Introduction to Concept and Form in Architecture: An Experimental Design Studio Using the Digital Media

Osman Ataman
Georgia Institute of Technology

Bruce Lonnman
Georgia Institute of Technology

ABSTRACT

This paper describes the use of digital media in a first year undergraduate architectural design studio. It attempts to address the importance of developing a design process that is redefined by the use of computing, integrating concept and perception. Furthermore, it describes the theoretical foundations and quasi-experiments of a series of exercises developed for beginning design students.

INTRODUCTION

Tools are extensions of human beings that partially differentiate humans from lower order species of animals. Throughout history, humans have developed mechanical tools to facilitate physical work. The wheel and lever provided humans with an enormous mechanical advantage. The industrial revolution added artificial sources of power to extend that advantage. The information revolution has further extended that advantage by extending the functionality and speed of tools. The nature and power of the tools available to the designer determine what he can conceive and accomplish. Conversely, the limitations of the design often result from the limitations of the tools. This is as apparent in architectural schools and offices today as it is in the history of architecture. The student or junior architect who cannot draw freely and thus design confidently within the limits of his powers of representation (Mitchell and McCullough 1991), is the victim of "analog take-over": these tools and models constrain his thinking. This is obvious enough, but the more general point that the architecture of any period is limited by its stock of models and tools has not been generally grasped.

Based on this assumption, computers (and computer-aided design in this context) have emerged as a vehicle for partnership between productivity and creativity. Several researchers unite in recognizing that current modeling systems offer the architect a sophisticated design aid. Existing models of design education, such as those described by Goldman and Zdepski (Goldman and Zdepski 1990) have attempted to explore the integration of computers into design studios.

In general the integration of computers in disciplines such as architecture has been slow for several reasons. First, in the field of architecture, computers have been seen as another medium of representation. Some members of this field dismiss this "new medium" as having little or no impact on architectural design education. The principles of proportion, harmony, programming, needs analysis, and development of form have nothing to do with machinery, they argue. According to this view, buildings that function well flow from a careful analysis of the needs of the client. The contribution of architecture is higher at the beginning. The real emphasis of the school has always been on the early phase by developing the form of the building. Second, the process of design is ill-understood, and therefore defies the precise modeling prerequisite to its computation. Third, no new methods and methodologies have been developed before this integration took place. The latter reason is important because the full potential of computing in architectural design can only be realized by the creation of new models of the design process appropriate to the new design medium, and these new methodologies need to reflect the nature of the design medium being used rather than simply the techniques of the traditional design media applied to the computer. Finally, unlike engineering field, most architectural schools during the 1980s did not emphasize digital technology in their curriculum, and those that did concentrated on high-end research and software development rather than present-day practical applications (Sanders 1996).

This paper discusses some problems with integrating computers into architectural education that can be used in design and particularly learning and using design concepts. It frames these problems in terms of the current debate in educational research between constructivist and instructionist approaches. Although this paper is primarily concerned with the application of theoretical issues of concept learning in architecture, these issues will be demonstrated within a specific context by utilizing a specific concept: the concept of form building within the field of architectural design.

We believe that technologies do not directly mediate learning and computers are not only another medium of representation. That is, people do not learn from computers, book, or the other devices that were developed to transmit information and there is a "causal" relationship between the medium a designer uses and the outcome produced. Thinking is activated by learning activities, and learning activities are mediated by instructional interventions, including technologies. Researchers have shown that there is a reciprocal interaction between the medium and aspects of the external environment (Greeno 1988; Pea 1993; Perkins 1993; Salomon 1993) and this interaction is strongly influenced by the extent to which internal and external resources fit together.

Consequently, we can see the potential for a relationship between media and architectural design outcome when we consider it as an interaction between cognitive processes and characteristics of the environment (Kozma 1993; Salomon 1993; Salomon, Perkins and Globerson 1991). In order to test this assumption we are presently conducting a comparative research study that may suggest some answers to the theoretical as well as practical issues that will be discussed in this paper.

FIRST YEAR DESIGN STUDIO - COMPOSITION AND FORM IN ARCHITECTURE

The introductory design studio at Georgia Tech called "Fundamentals of Architectural Design" is a studio course which emphasizes design process and principles of form and composition. The ten week quarter is made up of short design exercises which focus on isolated formal design concepts in an attempt to build a vocabulary of basic organizational and form ordering strategies. A final design project of longer duration seeks to combine the lessons of the design exercises and apply them to a problem of greater complexity and detail.

