The Transition of Computers in Design Education

Invited Paper

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INTRODUCTION

At the University of Virginia, a once predominant interest in "computer aided design" (CAD) techniques is becoming subordinate to broader interests in computer related design research and the more general application of computers to the practice of architecture, landscape architecture, history, and planning. This position paper describes some of the activities and makes a self-assessment of how information technology may be evolving within the Department of Architecture's curriculum. It makes a case for viewing information technology as subsumed under traditional areas of scholarship, and for viewing it no longer as a separate and isolated area of specialization. Specialized programs in "computer aided design" by definition may be making a too sharp-edged distinction between the use of computers and the broader set of scholarly activities that occur within schools of architecture.

The transition of computer based education from a specialized area of study into a more integrated part of the curriculum is not complete. Many schools now offer training in CAD modeling and drawing and other computer based visualization techniques. The use of computers in design studio may today fit comfortably into some schools and seems actively encouraged by the national accreditation review process.[1] Yet, computer abilities may be thought of as less vital than other traditional design abilities needed for the rough and tumble world of professional practice.[2] Although computer use is rapidly increasing towards full saturation of the design profession, the computer as a design tool is still viewed by some studio critics as besieging the finer aesthetic realm of traditional paper based media. The inclusion of it in the curriculum may be thought to be devastating upon or take valuable time away from the students exposure to traditional skills.

Arguments about computer literacy cut two ways. The unprepared design student who can not draw by hand may make his or her way through school relying upon computers, only to be unprepared when traditional skills are called upon in professional design practice. At the same time, ability in computer-aided design is viewed as essential preparation for entering the profession. Academic work with computers today in design appears to have one great trap: to achieve distinction one needs to claim expertise with respect to technology itself, and yet, this expertise sometimes carries the stigma of not really being interested in fundamental issues of design. This negative association may potentially obscure a more holistic approach to computer based and traditional paper based design methods that takes into view their complimentary rather than competitive qualities.

The label of "design theory and methods" rather than "computer aided design" may place computers more firmly within a number of traditional academic venues. Advanced studies in the field include such topics as knowledge representation, case based reasoning, shape grammars, constraints, geometrical modeling and visualization. Yet, in some institutions, these activities may take place on one side of an invisible sub-cultural divide, aligned in interdisciplinary collaboration with say computer science or cognitive science, and therefore perhaps perceived to be less directly concerned with the teaching of design.

Computer based design research is still a relatively recent phenomenon. It first emerged at schools of Architecture and Planning in the late 1960's and early 1970's. Early pioneers include MIT, UCLA, Carnegie Mellon, Cornell, and Cambridge University. Within the last 10 years, however, the computer as a teaching tool has spread to many schools as if sown upon the wind.[3] There may be some common approaches within these different schools with respect to teaching computer aided design at the introductory level. However, the schools may also be distinguished from one another in terms of bias towards certain areas of research, and differing attitudes towards the role of computers in more advanced courses and studio. For example, at UVa., the faculty have interests in a mixing of traditional paper based and computer based media. At other schools, the computer aided design studio may be more primarily based on computer media.

To establish a place for computer based work in the curriculum at the School of Architecture at UVa., it was necessary to consider research pathways that could cross the sub-cultural divide from the computer research lab and into the studio. The design studio is where students spend the greatest part of their day, and may be the core and most significant educational setting within the school.

RESEARCH INROADS INTO STUDIO

The most promising uses of computers in studio have roots within the long traditions of design methods. The "kit of parts" approach is used with traditional design materials in the introductory graduate design studio at the University of Virginia. It lends itself to computer based exercises where the kit consists of parent parts and also their children ***instances*** (see description of introductory graduate design course later in the paper). The adaptation of computers to studio is a two way street. On the one hand, the teaching mission is more closely achieved when use of computer technology is conceptually rooted in the design methodologies of the school. Converse, computer based design research at the school has some influence on the methodologies that emerge in studio. The idiosyncratic nature of these technologies is such that unless some underlying connection to design methodology is consciously incorporated into their use, much of the knowledge gained may otherwise as be as enduring as the all-too-brief life span of a particular product.[4]

