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Low-Threshold Modeling

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This is a case study of teaching at the University of Texas at Austin. It is about using an electronic design studio to provide architecture students with their first exposure to computing. It suggests that, despite the limitations of present technology, there is reason to lower the thresholds to computer-aided design. The study presents a studio which attempted such by allowing students to find their own level of commitment to use of electronic media for geometric modeling. More generally, the paper aims to document issues presently facing the many professional schools not having substantial traditions in computer-aided design education.

Response

Fascinated with our creation, we think ourselves dependent upon computing:

The computer was not a prerequisite to the survival of modern society; its enthusiastic, uncritical embrace... quickly made it essential to society's survival in the

form that the computer itself had been instrumental in shaping.

Wanting it to usable by all, we have learned to cover up its inelegant insides with convenient interfaces:

"Paradoxically, by virtue of digital computers, mankind may soon ignore the numbers." 2

Even in a discipline as small and conservative as architecture, we feel great practical and intellectual pressure to respond to the possibilities of computing. In contrast to the few who have researched and developed systems for computer-aided design, there will now be the many who actually use the stuff.

While the computer, (whether in its current data structures or in its very essence), may be inadequate for the work of speculative design conception that so preoccupies architects, it is already very good for the work of structuring, developing, and presenting, which design professionals really spend most of their time doing. While CAD researchers may still work on methods which do not generalize well to complex, useful problems, and CAD users may have done work without subtlety just for the sake of having it on the machine, computing today is in a position to help us *make beautiful things.*

Education

Schools hope to change their ways in order to provide general and critical introductions to computing for everyone . Computer-aided design education must now speak not only to a technical cadre but to the best and busiest of mainstream designers. Geometric modeling, which is easier than ever , makes computing both attractive to designers and teachable in a studio setting.

Most design schools, including the one discussed in this study, have recently become involved in such work, but few have an orientation toward research and development . Instead, they focus on professional education, where an immediate response to computing is in demand. Whether or not by choice, they use commercial technology, 'shrinkwrapped' CAD systems, which have power, ease, documentation, reliability, and support to make them more useful than in-house systems, but which also have their costs: using precise, production-oriented programs for ambiguous, conceptual designing requires great care. Technology-driven teaching can be academically impure 6 Work of this nature often has none of the image of scientific legitimacy so often sought after by researchers, and may have yet to develop any of the image of artistic legitimacy which presently motivates most architecture students and teachers.

It may be in the artistic realm that the design schools will more strongly influence good use of computing in *architecture. These* could be the places to disrupt the architects perception of the computer as a necessary evil, useful solely for documentation, (and therefore to be avoided by the aspiring). This perception, which holds partly as a matter of computings weaknesses mentioned above, and because of cost, owes also to habit: within the design education studio, the sense is that method was found wanting some time ago

and at the moment, for better or worse, improvisation dominates. To date, computing has mostly opposed this habit; it would do better to alter it, or if not that, then to serve. CAD must be accessible, intellectually, physically, and socially.

This is a case study of a studio that allowed students having no prior experience to seek their own level of commitment to use of computer-aided design. Hence the title: Low Threshold Modeling. This sort of studio was able to educate students who would never before have been interested. In comparison to its more specialized (and albeit less well equipped) predecessors, it was the most successful yet conducted in its school.

Conditions for the Lower Threshold

There are many necessary components to low threshold modeling. Some of these have only recently become available; this case study describes the first studio in its school to reach many of them [figure 1].

To begin with the technical conditions, which are more explicit: sufficient hardware is whatever will keep most students challenged with things other than compensation for machine performance. Given just about any current cpu power, sufficiency is then in fact more likely to be distinguished by peripherals. Adequate color is especially important. Display list processing (e.g. hardware zoom) helps. Laser printing (and not mechanical pen plotting), is a necessity not just for transfer to manual media, but for purposes of daily criticism.

With respect to software, this paper and its topic are made possible by affordable three dimensional modeling. On specific issues: software must be reliable, easy enough to use fruitfully in the first month, capable of delineation in any plane, and capable of rendering. It must allow rewarding returns on a wide range of time investments. In addition, software users must have adequate operating systems support 8 The costs of working without any of these should be self-evident. Beyond these necessities, particular advantages follow from integration of modeling with image processing techniques, and availability of an environment having sufficient stability over time to allow cumulative learning.

