Synthesizing Dualities:
Integrating Virtual and Material Technologies in the Design Studio

DAVID MATTHEWS and STEPHEN TEMPLE
University of North Carolina Greensboro

Fragmentation of the material and the virtual is at the center of many discussions of design process. Questions such as, "can the computer represent the physical world as well as traditional methods?" and "is the computer faster and more economical than traditional processes of design?" serve to fragment the understanding of the tools and processes of architectural education. These questions can place emphasis on irreconcilable oppositions — we must choose one or the other — material or digital. Instead, a theoretical model used to create a link between the physical and the digital in the context of architectural design process is needed as a component of current design education. The model proposed in this paper suggests that links exist between the mechanical and the digital. These links, more specifically, the processes involved to move to and from the differing poles of duality, can serve to build greater understanding of design processes and the resulting products. By building formal relationships between the physical (atoms) and the virtual (bits), the design process can move toward a more inclusive, holistic, and fruitful design experience. Both a formal model and the experiences in the corresponding design studio are presented as part of this paper.

The development of design programs entering the 21st century is being challenged by the changes in our culture brought about by the computer and has placed the education of architects and designers at a crossroads. The Bauhaus origins of studio experience — free exploration of material qualities and mechanical technologies — seems to be losing favor to implementations of "seductive" digitally manipulated pictorial representations. Steven Holtzman, in *Digital Mantras*, makes the following statement as an introduction to a description of virtual reality:

> The goal of being as realistic as the highest quality photographic representation of the world is particularly interesting when the source if the image is not the real world, but rather a world synthesized by a computer. Computers can be used to create visual simulations that model reality. These are virtual worlds: worlds that appear like the real world, but which in fact, are not based on anything that exists in the tangible, physical world.

The above quote serves to divide the relationship between digital representations and physical essences. Currently, this perceived "non" relationship between the "virtual" and the "material" defines much of the educational and professional use of digital and mechanical technologies for design professions. Often in design education, mechanical "shop" technologies and digital "CAD" technologies are instructed as support courses or are marginalized into separate, "specialized" studios with little formal relation being made to holistic design processes. To the contrary, the expanding use of digital forms of representation, dependent as they are on modes of abstraction, necessitates even greater inquiries into the physical essence of space and the subsequent "realness" of material qualities which can be (re)discovered through *acts of making*. Having a basis in making things (whether as material or as mechanical explorations or as models, mockups, and prototypes), once a primary form of inquiry in design activity, is increasingly viewed as anathema to digital representation. It is the intention of the authors to look beyond the obvious differences and/or oppositions between the "real world" and the "virtual world" and find relationships that can lead to integrations of digital representations and material essences in architecture.

The inquiry presented here has grown from discussions of commonalities observed in the experiences of the authors in teaching two separate design studios. One design studio had a pedagogy centered on the incorporation of making things while the other was taught primarily utilizing digital modeling applications. While compelling, even ancient, arguments exist that hold that the there is little relation between the physical world and the virtual world, our experience has revealed the contrary. As approaches to design process, operations in physical and virtual realms have a mutual basis in "acts of constructing." If the physical and the digital are not exclusive but *complementary*, this suggests an operational model as an integration of processes.

Both physical and digital processes involve a systematic manipulation of solids in space. Digital modeling can be characterized as a movement toward abstraction — a "building" of a virtual construct (the digital image) following rules

of physical geometry. Mechanical construction is movement toward the concrete — fabrication acts as a search for formulations of what is possible in the character of material qualities. In design studio education where enlightenment is a goal, our contention is that repeated cycling through processes of digital abstracting and making concrete can enable a basis for design decisionniaking that provides a material ground for representations.

A MODEL OF INTEGRATION

This inquiry stands on apremise that acts of designing involve constructing a dialogue between representations and the intentional manipulation of physical substance. The assumed opposition between digital and material can be restated in terms of an operative model of interdependence — where the digital is a transformation of the material and the material a transformation of the digital. Synthetic processes are opposed to mechanical processes. "Bits" are opposed to "atoms." Abstraction is opposed to the concrete. Transformations from digital to material and material to virtual occur as cyclical processes, analogous to the practice of design, where we move repeatedly from the hypothetical or fictive (digital) to the palpable and concrete (material).