Computer based design research at the University of Virginia School of Architecture is not conducted within a singular mind-set, but rather according to a number of separate interests.' These include: (1) the use of CAD and other visualization media in design studio, (2) exploring new representational techniques in geometrical modeling, (3) the application of computers to structure analysis, (4) lighting design analysis (5) site analysis and hydrology studies through digital terrain modeling, (6) planning applications of geographic information systems (GIS) (7) historic reconstruction of important works of architecture and sites, (8) electronic publishing, communication and instruction, (9) the merging of analysis worlds that cross disciplinary boundaries (CAD and GIS), or architecture and movie-making, or architecture and materials engineering. The school also holds promise for (10) computer-based design theory research as the graduate program re-establishes a stronger theoretical framework for master's thesis design program.

Most of these research areas may correspond to traditional areas of activity in design studio. Research areas (1) through (7) refer to uses of computer technology that serve directly as design media. Area (8) serves in the role of providing traditional reference material. Areas (9) and (10) offer non-traditional venues for newer interdisciplinary approaches to have a place in design studio. For example the use of animated mapping in an interdisciplinary design studio offers a framework of analysis that can be use to show how urban built form changes over time, and to identify causes and effects of more pronounced changes in urban growth. This technique is currently under consideration for an interdisciplinary urban preservation studio taught collaboratively at UVa.

HOW STUDENTS GAIN BASIC LITERACY

The essential skills needed to establish a working use of the technology are served by introductory courses offered through UVa.'s Information Technology and Communications organization (the university-wide academic computing organization). The university offers specialized courses in the use of scanning technologies, image processing, desktop publishing, spread-sheet database software, operating systems, word processing, electronic mail, the World Wide Web, and designing World Wide Web documents (HTML markup languages).

This new role of university-wide technical courses is significant because much of this exposure had at one time been a necessary part of introductory coursework within the academic departments of the university. These short courses are also in themselves a new kind of educational function served by the university, where the teaching load is no longer just the responsibility of UVa.'s individual schools and colleges. Today, instructors that use computer technology are beginning to assume that students have a decent working knowledge of these essential applications, or at least know where to direct students for appropriate instruction. The teaching mission within the school is less focused on basic instruction in how to use the technology and more on methods of using the technology which are important within the discipline.

Voluntary student ownership of computers at UVa. is an indication of a growing commitment to acquisition of basic literacy. A spring 1995 survey indicates that *65%* of graduate students and 54% of undergraduates owned personal computers, 54% own a modem, and 80% anticipated the need to acquire them for their work.[6] These figures perhaps validate the policies of other universities which require students to purchase computers. The student-owned computers are a "fact of life" in higher education. This spring term 100% of the students in all of the computer course were using electronic mail prior to enrollment.

EDUCATION SEQUENCE IN DESIGN AND COMPUTERS

A sequence of computer related courses might include instruction in CAD that provides basic competence in geometrical modeling. The introductory course at UVa., *Com-**puter-Aided Architectural Design,*** focuses on the reconstruction of existing works of architecture according to geometrical modeling and rendering techniques that explore their formal organization, materiality and tectonic qualities (see figure 1).[7] The students build "kits of parts" and combine them in different orders in order to reconstruct their projects. The skills and methodological approaches learned can then be applied to kits of parts design problems in studio. Citations and readings may include some modest exposure to ad-

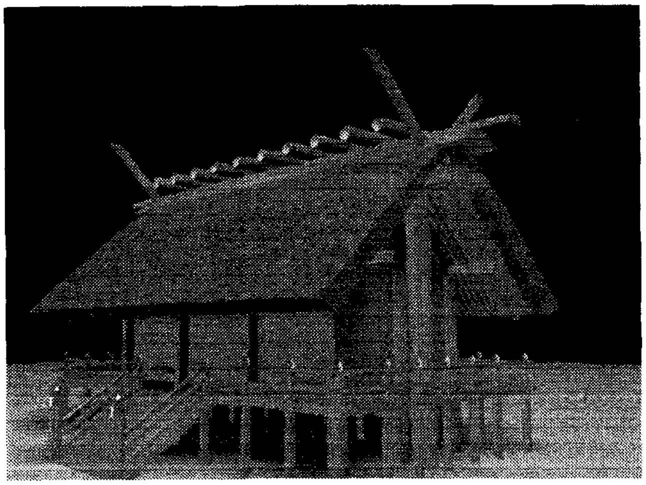

Figure 1: Ise Temple, Project by Matt Robinson, 1994

vanced topics that pertain to the use of technology and models of design process. For example, the topic of shape grammars extends the kits of parts idea into some additional formal studies.