In communications, the value of a network differs from that in professional situations; users here do not continuously share files. A network does offer easier sharing of peripheral devices and better control over software dissemination, but its greater value here is allowing use of many applications per project. In this way, the network serves to educate about the increasingly incremental and multi-media nature of computing environments.

The main social components of the lower threshold are access and with it relaxation. These can be a matter of logistics (dedicated machines, preferably almost one per student, and around-the-clock availability) or of atmosphere (correct lighting, artsy clutter, proximity to the traditional studio). They are realizable today. The idea is to minimize departure from the attitudes that motivate the studio.

Less obviously, accessibility can also take the form of ready conversion between manual and electronic media. The ability to fall back on manual methods can make it easier to try the electronic ones.

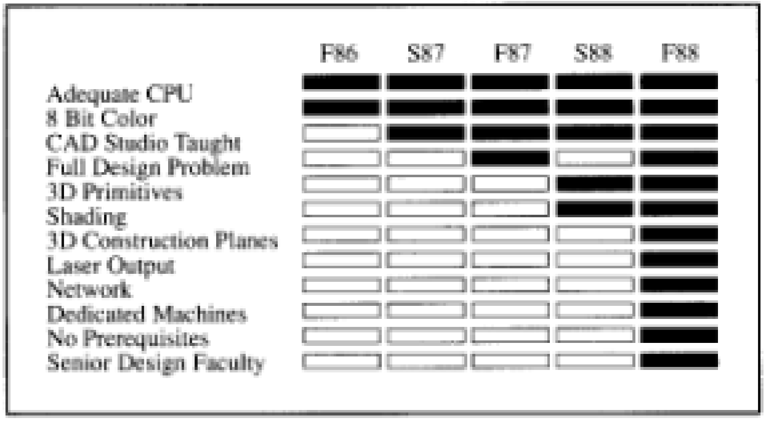


Figure 1 Arrival at CAD Studio Conditions

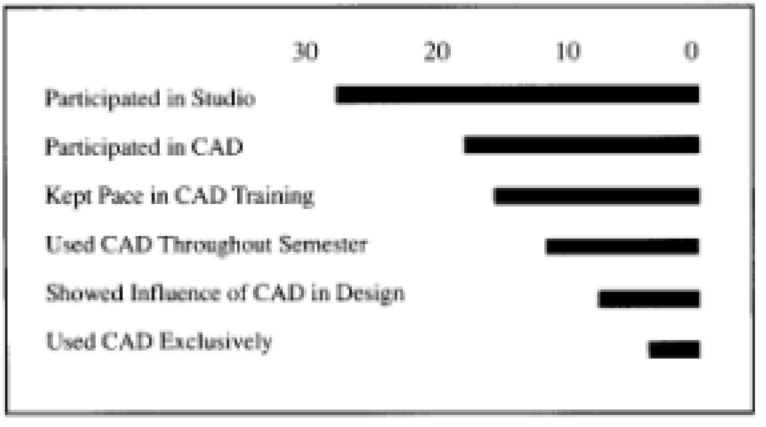


Figure 2 Students Using Computer-Aided Design in the Studio

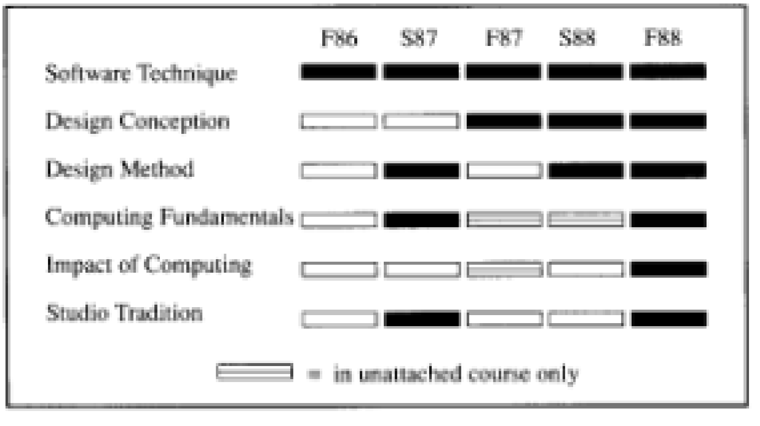


Figure 3 Topics of Investigation in CAD Studios

Access is also very much a matter of curriculum. If qualification for a CAD studio requires a lot of foresightful preparation within already overloaded student careers, most people will never have it. If the studio is perceived as a haven for those somehow deficient in conventional abilities, or as primarily a celebration of technical mastery, the busier designers are often the ones least likely to participate.

On the other hand, if the electronic design studio is presented as an imaginative way to develop what has become necessary knowledge, then CAD can become more attractive. If an established designer participates in teaching, perhaps to assess computing himself or herself, the students will follow.

In summary, sufficient access depends upon the possibility to investigate computing without much prior preparation, on a full time basis, in a relaxed setting, without having to abandon manual methods. What must then occur to maintain rigor has to be very intensive.

Studio Format

