Facilitating Conceptual Change:
Computers, Cognitive Processes and Architecture

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ABSTRACT

Computers have gained universal acceptance as tools that designers use. However, computers are often not used to advance the design process but just to make drawings. Many architectural schools still focus on a production orientation, which puts the highest value on information management, precise representations and drafting enhancements.

Mostly, computer education is limited with button pushing and training manuals. It is the contention of the author of this paper that students in Design Studio courses can benefit greatly from computer based educational pedagogy designed to provide them with experiences they currently do not possess. In particular, little time in the computer courses (outside lectures) is spent applying concepts and features of digital tools in design studio environment.

In architecture, computers cannot be simply defined as a presentation and production tools. As a cognitive tool, computers provide designers with intelligible and effective representational tools of thought and communication, changes the syntactic structure of design. Consequently, the conceptual structure of computers impacts the conceptual structure of the design project, fosters the analytical processes and facilitates conceptual changes.

This paper describes the use of computers in a first year 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 the underlying cognitive processes that contribute designers' conceptual development

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Las computadoras han ganado un aceptación universal como instrumentos de diseño. Sin embargo, no son generalmente usadas para avanzar el proceso de diseño sino solo para hacer dibujos. Muchas facultades de arquitectura todavía mantienen una orientación productiva hacia la computación que asigna el más alto valor educativo en el manejo de la información, las representaciones precisas y el mejoramiento del dibujo técnico.

La enseñanza de la computación esta mayormente limitada al uso de manuales y pruebas personales. Es la posición del autor de esta ponencia que los estudiantes de Taller podrían benificiarse enormemente de una pedagogía educativa que haga un uso diferente y enfocado del instrumento digital. Por ejemplo, muy poco tiempo se devota a la enseñanza y aplicación de conceptos y aspectos de instrumentos digitales en el ambiente mismo del taller de diseño (usualmente esto temas son enseñados afuera del taller).

En la arquitectura, las computadoras no pueden ser definidas simplemente como herramientas de producción y presentación. Como instrumentos cognitivos, las computadoras proveen al diseñador con herramientas representativas efectivas para pensar y comunicar. Consequentemente, la estructura conceptual inerente en la computadora impacta la estructra conceptual del proyecto de diseño, fomenta los procesos analíticos y facilita los cambios conceptuales.

Esta ponencia describe el uso de las computadoras en el primer año de taller arquitectónico. El objetivo es el de desarrollar un proceso de diseño que sea redefinido por el uso de la computación, integrando concepto y percepción. Además, se presentan la fundación teórica y los procesos cognitivos que contribuyen al desarrollo conceptual del diseñador.

INTRODUCTION

Compared to other disciplines, architectural education places more emphasis on the skills students will need to be successful professionals. Thus, architectural education is generally defined as "a process that renews and reinforces the architectural profession" (SpreckelMeyer, Carswell et al., 1985). As society shifts from an industrial to an information-based society, many in the field have called for changes in the way students are being trained. In short, architectural education has become a pressing issue. How should we educate future architects?

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), Richardson (Richardson, 1993), Sapene (Sapene, 1993), Miranda and Gribou (Miranda and Gribou, 1993), Akin (Akin, 1990), and others have attempted to explore the integration of computers into design studios.

In general the integration of computers in disciplines such as architecture has been difficult 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. 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 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 is the main argument of this paper that computers as cognitive tools provide students with intelligible and effective representational tools of thought and communication, and changes the syntactic structure of design. Consequently, the conceptual structure of digital media impacts the conceptual structure of the design project, fosters the analytical processes, and therefore contributes to the students' conceptual development. Using digital media to represent designs in a descriptive way allows the students to describe the conceptual complexities by showing how a design works as opposed to how it looks. Once the students are introduced to the digital media, even at a simple massing level, the clarity, variety, and consistency of these concepts can be improved.

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. Finally, this paper proposes a design for a comparative research study that may suggest some solutions to the theoretical as well as practical issues that will be discussed in this paper.

