The Future of CAAD Education

William L. Glennie
Rensselaer Polytechnic Institute
School of Architecture
Troy, New York 12180 U.S.A.

Abstract

The field of Computer-Aided Architectural Design (CAAD) is composed of two main threads of development, Academic and Professional, and can be described in three decades, which correspond roughly with three generations of computer systems. This paper presents a brief description of the entire period of school- and practice-based research and development on the applications of computers in Architectural design, and shows how these efforts have and have not been relevant to students' future experiences. Educators must take a fresh look at their current courses and research programs to make sure that they are relevant in the rapidly changing world of professional practice. With limited human and financial resources at most institutions, it is critical to make the best possible choices for the immediate and long-term benefit of today's students.

While it is not appropriate for Schools of Architecture to operate strictly at the behest of the profession, we must prepare our students for the world in which they will practice. Therefore, I believe that it is important for the faculty at each School to consider the following questions:

- 0 Are our students prepared to enter realistic positions as soon as they graduate?
- 0 Do they have the background necessary to use computers effectively in the future?
- 0 Do our research efforts have results that designers are likely to use today or any time soon to make better buildings or to make buildings better?

The First Decade (1962-1971)

In the beginning (the time of large- scale mainframe computers) came the academic, Ivan Sutherland, with his creation of the drawing program "Sketchpad" and initial work on virtual reality. Another early researcher was Nicholas Negroponte, with his vision of the "Architecture Machine," an expert assistant for the designer. Throughout this first decade, accomplishments were almost exclusively academic, as computers were too expensive for all but the largest design firms, and only a few schools took advantage of campus-wide computer systems.

one typical development was numerical engineering calculation programs, such as those for structural and mechanical systems. A significant parallel trend in academia was the appearance of speculation on a "systematic design method," which was to be similar in rigor and appearance to the "scientific method" and would guarantee good design in the same way that the latter assures good science. In its essence, the most succinct systematic design method can be stated as Analysis, Synthesis, Evaluation. Researchers at several institutions developed computer programs intended to assist in one of its three stages:

- understanding a design problem;
- generation of potential solutions to the problem; and
- determination of how well a proposed design actually solves the problem.

However, none of these efforts had a significant impact on actual practice. They may have been tested with one or two projects, but that is the extent of their realization.
At this time, there was no packaged software for Architects. To do any useful work, it was first necessary to create the programs. One of the few firms using computers actively for building design was Skidmore Owings and Merrill (SOM). By 1970, they had developed a program that could optimize the proportions of an office building to minimize the construction cost and to maximize the rentable floor area. Like almost every other program of this period, it was not graphical, relying instead on a collection of numbers as input and pages of tables as output. This was because graphic display systems were extremely expensive, beyond the reach of any design firm and even most universities.

During these years, graduates of the schools that were working with computers in Architecture created many programs used in practice. While there were very few positions for these early experts, most of them did not expect to pursue computer-aided careers. Because there was no prior history of computer use in design, there was no way for faculty to anticipate what kind of experience might be valuable for future designers. More of these graduates probably found rewarding employment as educators than as designers.

By the start of this decade of CAAD, the performance of minicomputers and graphic displays had increased to such an extent that they could be used for complex drawings, and their price had decreased to the point at which they were affordable to some medium and large design firms. Thus the profession began to use computers to produce construction drawings and other documents. These techniques and most of the few software packages offered had their origins in industry, with primary development occurring in aerospace and automotive companies.

Also during this period, an increasing number of engineering firms began to use structural and mechanical calculation programs, marking a successful transition from academic development to professional use. These programs were further developed to have some two-dimensional graphic output capabilities, such as mesh diagrams and deflected shapes, but were limited to numeric input.

At the same time, academic researchers began to experiment with three-dimensional representations. Wireframe and polygonal surface models could be created, manipulated, and displayed with hidden lines removed or with different shades of color on each surface. The use of graphic input devices (such as mice, thumbwheels and digitizing tablets) was an essential part of these programs. Some special purpose (and very expensive) hardware could be used to display dynamic images of simple three-dimensional (3-D) models.