A second introductory course *Computables of Architectural Design* explores the quantitative basis and invisible mathematical structure of architectural form.[8] This approach is less conventional in that students learn to make explicit certain computable phenomenon by expressing their understanding in a programming language. The students write computer programs which either drive a CAD system or directly create 3D computer graphics. They generate 3D geometrical patterns, and explore formal and spatial qualities found in nature and in architecture. For example, they may express the creation of some architectural forms as a recursive process (see figure 2). The output of the student programs include 3D fractals (see figure 3). Or students may develop a formal composition by programming a simple grammar based on a few base objects.

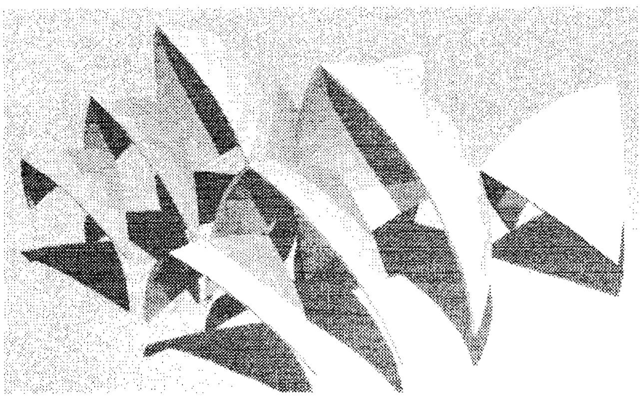

Figure 2: Sydney Opera House Shells, Sean Younis, 1994

A graduate seminar *Architectural Simulation* explores the potential of motion picture media, primarily computer graphics animation, to be used as a vehicle for examining issues of architecture in motion.[9] This is not only a course in animation technique, but is based on the study of such motion related phenomenon as (1) transformation of form over time (from real-time to geologic time), (2) transformation of light over time, **(3)** movement of the observer (or a walk through study), (4) movement of people and objects, (5) animation of the conceptual assembly of a building or place, (6) animation of the physical assembly of a building or place, and (7) montage of the related aspects of a design that may be formally or symbolically related although not necessarily physically juxtaposed (see figure 4).

The first direct application of computers to design studio is developed in a course titled *Computers* and *Design*. This course explores computer based geometrical modeling exercises in conjunction with design problems assigned in the entering graduate design studio. The computer lends itself well to "kits of parts" problems. Within the traditional paper based design studio, students construct the kit out of wooden blocks or other physical modeling materials. The kit of parts are then arranged and replicated in different formations to satisfy the requirements of the design problem. Similarly, the students build a kit of parts on the computer, and then replicate and scale the individual parts as part of their design process (see figure 5).