These design exercises are abstract spatial compositions with prescribed volumes and elements intended to engage the student in an exploration of spatial ordering, parti transformation, circulation sequence, structure, and compositional concepts of field and figure, frontal versus oblique, symmetry, hierarchy, etc. The pedagogical intentions of this method are well known and have been attributed to certain faculty at the University of Texas circa 1955-57 (Caragonne 1995; Lonnman 1994). In particular the technique of form making using discrete and prescribed elements has come to be known as a "kit of parts" approach and has been adopted by many design educators as an effective vehicle for building a strong design skill base (Friedman 1989). An additional feature of the exercises also included in the final project is the thematic investigation of parallel wall structure as a spatial and field ordering system. Through experience we have observed that a system of closely spaced walls provides an advantageous point of departure, encouraging a subtractive (as opposed to additive) approach to space making.

The final design exercise is a project of longer duration encompassing all of the lessons of the previous exercises. Past cycles of this project have shown it to be very successful in confronting beginning students with questions of architectonic form in conjunction with constraints of program, site, and construction. Although abstract in detail, the nuances of the exercise elicit a rich array of design solutions, which serve as a reminder to students that despite the numerous restrictions and parameters which are placed on the problem, many formal design possibilities still abound.

In the past, students have been encouraged to explore the design at each stage using traditional cardboard study models, so that the three-dimensional implications of design decisions are fully understood. With movement and sequence as important characteristics of the spatial composition, interior views and the general architectonic quality of the design as seen from the inside take on greater importance. Lacking a careful examination of the form and arrangement of interior space, many opportunities to enrich the design from this point of view are lost. For example, the diagonal or oblique views that exist within a design structure that is primarily orthogonal, are easily overlooked if the visual representation is limited to the two-dimensional plan view.

Beginning design students naturally attempt to overcome the presumed monotony of the grid by inventing skewed, shifted, or warped planes which immediately display their nonconformity in plan. When the physical model is eventually created it simply confirms the earlier assumption of contrast provided by the skewed elements without really testing the corollary that a composition predominantly of right angles and orthogonal planes will produce a varied perspective including many oblique views. To be convinced, students need to view this concept directly in model as decisions of form are being made. However, because of the labor intensive nature of model building (or of changing a pre-existing model), the discovery is delayed and the effort to revise the project accordingly will often not be made.

With the integration of CAD in the design studio, students are able to quickly model their studio project from the outset. This is certainly aided by the abstract, architectonic quality of the design problem which minimizes the complexity of modeling. Using Drafting and Modeling programs (Auto CAD and 3-D Studio), the design students are able for the first time to really get their eyes inside the project and experience the changing perspective of the spatial sequence from a non-stationary view point. Based in part on this observation, it is our hypothesis that the character of a student's approach to design might change in subtle ways. Several discoveries can be expected. First, a new appreciation of the complexity that is created with just a few simple forms interacting with each other. Positioning of the object elements, for example, in relation to view and procession takes on greater meaning. Second, the circulation and spatial sequence can be studied as a dynamic problem taking into account the oblique views mentioned earlier. Finally, there is the ability to observe shadow and light and material overlays without compromising the attention to basic form.

In a series of views illustrating the parallel wall design project by Julie Hiromoto (Figure 1), decisions regarding the positioning of wall and roof planes, object elements, etc. can be examined with regard to their impact on the spatial sequence. In view 1A we see the cylindrical object on axis from a position near the entrance. Wide portal openings in the wall structure create a cross grain spatial zone in the foreground which has the effect of leading us directly into the center of the design as we move towards the cylinder. While this room is striated and subdivided by the deep beams of the portals (accentuated also by their shadows on the floor), its lateral extent is suggested by the alignment of the sides of the portals. This alignment implies a pair of transparent planes which continue past the cylinder appearing to intersect the wall plane in vertical slots immediately behind the cylinder. The actual dimension of these portals, which decrease in span towards the cylinder (see Figure 2B-2F), creates a perspectival illusion of telescoping depth, making the cylinder appear much farther away than it actually is. Finally the view reveals an open yet bounded space, not readily apparent in the exterior view of the project (Figure 2F).

As we move on axis of the cylinder into the space we cross a narrow spatial zone (Figure 1B) bounded at either end by paired columns acting to frame this area as an entry space. View 1C presents us with the interior of one of the covered side aisles. In contrast to the non-roofed aisle of view 1D, this linear movement space begins to exploit the possibilities of solid and void contrast in the character of the roof manipulations as well as in the placement of the three cubic solids (given elements of the kit of parts) which fill in the end bays of the parallel wall structure. Vertical slots in the end wall again continue the phenomenally transparent planes described by the edges of the portals and the faces of the cubes through the end walls in a manner analogous to the central space. Lighting plays a key role in animating these interiors; revealed especially in view 1C.

