of abstraction that Photoshop affords. The students are challenged to emphasize a quality of the object and, at the same time, not destroy or overtly distort the object.

## Phase 3 - Building to Digital

Students in Phase Three take a “deep dive” into the realities of creating digital models with **form•Z**. Thirty pieces from the deconstructed appliance are chosen to be built in **form•Z** in a one-week period. The process requires the students to transform material form and shape into a digital abstraction. Note Figure 5.

This process has similarities and differences with the use of the computer in Phase Two. The similarity is the computer is being used to abstract a physical object. The difference is in the way the computer is being implemented as a cognitive tool. In this phase, the emphasis is on accuracy and precision. This process allows the student to understand how the computer can be used for detailed visual representation of shape and form.

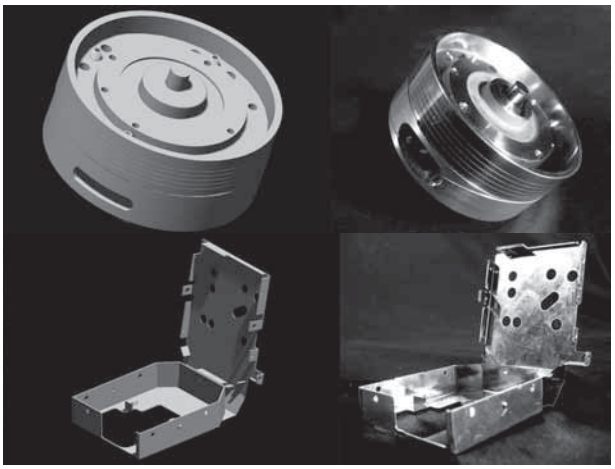

***Figure 5:*** Building to the Digital.

The exercise has pragmatic implications. By requiring the students to model existing objects, they are often challenged to learn modeling tools from necessity. This reinforces that the computer creates a tension between what exists on a physical level and the skill and knowledge of creating a visual representation on the computer. The brain is exercised in a manner that places emphasis on knowing the computer as a tool to represent desired physical realities.

## Phase 4 Abstraction - Building in the Digital

Objects modeled in **form•Z** during Phase Three are used to create a proposal for an inhabitable environment. The focus is on using **form•Z** as a tool of abstraction based on known physical forms. Attributes such as transparency, reflection, and color, added only by light sources, are exploited as part of the digital investigation. The transparency, reflection, and light color studies are selected due to the difficulty of reproducing them in a physical model.

***Figure 6:*** Digital Spaces.

Students focus on the creation of space and the representation of space with perspective. Diminishing space, foreground, mid-ground and background composition, foreshortening, atmospheric condition from using the blur post process, and the angle of vision are elements emphasized to enhance communication of space. Note Figure 6.

Students are encouraged to create an environment based on new relationships discovered in the 30 objects. The initial form of the appliance is greatly abstracted into new potentials of space. Objects are rescaled and placed in new ordering systems practiced in Phase Two. The creation of space requires complex skills of analysis, synthesis, and decision-making required in higher-order thinking that are practiced as part of the profession. Equal emphasis is placed on quality of spatial representation. Quality and manipulation of representation allow the student to learn how to use the computer to analyze the quality of space and synthesize shapes and forms to make environments. By emphasizing the quality of representation, the student learns attributes of accuracy and precision inherent in three-dimensional digital modeling.

At this point in the studio, the student has used information found in physical objects that have been abstracted with the computer three times. Abstracted once with Photoshop, once with constructing objects from the disassembled appliance, and once by building space with the objects from the appliance. The repetition of the computer use as cognitive abstraction tool based on physical realities is a practiced neuro-exercise.

## Phase 5 - Un-making to Making

The transformation from the digital to the physical is the focus of Phase Five. Students begin by making images that they estimate to be helpful in the construction of a material model, based on their digital model completed in the previous phase. The images are used to create models constructed from brown corrugated cardboard.