A digital representation can be characterized as a *synthetic* likeness created from a process using quantified bits of information originating from a presupposed physical essence. The geometric /Euclidian mathematics used in computer modeling applications are based on the presentation of order within the physical substances of our environment. It is not the resulting images that are the only likeness to the physical experience. Geometries that are imperative in understanding and experiencing the world are implicit in the computer modeling application, thus providing the basis for a link of experience and representation.

The proposed model of integrated virtual and physical processes is a dynamic model of transformations, essentially, movement from possibility to probability. Transforming the material to the virtual can be characterized as movement toward abstraction, a transformation of tangible substance into representations. Un-building/building can be characterized as utilizing existing and already structured mechanisms of synthesis to systematically disassemble a physical whole and then build it as a possible digital representation of those systems. Conversely, transformation of the digital to the material can be characterized as movement toward the concrete, substantiating synthetic images in a palpable reality. Unmaking/making, as a process, is a mechanism of synthesis that is discovered in an analytic deconstruction of a "synthetic likeness" that is then used to give probable concrete existence to its propositional nature. In practice, the use of this model would not be in the form of a linear circumnavigation. Rather, the model functions more as a referential structure for dynamic interaction between all parts of the model.

Un-building is the experience of understanding the nature of how objects or physical environments are built. It is describing objects and physical environments by deconstructing them according to a system existing in the original physical essence. For example, a chair, un-built, can be characterized as an organization of geometries, material characteristics, reflectivities, and evident qualities such as structural soundness, flexibility, and scale in a configuration which affords the meaning and idea of sitting.

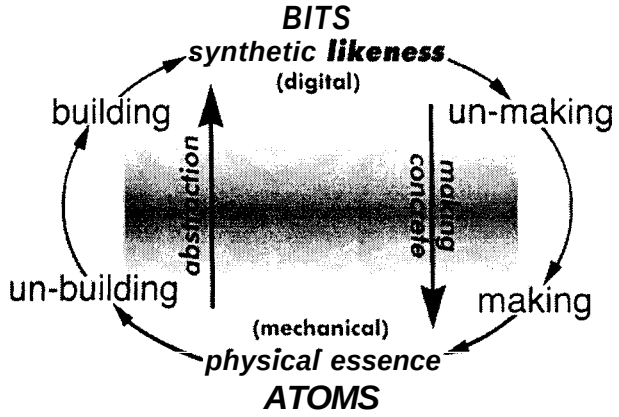


Fig. 1. Dynamic model of processes.

Building can be characterized as a putting together of parts or components which are potentially already wholes in themselves. The action of building is inherent and structured in the process of using digital technology. Building primitive digital forms and implementing tools such as Boolean commands allow the designer to implement an existing system within digital applications to build an abstract model and in turn create an understanding of the constructed digital model through visualization.

Un-making can be characterized as a discovery of a systematic nature of an abstract representation for the purpose of its subsequent translation into physical substance. Unmaking is a form of describing — a translation into relationships of material qualities; properties; surfaces; procedures; methods of transformation. Un-making is the experience of understanding the potential nature of how objects or physical environments can be made as a derivation of a synthetic likeness.

Making can be characterized as giving concrete existence to a synthetic proposition, in the implementation of a system discovered in un-making. It is the act of fabricating physical objects and environments — where fabrication is a "putting together," with specific regard to an idea of the thing to be made from a material such that the material properties are manipulated toward an end.

In the context of design experience, systematically linking abstracting and making concrete reveals a continuity in process. Digital production of images intending to represent a designed environment is a systematic abstraction from the concrete in a movement from processes of un-building to building. The action of making concrete is a transformation of