The remaining two views contrast frontal and oblique views surrounding the cylinder. In View 1E we obtain an oblique view around the cylinder in left foreground and into the main space. Looking back to the entrance from a position in front of the cylinder (View 1F) we note the opposite effect of the perspectival illusion described in view 1A. Here the openings of the entrance portal appear close as the space defined by the portals widens towards the entrance thus collapsing the apparent depth. The dominant central axis of the space is strengthened in the proportioning of the entrance portal openings with the central void being square; the inverse of the projected elevation of the solid cylinder.

THEORETICAL AND METHODOLOGICAL CONSIDERATIONS

Our approach integrates ideas about learning by doing and constructivist notions of learning. The constructivist theory of learning suggests that education is a creative human endeavor, and that its knowledge claims are not absolute (Driver and Oldham 1986). Constructivism attempts to link teacher dominated instruction (instructionism), the traditional didactic model of education, to student-led discovery learning, the progressive model of education. Driver and Oldham describe constructivist teaching as being characterized by a number of steps, such as orientation,

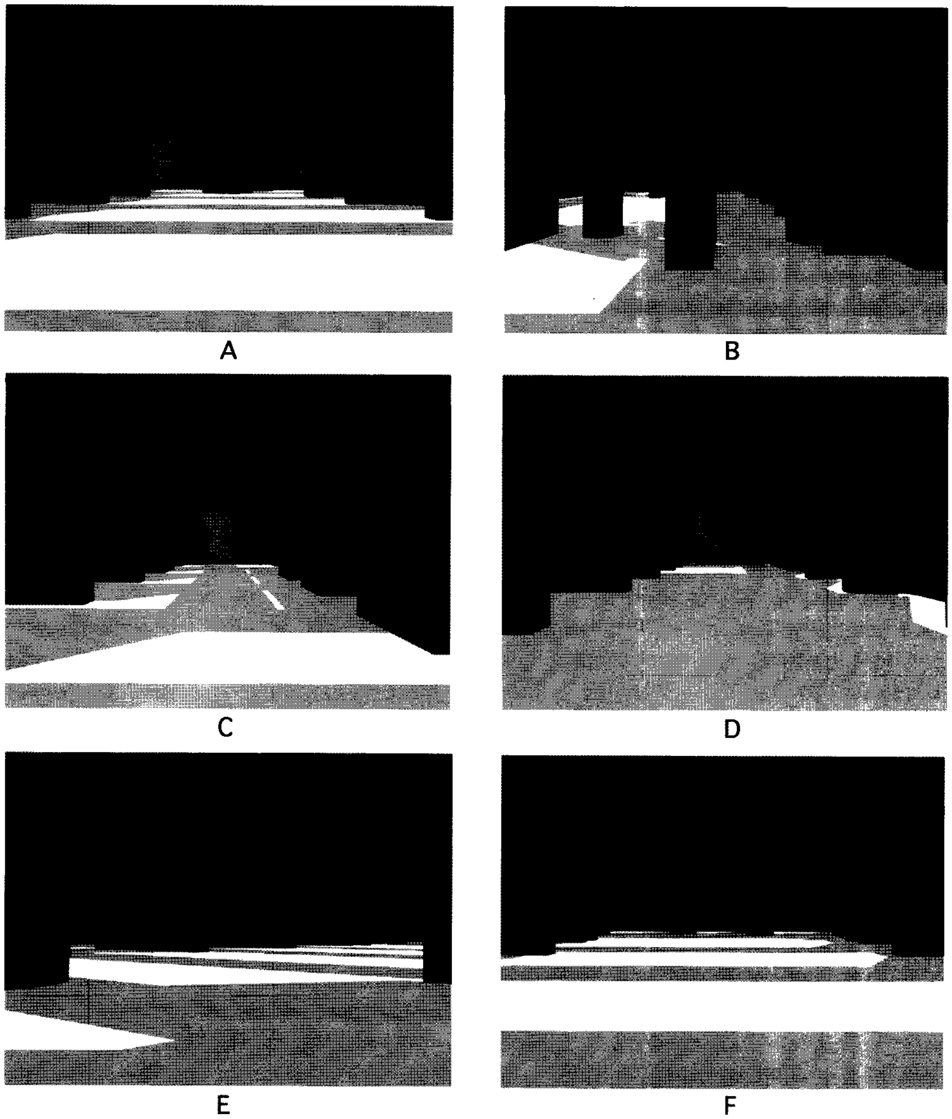

Figure 1. The parallel wall project: Positioning of wall and roof planes, and object elements.

elicitation, and restructuring of ideas. Constructivist methods emphasize the engagement of the student in the learning process and the importance of prior knowledge or conceptualization of new learning.