The studio described in this case study took place in the fall of 1988 at the School of Architecture of the University of Texas at Austin. Co-teaching with the author was senior design faculty member Lance Tatum. The thirty participants were fourth- and fifth-year undergraduates and third-year graduate students . The majority had never used a computer before. Two thirds of the students were concurrently enrolled in a support course on computing, and had the option to apply CAD to any extent in their work [figure 2]. These students were also enrolled in a support course which, when combined with the studio, allowed for almost undivided attention. The remaining third of the people planned to work manually the whole time.

The studio began with a two week site analysis from an urban design perspective, followed by an intensive three week software training period, and finished with a nine-week investigation of a design problem on the analyzed site.

The systems used included twelve dedicated PC / AT workstations equipped with expanded memory and eight bit color (PGA), and the Autocad release 10 and Autoshade software packages 10

The main design problem was chosen on the basis of having a strong context, the textures and planning of which would minimize the tendency with the computer to treat projects as isolated formal constructions, a simple program, clear hierarchy and modularity of which encouraged logic and inflection in the schemes, and arts-oriented clients, who could appreciate the innovative look at their buildings that the studio would provide.

The review format emphasized the combination of manual and electronic work and encouraged comparison between projects developed using the computer to varying degrees.

While the studio demanded mastery of software, the support course encouraged understanding of the conceptual basis of computers and subjective consideration of the impact of technology.

The studio built upon experience from efforts in its three predecessors [figures 3 and 4] and took advantage of always-better technology. The three earlier studios included a computer-only workshop doing two-dimensional problems, a mixed media studio using 2 1/2 D and manual methods on a straightforward building design, and a computer-only studio using three-dimensional modeling through macros to do pavilion studies 11 .

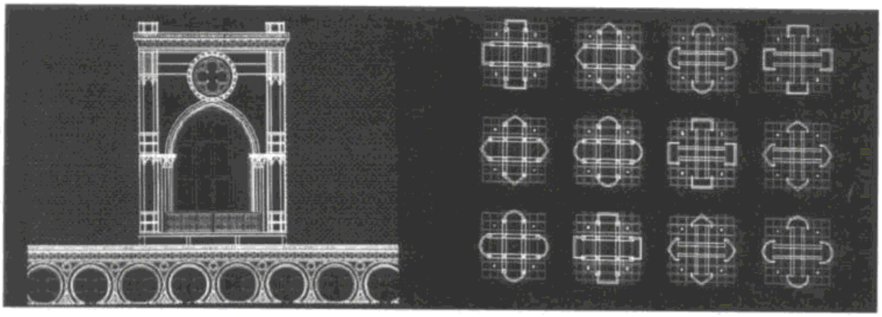
This studios format was innovative in this school in many respects. It was the first to integrate computer-aided design for use on an optional basis by a subset of its participants. It was the first to use off-the-shelf threedimensional modeling software. It was also the first computer studio to be cotaught by a senior faculty member having no experience with CAD. Finally, it was the first computer studio without any prerequisite software course.