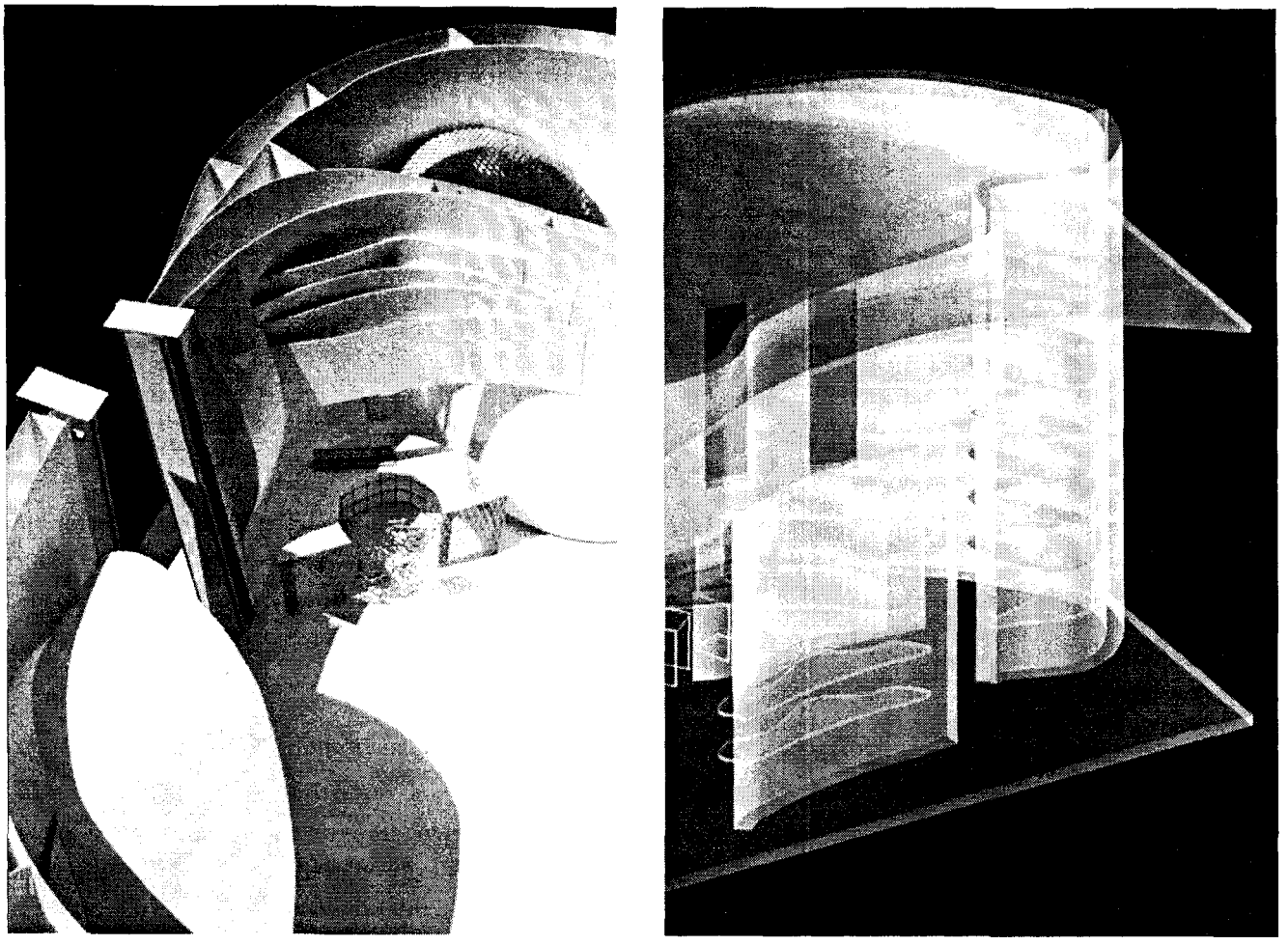


Fig. 2. Phase I - Material and digital transformation models (left and right).

abstract to concrete through a systematic process of un-making to making. The concrete is the intentional end of the design process, with human occupancy as the prime measure of intention. Representation becomes impossible without physical substance, and without representation, one cannot develop intentionality in physical substance.

While the representative technologies of the virtual and material may be mutually exclusive, processes of making and building are inherently integrating. Digital technologies are capable of creating systems to aid in visualization but this visualization may be so complete that the system of un-building has been omitted as an active part of the design process, creating images that can exist only in a virtual environment. A production of the synthetic likeness with a lack of awareness of a systematic un-building of the physical essence may lead to limited means to extract the systematic nature of un-making/making processes for the production of the concrete.

Not integrating digital and material technologies can lead to displacement of original presence with a valorization of synthetic likeness. Processes of design that integrate synthetic operations with the activities necessary to the actual making of the physical environment achieve a consciousness of process enhancing product. Typically, design studio curricula present mechanical and digital technologies as mutually exclusive entities, which places emphasis on product — product as image, in the case of the synthetic likeness, or product as object in the case of physical essence. Placing emphasis on one aspect of the model without relation to the model as a whole can mislead the intention of the design process and disrupt experience of the creation of built environments. Defining these technologies as *concepts of making/building* within the same context can more readily reveal design processes as dynamic mechanisms of transformation.