COMPUTERS AS COGNITIVE TOOLS

Computers as digital media, unlike other media (the way it is defined in this study) are capable of offering their users an intellectual partnership whereby the cognitive burden of carrying out an intellectual task becomes shared (Salomon, Perkins et al., 1991). Salomon et. al argues that digital media serves as a "Trojan Horse," gradually changing the nature of whole cognitive environment, it facilitates higher order thinking by means of freeing the designer from tedious labor and other lower level repetitive processes that often block higher order thinking. It promotes thinking and cultivates it (Salomon, Perkins et al., 1991).

Semantically, the cognitive ability of media is based on the assumption that media do not directly cause mediation. That is, designers are not directly effected by and cognitized from media. Rather, mediation occurs by thinking as a mental process and thinking is activated by learning activities, and learning activities are mediated by instructional interventions, including media. Based on this definition, it is fair to assert that media in architecture can stimulate different cognitive activities and foster -or hinder- design abilities. Cognitive tools, if properly conceived and executed, can activate cognitive and metacognitive design and design strategies. Consequently, digital media in this context, may have the following cognitive effects:

- Extends and capacitates the minds of intentional learners
- Provides designers with intelligible and effective representational tools of thought and of communication
- Encourages "Inductive reasoning"
- Promotes the use of comprehension-related strategies. Together with representational formats, it enables designers to register changing impressions effecting design factors
- Facilitates cognitive decision making strategies

FIRST YEAR DESIGN STUDIO - COMPOSITION AND FORM IN ARCHITECTURE

The initial experiment was conducted at Georgia Institute of Technology. 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.

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 (see Figure 1).

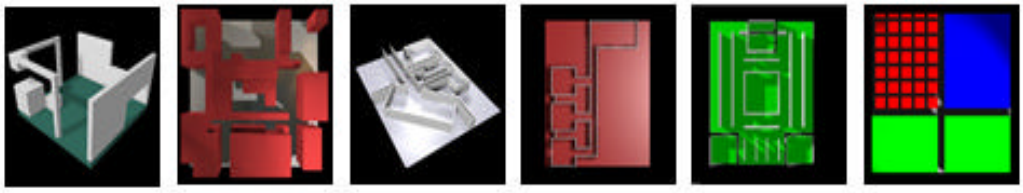

Figure 1: Design Exercises

As like many architectural educators, I believe that teaching by way of a "Design Kit of Parts" provides a lucid learning sequence from basic principles to enriched composition, while giving a vehicle for building a strong skill base (Friedman, 1989) .

The final design exercise is a project of longer duration encompassing all of the lessons of the previous exercises. In past quarters this project has been 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 suffice to provide 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 study the design "in model", so that the three-dimensional implications of design decisions are fully understood. In particular, the diagonal or oblique views that exist within a design structure that is primarily orthogonal, are often 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 cardboard or wood model is finally created it simply confirms the earlier assumption of contrast provided by the skewed elements without really testing the corollary that a composition of only right angles and orthogonal planes will contain a

varied perspective including many oblique views. To be convinced, students need to view this in model. However, because of the labor intensive nature of model building (or of changing a pre-existing model), the effort will sometimes not be made and the discovery made possible by getting into the space will not happen.

The integration of CAD in the design studio enables the design students to model their studio project at an early stage. This is certainly aided by the abstract, architectonic quality of the design problem that reduces the complexity of modeling. Using Drafting and Modeling programs (ACAD & 3D Max in this experiment), 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 (Figure 2).

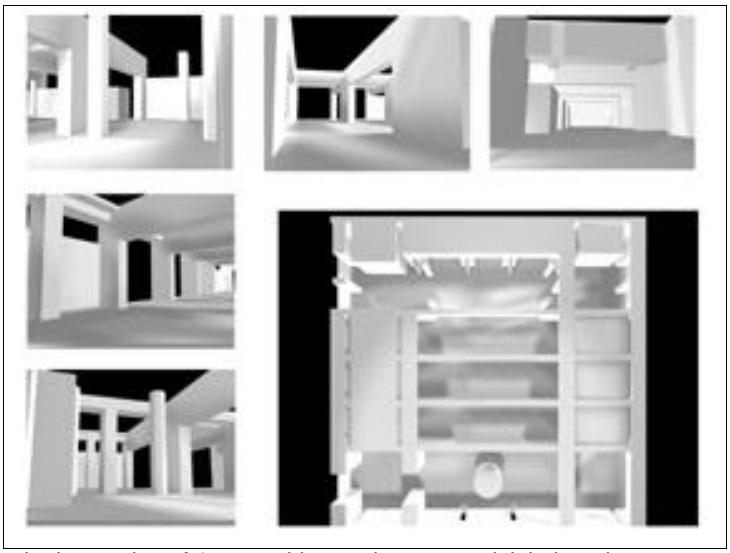

Figure 2: The integration of CAD enables students to model their project at an early stage