The model we are proposing is a means of permitting students to participate more fully in the learning process that will have an effect on their comprehension of the concept. The underlying theory of our approach is "media theory" advocated by Kozma (Kozma 1993), Salomon (Salomon 1993), and Salomon et al. (Salomon, Perkins and Globerson 1991). According to this theory, there is a causal relationship between the medium and learning. Each medium has causal mechanisms by which cognitive and social processes are influenced as students interact with medium's capabilities. Based on this framework, we believe that by integrating computers into the design studio, not only the end-product (that is, the design solution) will be enhanced, but also the design process as a cognitive affect will change. In terms of the product enhancement, it is our prediction that a more spatially rich and sophisticated project will be attainable. In terms of process enhancement, we think that students will adopt different design decision making strategies. Technological tools, if properly conceived and executed, should activate cognitive and metacognitive decision making strategies. They are computationally based tools that complement and extend the mind.

Their approach can be less intuitive and they can explore possibilities in the spirit of hypothesis testing. We assume that these exploratory processes are carried out in an organized and systematic way. In terms of conventional research on information-processing, mechanisms in human cognition, we would expect that local, serial forms of processing would predominate in the exploratory phase, where the search for "creative" possibilities would typically occur in a deliberate and controlled manner. For example, upon arriving at an initial parti , perhaps through sketch drawings and/or study model, a digital model is built on the computer. At this point variation and transformation is easily accomplished and a number of alternative studies can be created for comparison. Each new model is complete in terms of graphic representation, as this task is now an instantaneous operation on the computer. Various views, both external and internal to the model, can be examined. The experience of sequence as a progression might be studied in a series of perspective views. Subtle changes affecting interior lighting conditions (natural light) can be tested by trial and error. Although these kinds of comparative studies have always been encouraged by critics, and are common practice in some design offices, the amount of time involved in creating precise drawings or models by traditional means is a frequent dissuasion to the single student working alone. See Figure 2.