DESIGN STUDIO UTILIZING THE MODEL

A design studio was developed as a test of the model. The studio was a semester long experience that provided the students with a structured, yet variable, experience of both the digital and the physical. The studio began with a formal experience of the perceived dualities and advanced to the integration of digital and physical according to a methodology represented in the proposed model. The studio was conducted as a vertical studio involving third and fourth year students. All students in the studio had previous foundational experiences with digital modeling applications as well as projects whose primary focus was working materials.

Phase One

Phase One was intended to introduce, provoke, and stimulate awareness of the effect on design decision-making of transformations of the phased utilization of specific differing materials and the phased application of additive/subtractive, wire-frame, and transparent and solid digital modeling. The second part of Phase One provoked and stimulated awareness of the potential for design decisions born of a transformation from digital or material to its respective polar duality.

Design exercises that respectively maximized digital or physical processes were presented separately to two groups of students in small scale formal design projects. Both projects contained the same programmatic requirements. Physical investigations included the sequential construction of large scale models in differing materials, exploring the physical and formal implications of each successive material transformation. Digital design process experiences emphasized the nature of the order of form, space, and light. and the ability to quickly manipulate point of view. After three weeks in either the digital or material mode, students with a digital project were required to transform the digital into the material and those with a material project, the material into the digital. Processes of transformation, abstracting or making concrete, were the central issue of Phase One. The transformation between physical and digital occurred only once. Phase Two emphasized further transformations adding repetition and choice.

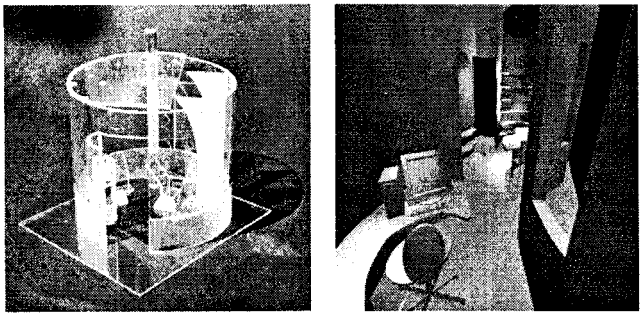
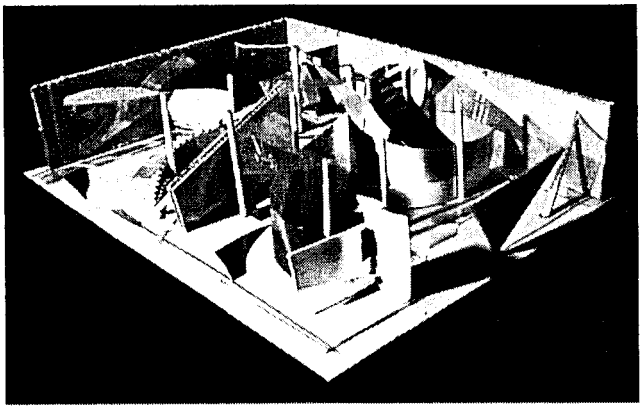


Fig. 3. Phase 1 - Material and digital transformation models



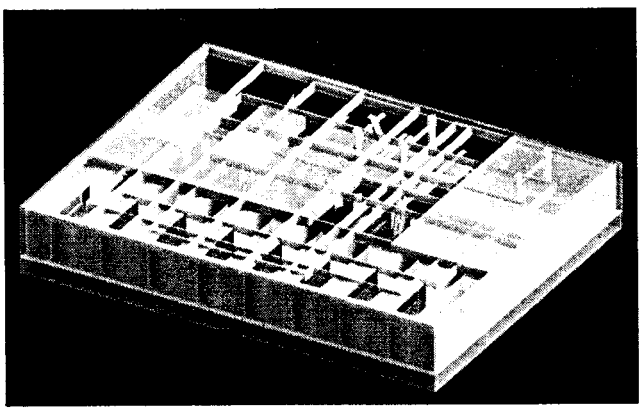
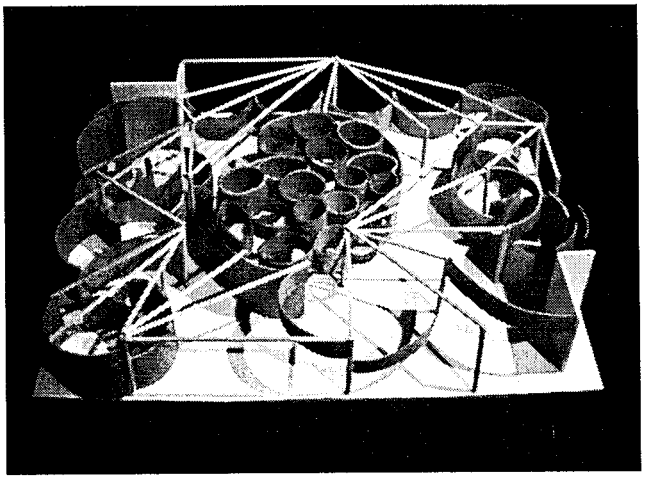