INITIAL FINDINGS

In all analyzed conceptual categories (parti, spatial organizations, and ordering systems), it was found that unclear conceptualizations were more likely to appear in manual media group regardless of the sequence of the concepts they employed. During the analysis, new "Unclear" category needed to be added to classify unidentified concepts. Another important finding of the concept development analysis that would appear to be an effect by the media was the variation of the samples. The manual media group seemed to produce some easy-to-built concepts and created fewer categories. For example, in "parti" development, the manual media users distributed their designs among two major categories. In "spatial organizations" and "ordering systems" the manual media users used three major categories whereas the digital media users distributed their designs more homogeneously over various categories. Furthermore, the resulting concept implementations by this group tend to be less complex and more ambiguous and displayed fewer features. The digital media group appeared to overcome this problem. These results indicated that from the manual media users' point of view, there was simply not enough flexibility and sufficient time to develop and explore a wide range of alternatives and refinements. This kind of exploration and efficient conceptual representation of content was essential for concept development.

Designing with an abstract system such as two-dimensional representations raises questions and creates problems, which are not immediately apparent. For example, the greatest difficulty that students experienced was their tendency to resolve a plan as a flat graphic pattern rather than as a drawing of a three-dimensional design. In this way, major organizational concepts could be developed which seem logical from the plan viewpoint, but which in fact may be relatively indecipherable, or could not be experienced in an overall composition. Examples of such problems were apparent in most of the manual media group's designs where the

conceptual intentions, which order and shape the plan were virtually unrecognizable in the perspective view.

DISCUSSION

These findings suggest an initial evidence on the issue that the conceptual structure of digital media impacts the conceptual structure of the design project, allows students to create more clear, consistent design concepts and to distribute them evenly. Manual design instruments handle a very restricted formal domain with limited flexibility and efficiency and obstruct concept exploration. Therefore, the group with a more flexible media (digital media) is able to examine different conceptual schemas and to create more variations. This kind of exploration is media bound.

However, more research is needed to support this argument. Mainly this study has three goals: to describe a model for teaching architectural design concepts; to conduct a research about the relationship between the computers 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 I 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, I believe that this study will allow the creation of a new research agenda. In my 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 concept and applying it 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 I 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 a 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.

REFERENCES

Akin, O. (1990). Computational Design Instruction: Towards a Pedagogy. The Electronic Design Studio. M. McCullough, W. J. Mitchell and P. Purcell. Cambridge, MA, MIT Press**:** 301-317.

Goldman, G. and M. S. Zdepski (1990). Twiddling, Teaking, and Tweening: Automatic Architecture. ACSA Annual Meeting, Washington, DC, ACSA.

Kozma, R. B. (1993). “Will Media Influence Learning? Reframing the Debate.” Educational Technology Research and Development(1): 1-31.

Miranda, V. and J. Gribou (1993). Integration of Computing into the Architectural Curriculum at Texas A&M University. Proceedings of the ACSA/EAAE Conference, Prague, ACSA Press.

Richardson, M. (1993). Technology and Computers: An Educational Approach. Proceedings of the ACSA/EAAE Conference, Prague, ACSA Press.

Salomon, G., D. Perkins, et al. (1991). “Partners in Cognition: Extending Human Intelligence with Intelligent Technologies.” Educational Researcher **20**(3): 2-9.

Sanders, K. (1996). The Digital Architect. New York, NY, John Wiley &Sons, Inc.

Sapene, C. P. (1993). CADD as a Design Tool: A New Approach for Teaching CADD in First-Year Architecture. Proceedings of the ACSA/EAAE Conference, Prague, ACSA Press.

SpreckelMeyer, K. F., J. W. Carswell, et al. (1985). Perceptions of Architectural Education: A Study of Attitudes and Trends in the Profession. Architecture and the Future: Proceedings of the 72th Annual Meeting of the Association of Collegiate Schools of Architecture.