Academic research with systematic design methods also continued and broadened. While most of these attempts were limited in scope, a few research centers developed programs that addressed the complete design of highly engineered buildings, such as hospitals and modular structures. Another area that saw extensive investigation was automated plan layout, often called space optimization. Work also began on understanding the rules of good design as analogous to a language, or "shape grammar." The energy crises of 1973 and 1978 led to the creation of several programs for the calculation of solar heating and natural cooling of buildings.

Very few of the efforts described in the above two paragraphs became a part of professional practice during this decade. The primary exception was 3-D representation, which had a very limited impact. By 1980, a few Architecture firms were using programs created by Intergraph, SOM, and other companies, which could manipulate 3-D models. This was largely due to the cost of the required hardware, which ranged well above $200,000 per user.

Around the world, by the end of this decade, there were only about twenty-five academic institutions that had a significant curriculum related to the use of computers in Architecture. Because the use of computers in the profession was still uncommon (fewer than 70 firms are listed in 1985's Pioneers of CAAD in Architecture), graduates of those schools continued to be responsible for making their own place in the world. In addition, there was so little activity in the profession that it offered no compelling guidance for researchers. Finally, the small number of computer positions that were available in practice and with program developers matched the number of graduates prepared to enter the field. Most entry-level positions required no computer knowledge.

The Third Decade (1982-1991)

The year 1982 marks both the start of widespread acceptance of the microcomputer and the formation of Autodesk (the company that produces AutoCAD, the most popular drafting program for microcomputers). This is the decade that has seen computers become commonplace in design firms as the price for hardware with enough power to manipulate complex drawings declined to less than

$5,000. And what are professionals doing with those thousands of computers? Their primary task is drafting, producing the same kinds of representations used by architects and builders for hundreds of years.
A few techniques made the transition from academic development to professional use, most notably those that relate to 3-D representation. In some cases, such as the rapid appearance of radiosity rendering algorithms developed at Cornell, there has been a very direct connection between industry and educational institutions. The long-promised rewards of virtual reality are also beginning to be realized through such joint research.

On the other hand, researchers at some schools have continued to pursue the still distant goal of totally automating the design process. Others have concentrated on developing solutions to particular aspects of design, such as lighting, heating, cooling, and acoustics. And there are entire Schools that have essentially ignored computers in their educational and research agendas.

Finally, there are new techniques developed in practice that have begun to be investigated in schools, such as video editing and overlay. The professionals who are working with this new medium are motivated in part by competition with other firms. Another factor is the enhanced understanding (and appreciation) of a proposed design that clients, zoning officials and members of the surrounding community can gain from realistic video images.
With the recent dramatic increase of computer use in Architecture firms, the demand for knowledgeable graduates has outstripped the supply, even though most schools have begun to provide some form of CAAD curriculum. The most significant hindrance to the widespread use of computers in academia is resistance from faculty and administrators who are not comfortable with this technology. Equipment that rapidly becomes obsolete and limited budgets have compounded the problem. Schools have been slow to adapt to the new reality of design practice, and many graduates do not have a basic understanding of the operation or future potential of computers.

The Future (1992-2001)

The next decade of development will bring major changes in the way that Architects do their work. Affordable computers will continue to increase exponentially in performance and capacity. While they will not eliminate the role of paper in the design process, the availability of systems that can manage elaborate three-dimensional models will have a dramatic impact on the nature and production of design development, presentation and construction "documents." Extrapolating from the past decade of development, the power of today's $200,000 Silicon Graphics "Reality Engine" will be available in ten years for about $4,000, which is well within the reach of most firms. What will designers be doing with that computational power?

- Interactive construction and exploration of "live," multi-viewer 3-D models.
- simultaneous engineering calculations (structure,

construction and operating cost, heating and cooling, mechanical equipment, lighting, electrical, piping), so that results can influence the early stages of design.

0 Dynamic (possibly real-time) combination of computer renderings with a recorded or live video source.

What research efforts will be most beneficial for the immediate future?