Fig. 4. Phase 2, Transformation 1

Phase Two

The second phase naturally developed from the discoveries about modal transformation in design process made in the first phase. The scale of the project was expanded and the systematic context of transformations of digital and physical were expanded into a scenario allowing students to select the mode (digital or physical) of operation and the sequence of modes through five separate transformations, each becoming successively more detailed.



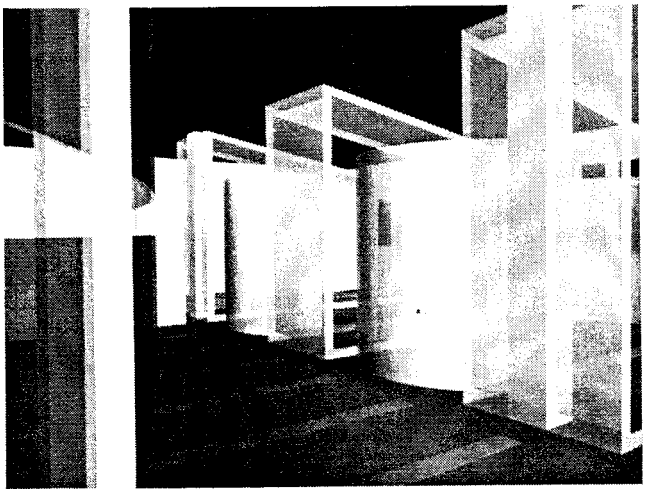


Fig. 5. Phase 2, Transformation 2

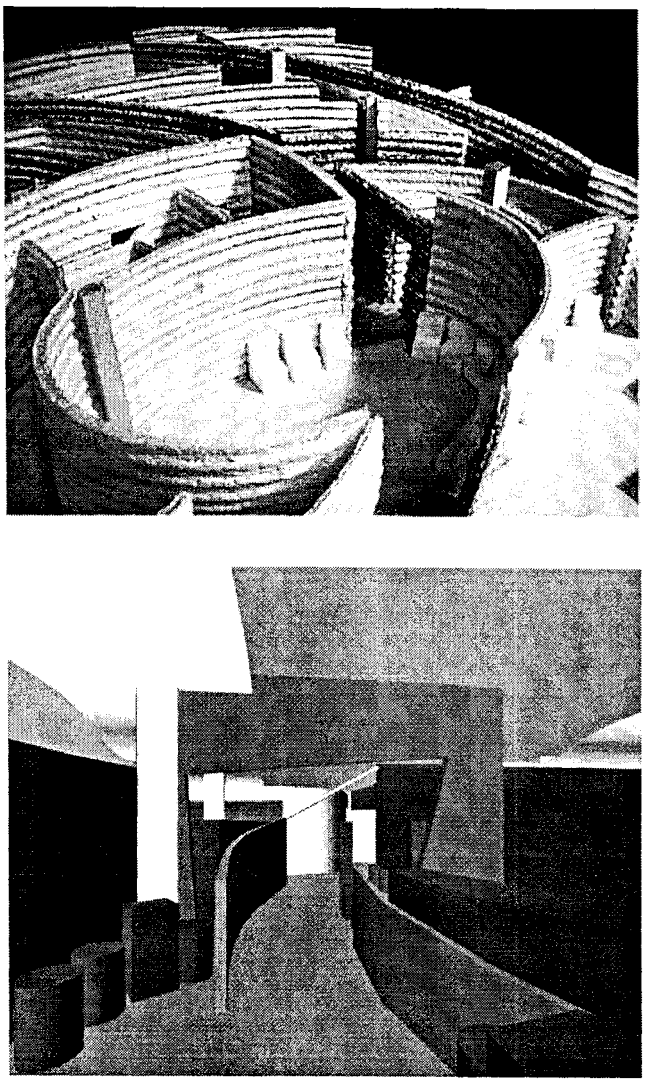


Fig. 6. Phase 2, Transformation 3 (top and bottom)