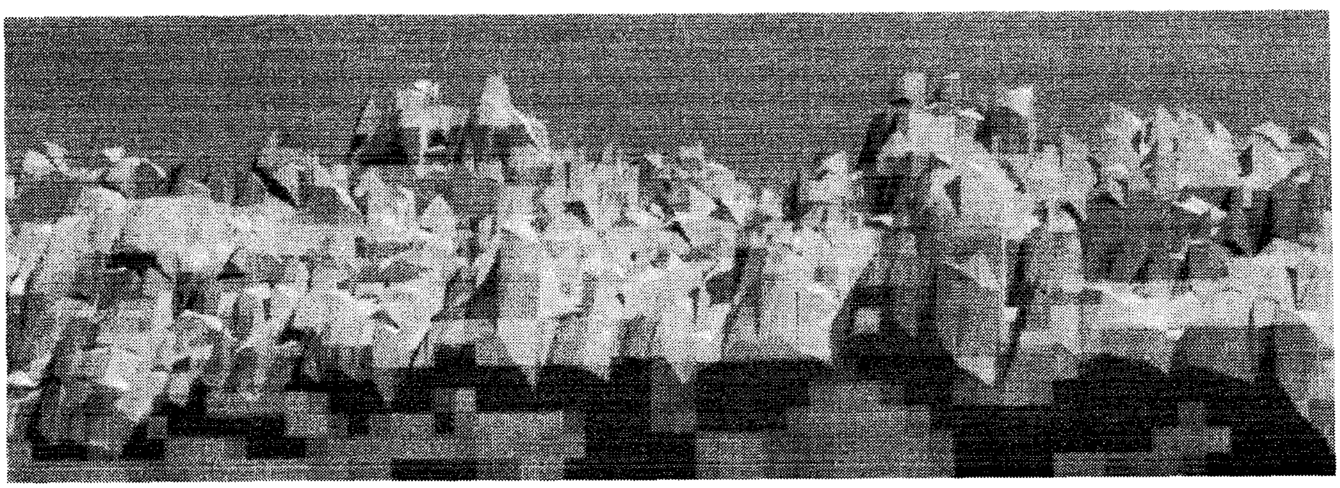

Figure 3: Fractal Mountain

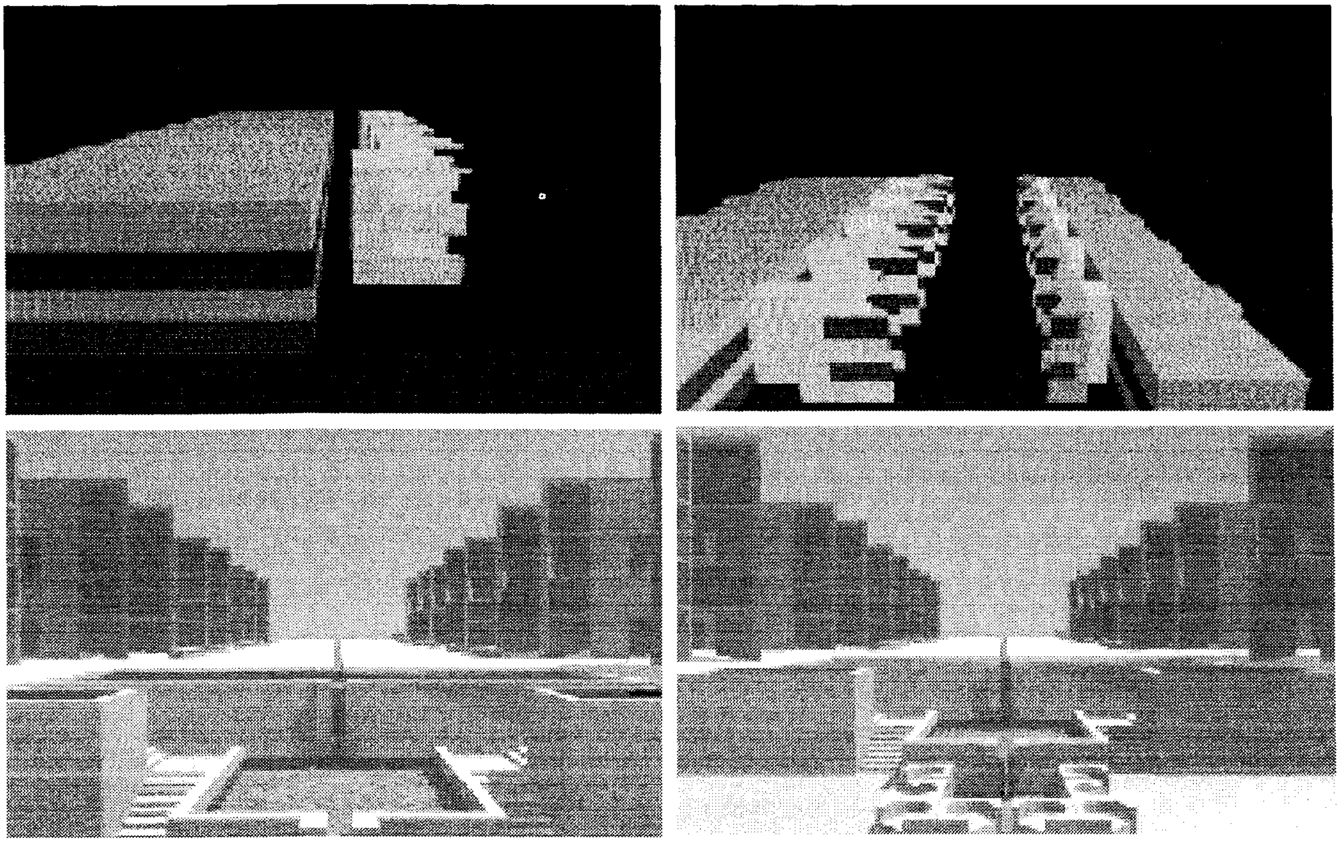

Figure 4: Frames From Animation Sequence by Han Yi, 1994

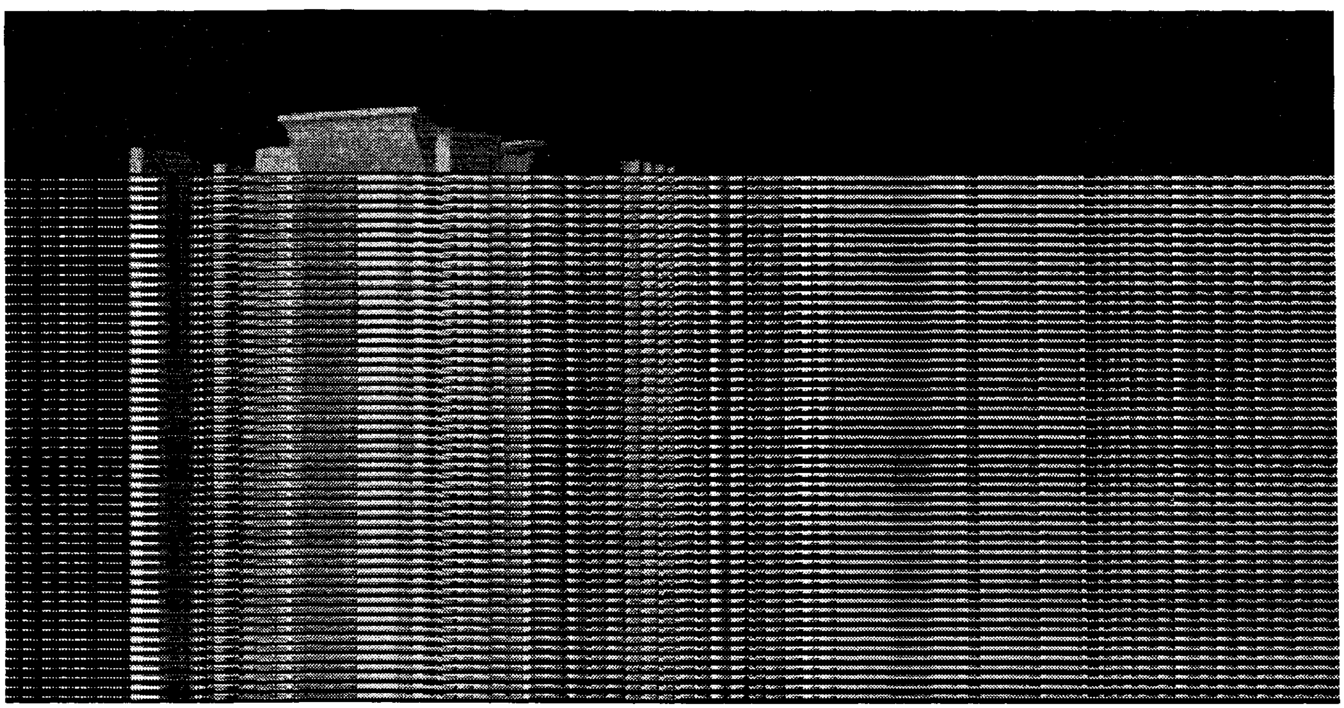

Figure 5: Kit of Parts Model, Vivian Su, 1994

An advantage of the computer-based kit is that the replication process is flexible and easier. A master component to each part of the kit is retained. Modification to the master component of a particular part can be automatically propagated to all the children instances of it used in a design. Therefore, the designer has the option to modify the design indirectly by controlling the shape of the master components. More sophisticated treatments of the kit of parts include the techniques of *instantiation, parametric variation,* and *constraints*.[10] The students also explore issues in lighting, rendering, perspective, materiality and other aspects of computer representation.