0 Formulate new "object-based" 3-D modeling constructs (methods and mechanics).

0 Create transparent two-way links between engineering calculations and geometric models.

0 Develop rapid techniques to extract point-of-view and masking (foreground/background) information from a series of video frames.

How can we best prepare our students for that future, using technology that is affordable today?

0 Provide 3-D model building experience with rendering & animation, which can be accomplished using inexpensive equipment and carefully chosen programs that do not require many hours to learn.

0 Integrate computer-based engineering calculations (within technology courses), although do not sacrifice the initial manual understanding of the various methods and algorithms.

0 overlay individual computer-rendered images with captured video frames.

0 Above all, we must help our students achieve a solid fundamental understanding of computer technology that will enable them to appreciate the unimaginable new

It is well recognized that the practice of architecture is changing. The opportunities for "green field" construction are limited and declining. Most of the projects that our graduates will encounter will involve renovation, reuse of existing structures, and infill construction. These situations are well-suited to the strengths of computers: a high degree of precision and the ability to modify previous drawings.

Another emerging area of concern is sustainable design, which is much more than the design for energy efficiency of previous years. While this is still important, there are additional considerations of resource conservation and environmental impact (both within the building and around the world). Once again, these requirements mesh perfectly with the use of computers: extensive calculations of energy use can be made easily, and a huge database of resource and recycling information can be searched in seconds. Imagine, for example, that the existing scattered companies that salvage building products are linked in a world-wide network. It would then be a simple matter to locate finish material or furnishings for a new project. As another example, designers cannot be expected to know all of the potential physical effects of substances used in buildings. By combining an expert system with the collected results of medical investigations, future buildings would be healthier places for occupants. By capitalizing on their unique characteristics -- a pool of inexpensive labor to create massive databases and the existing international connections through the Internet computer network -- schools can play a leading role in the creation of these new methods and information sources.

Another important role for schools in the future is continuing education. The practice of architecture has changed dramatically in the past decade, and many professionals are not equipped to do their best possible work. As the American Institute of Architects will soon require some form of life-long learning for membership, it is likely that state registration boards will implement similar procedures. Once again, by establishing a partnership between education and practice, all participants will benefit: schools from having an additional source of income, and designers from learning the latest tools and techniques.

What would be the result of continuing the separate, closed paradigm of the third decade? Education and practice would both suffer from the isolation from each other's interests. Our students would have to learn the appropriate tools on the job, making them less prepared for employment at most firms, which do not have mandatory computer training sessions. Our schools could not draw on the knowledge and experience of full-time practitioners as lecturers and adjunct faculty. We would also be likely to waste resources in the pursuit of results that are likely to sit on the shelf. Most professionals would be inclined to go on with business as usual, not making the modest changes in approaches to work that can have substantial benefits.

On the other hand, by understanding and promoting the trends that are already developing in the profession, academic institutions can gain valuable economic resources and less tangible support. our graduates will inspire rapid advances in practice, by demonstrating immediate real advantages. We can have some assurance that our research efforts will have a noticeable near-term benefit for the profession. As an unknown sage once said, "The way to be a leader is to find out which way the crowd is running, then get ahead of them and yell 'Follow me!'"

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MultiMedia in Architectural Education

Volkmar Hovestadt
Institut fuer Industrielle Bauproduktion IFIB
Prof. Dr. Niklaus Kohler
Universitaet Karlsruhe
Englerstr. 7
D 76128 Karlsruhe

fon: + 49 (0)721 608 2168
fax: + 49(0)721 661115
e - mail: volkmar@ifib1.ifib.uni-karlsruhe.de

Abstract.
Introduction
Developments in the field of Computer Science and Architecture are leading to new relationships between these two areas, which should influence architectural education. I would like to present a model in which the new possibilities of computing in the field of multimedia are experimentally introduced in architectural education.
[*keywords : multimedia, video, intelligent buildings, autonomous buildings*]

Computer
Developments in Computer - Hardware and - Software show a clear trend towards more intuitive use of computers.
Progress in hardware has resulted in the integration of different media , like audio, video, speech, telecommunication, new input devices or new display devices. On the side of software one call make out developments in *multimedia* environments with graphical, audio-visual interfaces, the integration of different systems for images, video or sound editing, CAD, DTP, animation, simulation and different expert tools on one database platform with multiuser abilities. Besides the integration of different media, one interesting, area for us is the increasing *dynamics* of information. Thus animation gets more and more important in contrast to just graphics.
In the last years especially the offer of multimedia products is increasing and the price becomes affordable for universities.