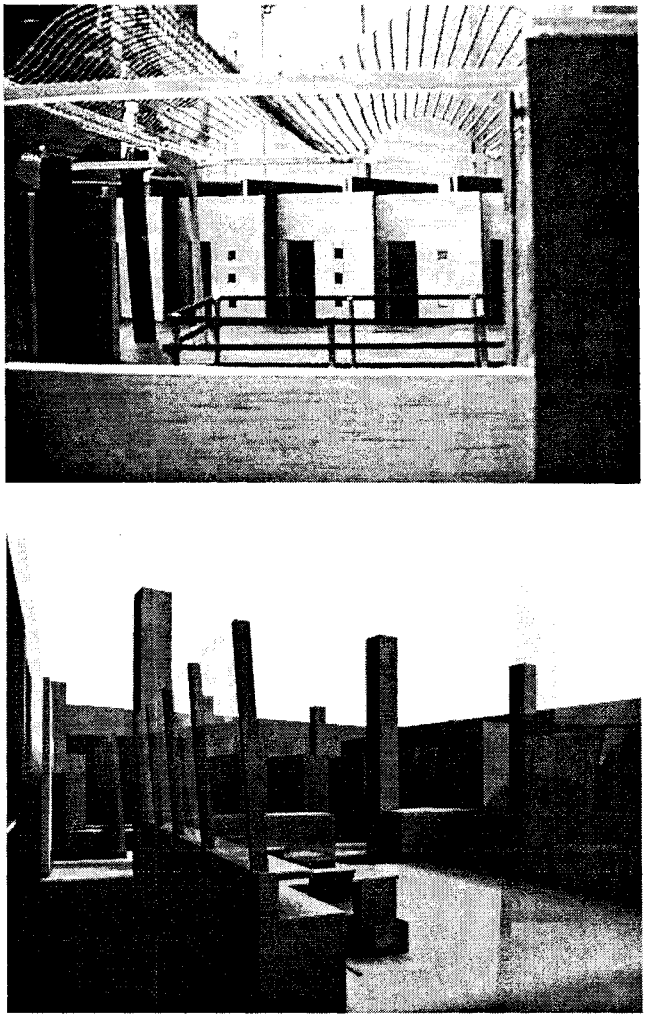


Fig. 7. Phase 2, Transformation 4 (top and bottom).

Exercises were designed to include options for either physical and/or digital models as well as the graphic representation and construction of prototype full-scale details. This phase emphasized the relationship between the digital and physical with more intention to unification and synthesis as they developed the project through conceptual, schematic, and detail development. Each student had to choose to complete either the physical or digital component of each of the five exercises selecting the mode they felt was correct/natural to the design process at that stage. Students were instructed to complete three of the five exercises in one mode, although the specific sequence was their decision.

Phase Two was designed as the principle test of the modal process model in the design studio environment. Whether to develop toward the abstract or to the concrete was left to the choice of each student. This emphasized independent process and allowed them to decide the flow of the transformations as they perceived the benefit to their own design process. Our discovery was that students reconstructed the model from a circular form to a web — crossing to the process needed at the moment. "Building" can transform to un-making, un-making to making, making to unbuilding. This is key to how designers work. Any path within the model is possible, within the *conceptual framework* of the model.