This step is one of the formidable phases in the process. The cardboard becomes more than a representation of space. It is an element of design with affordances and resistances that dictate transformation of the design. Students must employ critical thinking skills such as “formulating inferences, calculating likelihood, and making decisions” in the transformative design process. By creating a design in cardboard initially created on the computer, the student must make new decisions based on the quality of the material, infer new possibilities of space based on the material, and transform ideas.

At the same time students are realizing the palpable aspects of cardboard, they are reflecting on the abstract nature of **form•Z** modeling. Students in later studios will be making design proposals of environments constructed from physical materials and represented in a digital form. This phase is to exercise the tension between the affordances and resistances of the digital realm with the realities and resistances associated with the physical environment. For example, making a primitive shape such as a sphere in **form•Z** is relatively easy. It can be represented

***Figure 7:*** Cardboard Models.

***Figure 8:*** Foam core, wire, and plexiglas models.

with great accuracy on the computer. Making a sphere in cardboard requires a transformation in thinking that is based on the knowledge of the material and fabrication of cardboard. The link between knowledge of material and the creation of space, form, and shape is a neuro-exercise repeated in the following phase.

## Phase 6 - Making Again

Foam core, Plexiglas and wire are used as new modeling materials in this phase. To reinforce the importance of the knowledge of materials in the design process, students must analyze and evaluate the new set of materials. Students must think critically about the nature of the materials and the processes required to transform a design made in cardboard into new forms and shapes based on the inherent physical nature of foam core, Plexiglas, and wire. The use and exploration is beyond the visual nature of the material. The model is intended to be a microcosm that also investigates structural capacity, fabrication methods, and tactile texture investigations. Note Figure 8.