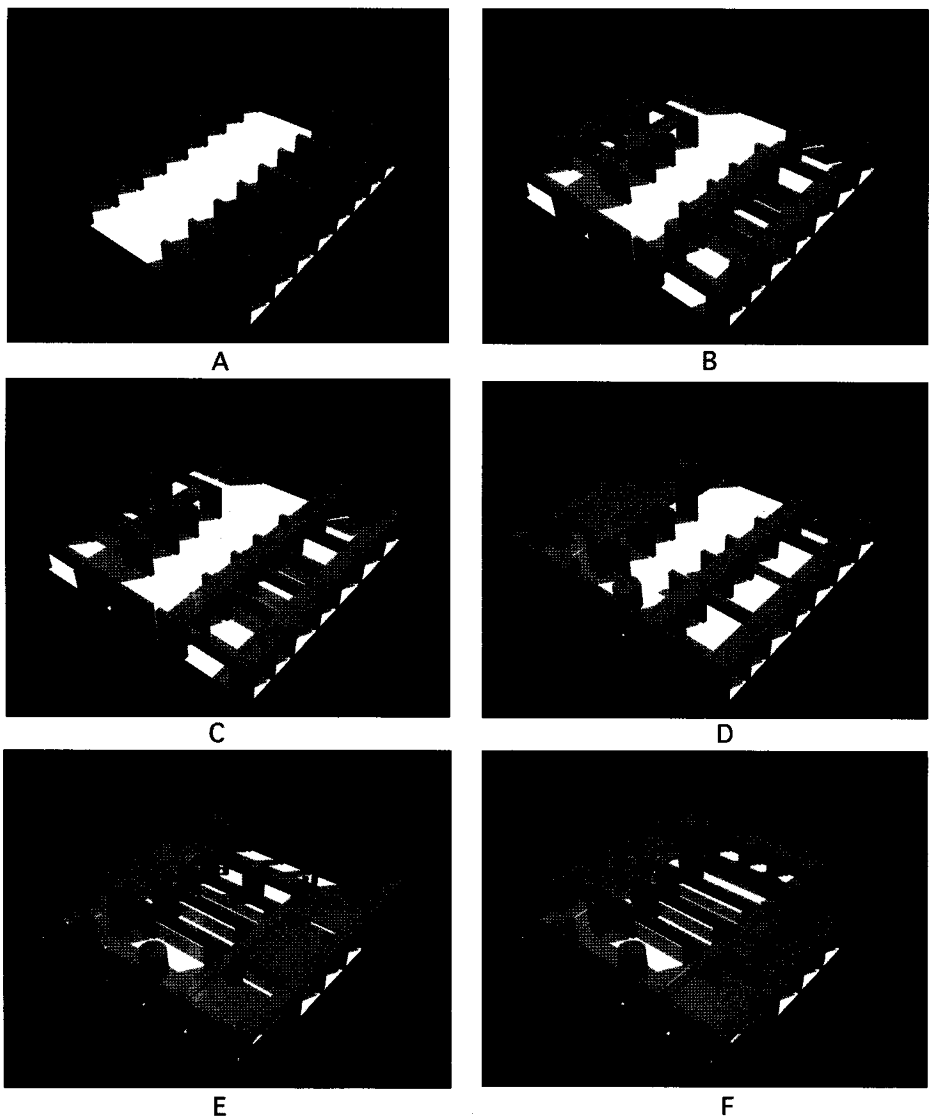

Figure 2. The sequence as a progression

We are also very careful by predicting "better" products. Structuring opportunities is a very different approach from that normally taken in cognitive research, where the usual procedure is to generate a set of predictions according to some model or theory and then measure accuracy or response time to verify the predictions (Anderson 1990; Shepard and Cooper 1982). Although these traditional paradigms have their usefulness, we prefer not to rely on them in our research. As a rule, we do not attempt to predict exactly the particular performance or the product according to "some criterion." It is useful to distinguish between predicting when students are most likely to create better products and predicting the exact nature of the products they generate. We are more concerned with the former.

In choosing the types of methods for our study, the goal is to devise experimental techniques in which the subject has the opportunity to create better products but in which the task can be constrained in such a way that it qualifies as a legitimate, scientifically controlled study. These can be 'restricting elements and components' and 'encouraging hypothetical exploration'. These techniques are not necessarily unique to our study; most have already been used to some extend in different research studies. We also need an operation to demonstrate that two variables (medium and design) are correlated. For that purpose, 55 undergraduate (first year) students are selected and their results are compared. Of these 55 students, 33 are registered for the Arch1023- First Year Design Studio and out of 33 , 23 are assigned to a control group that is used traditional design medium (paper, pencil, t-square, etc.). 22 students who are registered for Arch2322-Introduction to Computing in Architecture class are assigned to the experimental group and this group uses computers as a design medium and the usage of traditional medium is optional. Ten students are taking both courses at the same time. The comparison will be made by a blind review at the end, that is all design results are going to be presented in the same medium and evaluated according to similar criteria. This can be done by either converting the results of the experimental group to physical models or vice versa (converting the results of the control group to computer models).

DISCUSSION

This study has three goals: to describe a model for teaching architectural design concepts; to conduct a research about the relationship between the (digital) medium and architectural design; and to situate this particular study in a general theoretical framework called "constructivism. "It offers a comprehensive model for the constructivist vision of education in general, and for the integration of digital media into architectural design, in particular. It also offers a model for the kinds of research we find insightful and beneficial to our understanding of learning and development, thinking, teaching, education, and the use of computers to facilitate these processes.

At this stage, this study should not be viewed as a "controlled experiment". Pedagogical issues are quite complex, and one could formulate innumerable conjectures about the "real" source of students' outcomes. Nevertheless, we believe that this model will allow the creation of an integrated environment. In our view, a more complete understanding of the learning process can come through an integrative and accumulative process of experimentation and theory-building. This paper is intended as a contribution to that process.

One can hypothesize, for example, that learning architectural design concepts and applying them to the design process could have been affected by factors related to: the media itself; the student's constructivist involvement ; the integrated learning principle; and hypothesis testing methodology.

One important point we want to emphasize is that each one these conjectures, when considered alone, would give only partial information about this study. By considering them together, and their interrelations, we can make use of an holistic approach, -knowledge, cognition and transfer, and development of learning environments.

Reflecting on Kozma's media theory (Kozma 1993), it seems that we need to be able to answer the question "Why is this particular implementation dependent on the media it uses?" The theory suggests that answers to this question should describe matches between the symbol systems, processes, and technology characteristics of the task to be performed by the user to those of the media being used. In this case, the media of the learning environment and that of the subsequent transfer situations (the students' later design projects) are identical. In addition, the computer allows certain processes (e.g. data collection, immediate feedback) to be utilized at a level that would be difficult if not impossible for traditional media. Finally, decisions about whether to allocate some tasks to the computer or to the experimenter/facilitator will be based on issues that are part of media theory.

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