Phase Three

Emphasis of the studio shifts from a primarily developmental mode in Phase Two, to include the representation of design in Phase Three. The authors acknowledge the idea of repeated shifting from creation to representation is a limited view and aspects of representation are important in Phase Two and designing will continue in Phase Three. Students began Phase Three by developing a set of goals for a set of combined digital/physical representations of the design in conjunction with the results of Phase Two. The students were given complete freedom of choice to use any sets of processes that investigated in the previous two phase or add processes they had not yet investigated in the studio. Students were able to transform the model on their own terms, suggesting modes of design outside the model suggested in the paper but still incorporating ideas of the relation between digital and physical modes of operation. This was especially suggestive of

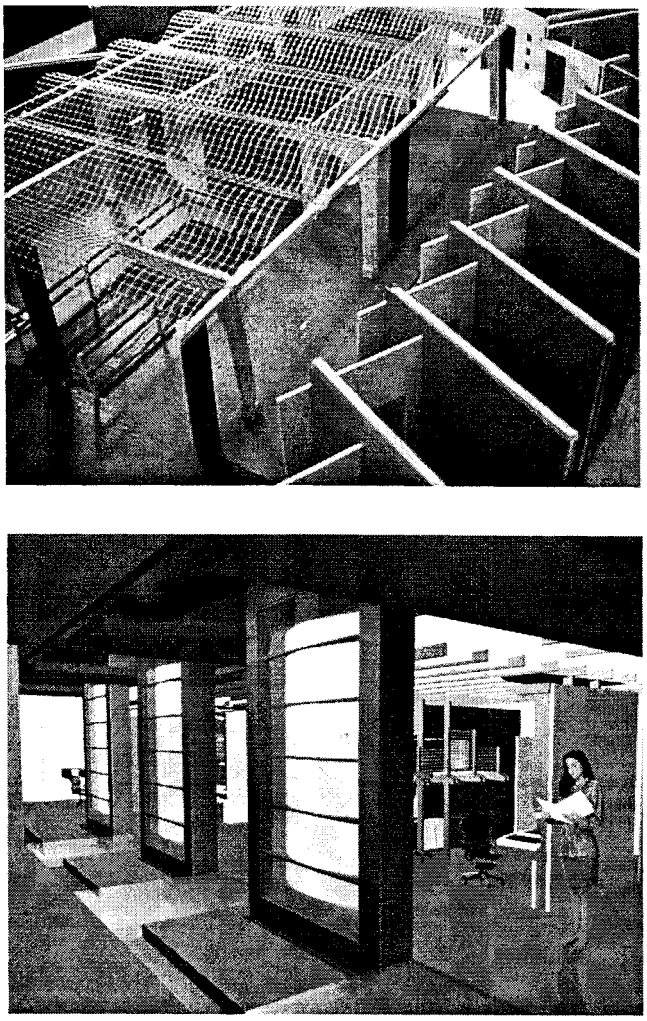


Fig. 8. Phase 3, Final transformation (top and botom)

forms of representation where an interaction of the digital and physical could enhance the communication of the ideas of their proposal.

FINDINGS FOR A MODEL OF STUDIO EDUCATION

Advantages

Students worked better and were more enthusiastic with deadlines where the purpose was to make "only" a single tranformation from material to digital or visa versa. What they did not realize was that the transformation caused them to make more decisions than they were otherwise aware of. Transforming from one system to the other involved shifting the process of building the design according to the media - a manuever which forces rethinking sometimes the entire concept (e.g., could not build out of wire mesh the same way as Bristol board functioned).

Design projects received many more transformations than is typical; the ability to impose an external limit on the inclusive nature of the transformation appealed to the students as a kind of freedom. They did not need (nor was it possible) to solve every aspect of the design with each transformation phase, although I believe emphasis on refinement actually was significantly greater.

Design projects expressed great integration between what the material offers and the digital offers to design decision-making. Students forced transformations between digital and material early in the project but in the latter half of the project they were willingly and frequently shifting between modes as a way of making quick progress or extricating themselves from difficult moments of pause. Integration of design ideas with pragmatic issues and material and lighting decisions seemed more natural to the students when applied within an "outside" methodology of transformation.

Students expressed greater independence of creativity and decisionmaking; model transformations allowed flexibility in design undertakings and greater growth as adesigner on the part of the students through a greater emphasis on an awareness of design processes that may have been implicit. Students expressed more excitement and energy devoted to each successive exercise and there were less feelings of dread for the work due to compartmentalization of phases.

Students can have an either/or mentality to material versus digital media; sometimes they feel both is redundant. No students indicated an attitude that the transformations seemed redundant or repetitive of work as they made transformations from mode to mode, indicating that each phase was progressive. This model explicates the complimentary nature of digital and physical modes as modifiers of the other.