OPPORTUNITIES

Twenty years ago it was assumed that computer aided design would become a vital factor in architectural education." Twenty years from now, the computer screen might be regarded as no more unusual than the traditional drawing board. Computation may be widely dispersed in all aspects of an architectural education so as to be inseparable froincomework. The days of the computer lab as an island of isolation will perhaps end as experts within different fields of architecture are not just valued for their knowledge of the technology per se, but are distinguished by their ability to integrate the computer into specialized areas of teaching or research.

A promise of the technology is to make new representations of architecture to designers. The "kit ofparts" paradigm cited earlier has its roots in a traditional and physical modeling materials. However, a kit may refer to not only physically real objects, but also to less concrete representations. For example, we might use a symbol within the "kit" to represent the class of "wall" objects, or to represent the class of "green objects." Or the kit may include a symbol to represent the logical class of all "green *and* wall" objects. The concepts underlying these high order kits can suggest new approaches to representing the real physical world that may of value to designers.[12]

Recently, UVa.'s architecture faculty have been encouraged to provide written statements about their design methodology and theoretical interests with respect to studio teaching. These statements are presented to students at the beginning of the term such that the broader pedagogical intentions are consciously raised at the outset. Each studio is described not only in terms of its specific building program, but also in terms its methodological approach. The "kit of parts" concept is used to describe the introductory graduate design studio, and it encompasses an object based view of architecture. This trend is not unlike the long-standing search for explicit formulations that have been a goal of much computer based design research. Computer aided design encompasses precise descriptions of geometry, and also describes logical and other kinds of conceptual relationships among architectural objects.

The field of *Design Studies* is a telling way to label these mainstream research interests, whether handled on the computer or not. These research interests include the use of highly abstract "kits of parts" and other open-ended representations of "low specificity."[113] Design methodology is described in the *logical* terms of "additive composition" and "subtraction." The strong re-emergence of *Design Studies* may predict the waning days of computer aided design as an area of technical specialization. Rather, *Design Studies* may encompass *computer-aided architectural design* and place it within the broader context of how design theory interests are being articulated within the curriculum.

NOTES

This assumption is based on the accreditation report on UVa. which was completed prior to my appointment as a new faculty member there.

This became an issue when a computer graphics course at UVa. had been proposed as a substitute for a paper-based graphics course.

3 This is evidenced by the surge in World Wide Web home pages for various schools, as listed at http:/lwww.aia.orglschools.html.

4 Within the introductory course to Geometrical Modeling, there is extended discussion about the first CAD system. The significance of design methodology in the initial Sketchpad system experiment, 1963, is covered to place the use of technology within an appropriate context.

5 This work is now carried out by myself and a number of colleagues including Professors Michael Bednar, Donald Dougald, Kirk Martini, Ayse Pamuk, David Phillips Kathy Poole, Bill Sherman, Reuben Rainey, Bill Westfall, Richard Wilson.

6 *Survey* of *Computer Resources and Needs,* Spring 1995, Conducted by Daphne Spain, School of Architecture, University of Virginia.

7 See http://urban.arch.virginia.edu/~arch541/ on the World Wide Web.

8 See http://urban.arch.virginia.edu/~arch548/ on the World Wide Web.

9 See http://urban.arch.virginia.edu/~arch544/ on the World Wide Web.

10 These techniques are beyond the scope of this paper. They are described in Mark, Earl, *The Physical and Conceptual Assembly of Architectural Form,* Proceedings of the Symposium Cinema & Architecture, Department of Architecture, University of Cambridge, Cambridge, England, 5. 1995 (in progress, publication forthcoming from BFI Press, England).

11 Mitchell, William, *Computer Aided Architectural Design.* Published by Mason/Charter Inc. 1977.

12 This discussion generally refers to work on logical and formal systems such as shape grammars, or other related systems. The author's research is based on representing architectural objects within a multiple-inhcritance frame based system, *Conceptual Structure: A Multiple Inheritance Classification and Design System,* Ph.D. Dissertation, Harvard University, 10.1993.

13 Professor R. Dripps at UVa. uses these terms in describing a grammar of representation for the Palmyra Design Studio, a preservation studio taught Spring 1996.