Teaching the Low Threshold Studio

Teaching computer-aided design to neophytes at the same time as using it to resolve a substantial design problem is the essential problem raised by the low threshold strategy. Such a challenge is not ideal, but is forced by the already overwhelming amount of subject matter that young architects face in a few short years in school. Few of today's risk-averse students are ready to give up a valuable studio to one in which portfolio quality results are less guaranteed, and fewer still are willing to work hard on anything other than the studio, so the computer-literate design instructor is lucky to get exactly one semester with most of them. During this time, there are several teaching priorities that come into play [figure 3]. Here are a few that we faced:

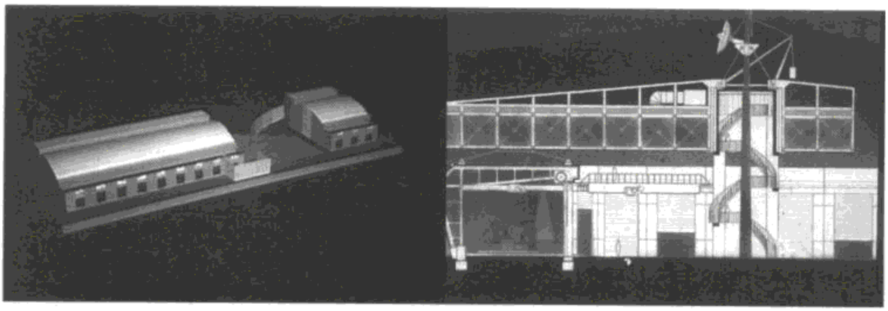
Technique-Skills, which still come first, can come fast. In three weeks, the studio moved through two-dimensional measured drawing of a neoclassical facade, two-dimensional logic manipulations on a motif and variations, and three-dimensional construction planes followed by surface construction and shading for a simple pavilion [figure 5].

Conception-The computer was presented as a means of structuring and resolving, as opposed to fully conceiving or merely documenting design. Its use called attention to the influence of any representation, including the pencil, on the issues considered. Its externalizations were predicted never to become a substitute for imagination [12] Its limitations as a medium were presented as the source of strength for design [13] In the long run, it was asked not to disrupt the



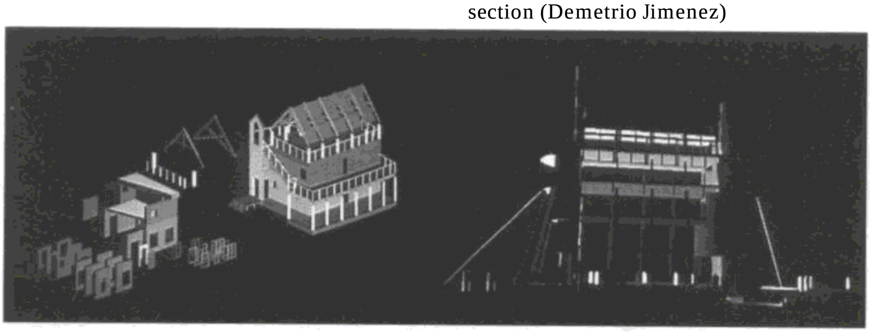
(a) two dimensional delineation, historical work (Andrew Kjellberg)

(b) dimensional cycle of variations (Eric Kotila)



(c) first 3D work (Kirk Ellis)

(d) mixed media: airbrushed plot of a section (Demetrio Jimenez)



(e) pavilion parts study (David Nobles)

(f) pavilion lighting study (Ron Bateman)