Limitations

Some students had a tendency to incorporate expedience as one of the factors in choosing the sequence of digital or physical modes. At times expedience was used to make a transformation instead of diligence, but occurred rarely. The model making experience can also be manipulated as acrutch and the methodology can too easily be manipulated for economizing time rather than optimizing design decision-making. As this studio was used as a test of the application of the model, we were also testing is efficacy with student initiative. Since the process involved giving the students more choice this was unavoidable; however it was only in one instance problematic.

There were limitations of technology. Only computer modeling applications were used, along with image processing applications such as Photoshop. Next time this method is used the authors will include virtual reality and animation applications. The physical/material transformations were primarily model-making. The authors need to incorporate more extensive shop activities, especially presentingagreater variety of material alternatives (i.e., actual material mock-ups).

Speculations

As this application of the model to a design studio was an initial attempt, its use suggests that a more research outcome-based application will yield data about the specific manner

that students used to navigate the choices between modes, and how these choices more specifically inform design decision-making and refinements. Its continued use will undoubtedly lead to amplifications of technique for the use of digital methods modified by material and the reverse. Our students found the potential for modifications provocative but just scratched the surface of possibility.

Using digital representations in design is both positive and negative. Digital modeling and rendering applications offer a form and methodology capable of giving designers increased abilities to model, visualize, and communicate their proposals while threatening to reduce connection to methods and techniques necessarily rooted in physical essences. Our model has attempted to demonstrate that this need not be inevitable.

Computerized abstractions offer the opportunity to (re)integrate the actual "stuff' of buildings — materials and light and their perception through occupancy. Using a computer modeling program (such as Form Z) is an act of building directly analogous in method to laying up bricks one by one, depending, as both methods do, on being informed by experience and knowledge of physical qualities. The ability to abstract material qualities into other forms, particularly a mathematical form, is a methodology formed of a natural interconnectedness between digital and material technologies. In appearance, this connection obscures the essential nature of material qualities, but as a holistic process it reveals a deeper refinement of material presences. The perceived opposition between digital and mechanical technologies is a traducement, and recognizing this is a step toward design curricula aimed at (re)unifying designing and making.

This raises questions for design education and the profession of architecture at large. If digital technologies are replacing and expanding a system of existing abstract representation, how will ideas and experiences of material essences be explored? Will the design processes of the future incorporate material essences as directly as we seem to be currently embracing digital representations'? The proposed model links digital and mechanical technologies in such a way that they cannot be separated. The model suggests that the traditional design studio be reinvestigated in a manner that acknowledges the relationship between material essences and digital representations. As computers enter the studio and displace the drafting table (a tool of physical essence and abstract representation), how will technologies of material essence be part of the educational experience? The studio that incorporates digital technologies may be most effective in combination with an already existing wood shop, metal shop, or foundry.

REFERENCES

Architecture and Abstraction, Pratt Journal of Architecture. (New York: Rizzoli, 1985).

Behrens, Paula & Anthony Fisher. (Eds.), *VIA 7: The Building of Architecture.* (Cambridge, MA: MIT Press, 1985).

Benedikt, Michael. *For an Architecture of Reality.* (New York: Lumen Books, 1987).

Bouman, Ole, *Realspace in Quicktimes: Architecture and Digitization.* (NAi Publishers, 1996).

Carpenter, William J. *Learning By Building.* (New York: Van Nostrand, 1997).

Dooling, D. M., *A Way of Working.* (New York: Parabola Books, 1979).

Holtzman, Steven R. *Digital Mantras The Languages of Abstract and Virtual Worlds.* (Cambridge, MA: MIT Press, 1994).

McCullogh, Malcolm. *Abstracting Craft: The Practiced Digital Hand.* (Cambridge, MA: *MIT* Press, 1996).

Mitchell, William J. *City of Bits, Space Place and the Infobahn.* (Cambridge, MA: MIT Press, 1995).

Negroponte, Nicholas. *Being Digital.* (New York, NY: Vintage Books, 1995).

On Making, Pratt Journal of Architecture. (New York, NY: Rizzoli, 1992).

Pye, David. *The Nature and Art of Workmanship.* (Great Britain: Cambium Press, 1995).

_____, *The Nature and Aesthetics of Design.* (New York: Van Nostrand, 1978).

Stewart, David and Blocker, H. G. *Fundamentals of Philosophy.* (New York: MacMillan Press, 1982).

Wayne, Kathryn M. "Form follows Information." *Journal of Architectural Education, 49.* (May, 1996). pp. 269-271.