Architecture
The architectural planning process in its individuality and uncertainty is characterized by the integration of different media and planning instruments and thus it can be called *multimedia* based. The described possibilities of computers fit more and more these characteristics.
The more it fits, the more one can think about a real introduction of computer facilities in creative areas like architecture, especially ill early design stages.

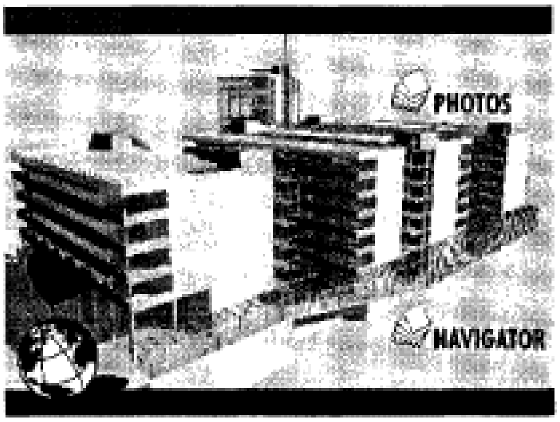
In architectural discussions *dynamic* aspects become increasingly important. First there is the new understanding and sensibility for the environmental behaviour, for the energy and material flow of buildings and its influence on planning in the form of simulations and life cycle studies. Second there is a speeding up of social movements and the change of social needs which makes it nearly impossible to fix problems over time. Third, the increasing integration of industrial production methods to architecture changes the architectural planning towards a more strict time management, just in time production and parallel and cooperative design. Last but not least, the increasing number of "intelligent" building components, such as "intelligent" facades, new airconditioning installations or fire control and access control systems, make the building structure itself "moving". All this leads one to the conclusion that architectural planning can't be fixed any more to one single result, but instead of this should see its further step in the process and control of this dynamics. Temporal behaviour of buildings, components and building material during their daily, yearly, usage cycles as well as the entire lifecycle becomes a new and important dimension in the architectural planning process.

Zukunftswerkstatt : Neues Planen mit Neuen Medien
(Factory of the Future : New Planning with New Media)
The described developments in the field of computer and architecture are in their preliminary stages. One can only make out the phenomenon of convergence of these two areas, but it is not yet possible to give any professional solutions. It is still a big field of experiments, of testing, how out- thinking about architecture, how the planning process will be influenced by the new media.

Since 1992 the IFIB has focused on this problem. It has assigned different design problems of an experimental character to the students. The task has been to design, emphasizing the dynamic processes in architecture with the new dynamic tools, mostly using animation and multimedia techniques. The students are working with all media, like hand-sketches, CAD drawings, video and sound, texts and photographs, which they combine through the design process into computer animation. The final presentation medium is a videotape.
This educational approach is integrated into the year's research effort of the IFIB in the field of CAAD. Our research on this area hits made clear the importance of multimedia for all integration questions in the architectural planning process and the meaning of interfaces between man and computer.

Selection of design problems
intelligent buildings, working
tables, of the future,
design space,
autonomous structures
threedimensional cities

Illustrations
video frames of Christian Ziegler



Technical equipment
hardware:
ethernetwork of 1 Macintosh Quadra 700 (video-in, -out, sound-in, -out, MIDI),
7 Macintosh llci
scanner, lprinter, video recorder, camcoder, videocutter, TV, CD, MC
software:
MacroMindDirector, SoundEditPro, Premiere, ModelShop, InfiniD, SwivelMan, FormZ, Architrion, MiniCad+, PhotoShop, PageMaker, MSWord, MSExcel etc.

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