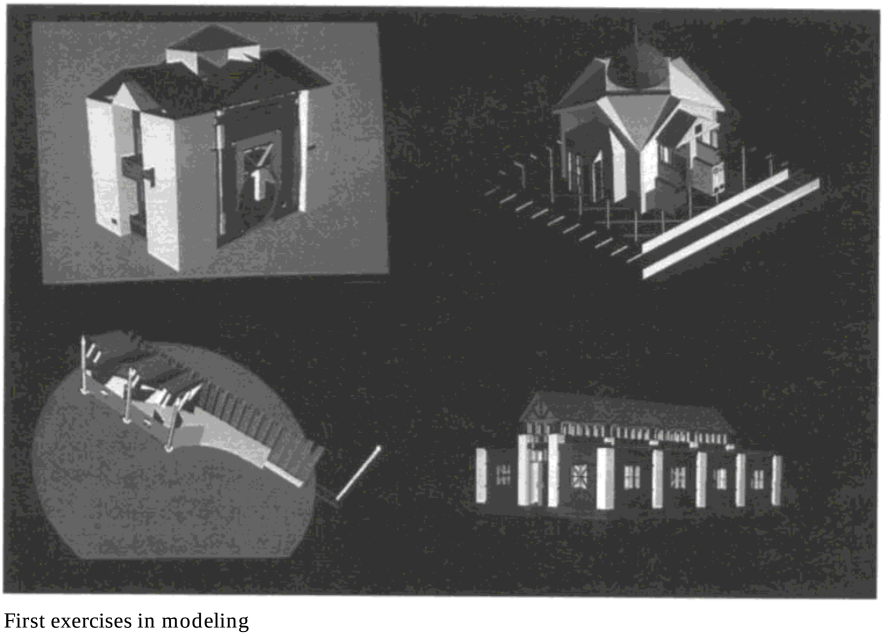
Figure 4 some work from the three preceding studios importance of the reflective process or the unconscious content of expertise, 4, but nevertheless was presented as capable of strongly influencing design thinking.

Method: While there was no attempt to alter any current pattern of improvisation, the studio did guide the students through a kit-of-parts approach to geometric modeling and a combination of analytic and experiential presentations of resulting designs. Attention was to design logic or construction and not to numerical description. Computer is the wrong name for the systems we used; ordinateur is closer.

Technology: It was presented that comprehension of the basis of the underlying technology improves the chances for best use of CAD. Lectures outlined fundamentals of hardware, software, and data structure in the most general terms possible. An exam helped students to distinguish concepts and identify trends in the technology. Students were to have a detailed idea of what happened 'under the hood' when they drew a line.

Interpretation: While applying computers in the studio, the students also read from selections intended to show contrasting expectations of computing in the longer term. Much to contrary to habit, they then formulated their own positions in responding papers.

Social Conditions: Students rapidly identified preconceptions by writing short papers in the first week. They learned software technique fast and hard before the studio chemistry was set. They made the mood of their work area more relaxed by means mentioned earlier.



First exercises in modeling
(Tracey Denison, Pat Tangen, Mercedes de la Garza, Michael Mauldin)

Knowledge-Presented as a justification for current inconveniences was the eventual possibility that computing could make it possible to restate the principles of architecture more eloquently.

Observations and Consequences

The primary advantage of this studio was the opportunity to reach busier and better students; the primary disadvantage was the tendency to overwhelm weaker ones. It is the opinion of the author that for the first time at UT Austin, a representative sample of the most talented and creative students enrolled in an electronic design studio 15 Such a trend has important implications for eventual improvements of computer-aided architectural design media, for it will bring new input to the debate on better data structure. Here in the short term are some observations on progress toward artistic legitimacy:

-The best-received designs were more dependent upon the capacity of the students than on the choice of the medium. Juries inexperienced in critiquing computer graphics had no trouble identifying well conceived projects.
-Several of the projects showed distinct influence of the computer upon their content. Some were designed expressly for the experience of walking through, (which could now be represented more easily than on paper [figure 6]). Several showed a clear hierarchy of components [figure 7]. Fewer showed the stylistic clichés that were currently fashionable in the school. On the other hand, fewer showed attention to material and texture, which were all but impossible to represent on the software at hand, and fewer were as completely resolved as those done with familiar media.
-The least-resolved designs were those of students for whom the computer amplified any lack of confidence. Faced with designing a building, and learning to model, the weaker students did neither. They did imitate manual methods and got locked into flawed schemes, insignificant aspects of which they resolved in great detail.
-Concentration upon three-dimensional modeling reduced the tendency to treat the software as a drafting system. The experience of genuinely drawing in three dimensions was enough to disrupt many habits.
-The computer interfered with criticism. It disrupted the conventions of formal juries, and particularly discouraged overviews in individual consultations.