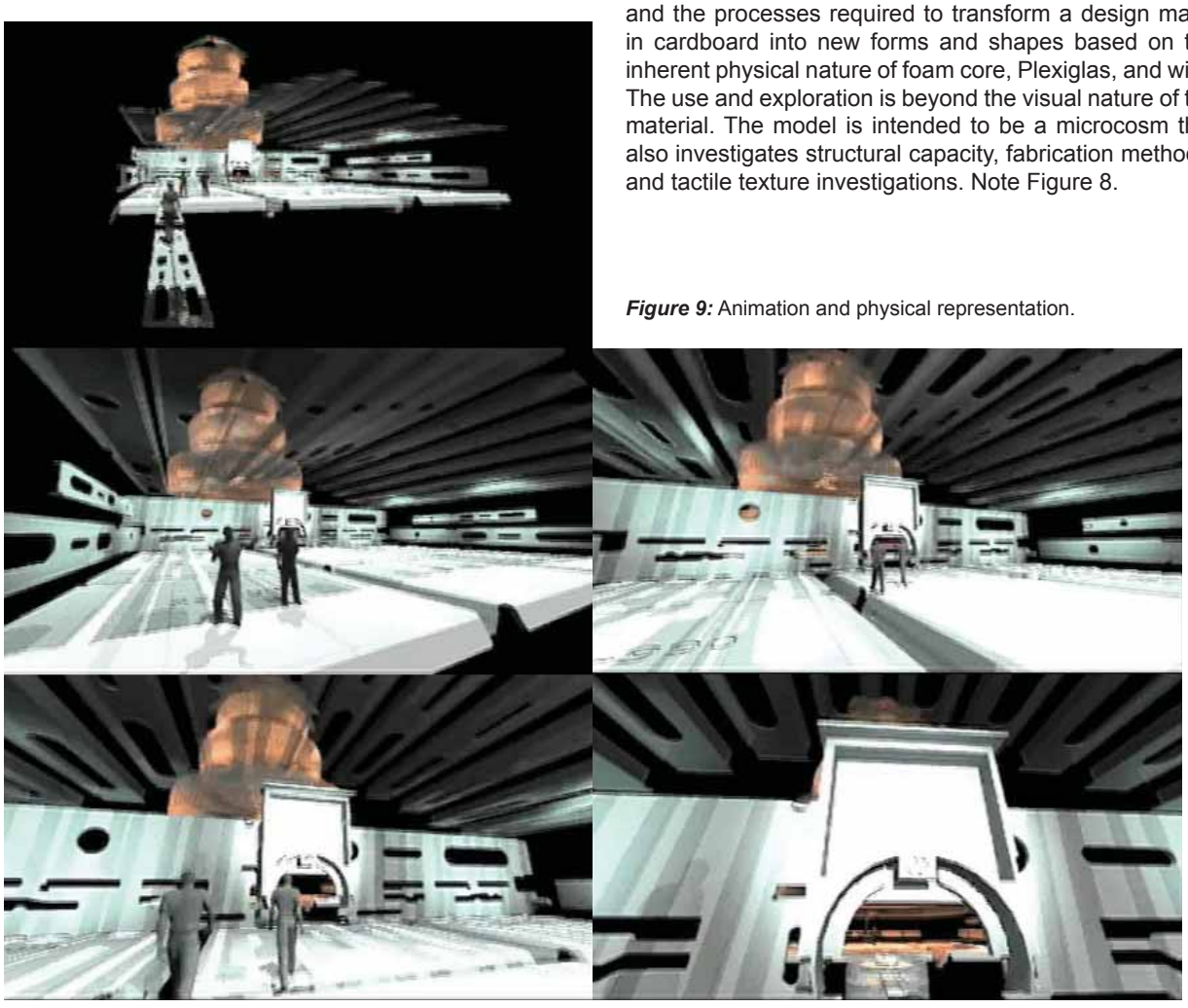

***Figure 9:*** Animation and physical representation.

In Phase Five and Six, understanding material is introduced as a primary higher-order thinking skill that is abstractly related to the computer. Students are building meaningful relationships between the use of physical models and digital models through transformation. Students are synthesizing the abstract nature of the computer with the palpable realities of materials.

### Phase 7 - Digital Representation

The final phase of the studio is to return to a digital medium and explore unique aspects of digital modeling difficult to reproduce in a physical form. Students are to investigate concepts such as transition, sequence, movement, change, and speed. The aforementioned concepts can be thoroughly explored through the animation of digital models. The students are asked in this phase to explore how they can bring physical qualities to digital models. The integration of physical qualities is described as a process of abstraction and should be realized for the affordances the computer application can provide. By returning to the digital model in the final phase, the student can incorporate aspects of the physical explored in phases Five and Six and simultaneously exploit the advantages of the computer model.

### Conclusion

One of the major limitations of the studio is limited movement back and forth between the digital and material. To build strong neuro-pathways, the process outlined in this course must be repeated in concept within other courses. Other limitations include the formal investigations with minimal regard to cultural and social issues associated with the design of environments. The studio experience is one largely based in formal investigations of design.

Leamnson provides a structure to understand learning as a biological process. Within the biological process, special care must be given when new information and experiences are presented, as these first neuro-pathways will tend to be the ones that will be repeated. The introduction of the computer in the design process is one that should not be isolated but rather integrated in a tension between the realities of the digital realm and the material realm.

The strength of the studio is reinforcing analysis, synthesis, and evaluation of digital and material realities. The motivating factors for the above strengths are transformation and tension. Students are transforming materials into digital representations and back to material models. The transformative process creates a tension between understanding material and space as represented with digital modeling and physical modeling. Students who successfully complete this studio tend to have good decision-making when deciding how to investigate space in advanced studios. Students are introduced to when and how to use a computer, when and how to investigate materials in relation to digital mediums, and how to synthesize the two to create and represent and idea larger than either medium alone.

The processes and methods introduced in this beginning design studio are to reinforce cognitive processes required in advanced design courses. The introduction of digital modeling with **form•Z** is presented as a part of a holistic process of design that engages many different media simultaneously. The objective is to exercise the brain in a foundation design studio in a manner where digital tools are part of the larger investigative realm that introduces higher forms of learning and critical thinking as essential aspects of design.

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