Figure 6 Walk-through (David Wolff)

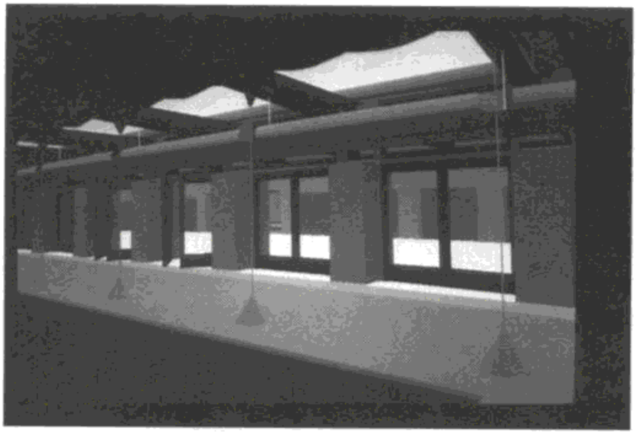


Figure 7 Kit of parts (Peter Funk)

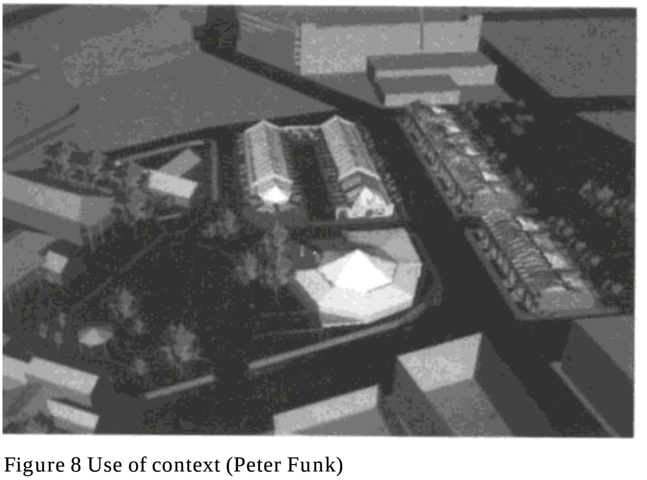


Figure 8 Use of context (Peter Funk)

Figure 9 Interior modeling (Tracey Denison)

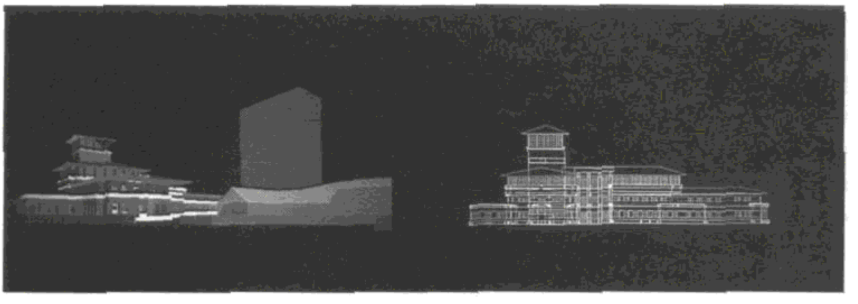


Figure 10 Combination of modeling wih conventional drafting (Michael Mauldin)

There are several concerns with logistics:
-Those who gave upon the computer did so quickly. The early conceptual stages of the project, during which the system's precision was most spurious, coincided with the early stages of learning technique, which are the most difficult.
-Overall, the output of the studio was hurt by the computer. Everyone spent a lot of time waiting through view regenerations.
-The main cost of the studio was in design education lost by those overwhelmed by the new medium. Working well with the structured models of current commercial CAD systems had a higher threshold in design ability than in technical facility in particular it required much more specific knowledge and images of what was being designed. Many of the students needed confidence as designers first.
The main advantage of the studio was the chance for most of the students t develop a strong sense of the capabilities of CAD through intensive use of and critical choice over its applications. Use of a new medium offered fresh angles on fundamental issues in design. The wide range of levels of use of computing coupled with the lectures and readings allowed many students to go away with a sense 01 perspective on the technology. That several people suggested improvements that are viable or in progress today illustrates that expectations were neither too high nor

bound by the media at hand. Among the improvements requested were: faster hardware, good color hard copy, the ability to express texture, the ability to represent simple formal relations without having to express them in cartesian coordinates, allowance for painting and sketching over vector and polygon images, easier data management interfaces, and the ability to draw more with operations on shapes.

Recommendations

Testing the premise of low-threshold modeling has resulted in these reinforcements of or contributions to our knowledge of computer aided design eduction:

-Low threshold modeling is a reality. Current possibilities include conducting a meaningful studio using off-the-shelf technology, for the successive stages of learning to model to be stimulating enough to motivate the students to proceed to further ones, for students to go from no experience to proficiency in geometric modeling in a few weeks, (provided that is about all they are doing), and for students to alter their commitment to use of the computer during the course of a design project. It is also possible, if the necessary conditions described earlier are not met, for none of the above to occur.

-There are unresolved difficulties in both criticizing and altering designs represented exclusively on the computer. Not only because people lose time learning the new medium, this kind of studio will produce less work than a conventional one.

-The real threshold to computer-aided design education is design ability, whose presence or absence CAD amplifies [16] The low (social) threshold should include a high-pass (design) filter.

-Theoretical supplement to the studio is important. Presentations of the fundamentals of computing help to maintain rigor in a situation where concessions to expediency in confronting a design problem might not. Discussions foster a critical attitude instead of blind acceptance.

-The studio can be the correct place to introduce the computer in design education. Nowhere else is there enough time for simulataneous development of both intuition and technique. Within the studio, daily use of the current technology produces genuine interest in any accompanying explanations of computing theory. Also, the studios prevailing conventions and biases fall under study in the presence of new media.

-Making computer-aided design with all its current shortcomings accessible to talented and influential members of the design community promotes a useful debate which benefits all.

The conditions which make computing more accessible without sacrifice of clarity or capacity are becoming easier to achieve. By lowering the threshold to computer-aided design education it is possible to reach a wider range of students. It is possible to improve the quality of the application and criticism of the CAD medium, to raise the extent to which the design community becomes aware of computing's implications, and to encourage students to actually use the computer to learn about design.

Acknowledgments

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Notes

I [Weizenbaum]

2 [Davis & Hersh]

3 For a normative position on this issue, see an editorial by 1987 AlA president Donald Hackl, in *Design Graphics World,* Feb. 1987.

4 Thanks, for example to 3D in standard AutoCAD, easy and innovative modelers on the Macintosh, and affordable, appealing, links to painting and image processing.

5 [Solomon] notes 57% of ACSA member schools using computers in the studio in 1988. A few years earlier, *Pioneers of CAD in Architecture,* Kemper (ed.) 1985., accounts for only ten schools. But studio case studies aside, the present volume cites present research in only seven American archiecture schools.

6 On such sophistry: "They... do in fact teach nothing but the opinion of the many... might compare them to a man who should study the tempers and desires of a mighty strong beast who is fed by him-he should !earn how to approach and handle him. you may suppose that when he has become perfect in all this, he calls his knowledge wisdom, and makes of it a system or an art, which he proceeds to teach, although he has no real notion of what he means by the principles or passions of which he is speaking. Plato, *The Republic,* Book VI.

7 As this generalization relates the computer, see [Bruegmann]

8 Mastery of data management remains a crucial factor in achievement of successful projects done mostly or entirely on the computer.

9 Much of the didactic nature of the teaching described here is based on the undergraduate audience; teaching postprofessional students would be another matter.

10 AutoCAD has an undo trail which is indispensible in lowering thresholds and powerful user coordinate systems for disrupting old drawing habits.

11 [McCullough]

12 It is sad that this even has to be said. See [Meurant]

13 [Gombrich]

14 [Dreyfus]

15 Despite the efforts of the registrar to reduce all students to numbers, documentation of this occurrence would be very difficult.

16 This is interesting in juxtaposition with the fact that many professional firms cite reluctance to enlarge as one incentive for automation. The thresholds to becoming an architect may be increasing.