1. **The Computer-Aided Studio Critic: Gaining Control of What We Look At**

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This paper presents an approach to teaching that put computer resources in the hands of a studio instructor. A design professor or tutor that is expert in the use of the tool. The studio master used the computer to "study" the propositions of students. This was done as an extension of his current teaching practice. The critic used the computer as another tool additional to discussion, pencil and paper, and working models. Computer walk-throughs and visual representations of concepts were used by the professor to convey his interpretation of the work to students. In this model the students did not have to use the computer. The model recognized the years of experience and expensive equipment required to create an adequate representation of a design scheme and view it in the very short time period available during desk critiques. This approach for studio teaching has not been identified and discussed in any depth in recent literature on CAD studio teaching. The emphasis of papers presented at CAD conferences has been on how to provide students with better software and skills needed to make effective use of computers in their studio work.

**An Emphasis In the CAD Literature on Better Training, and Training Methods**

A body of knowledge and experience with using computers in design studios is emerging in the conference proceedings of ACADIA, ECAADE and CAAD Futures. The authors of papers in these proceedings are reporting the results of their efforts to use various tools, and methods to introduce computers to the curricula at their schools. It appears that people are very encouraged by their experiments. People are discovering new ways of looking at designs and analyzing them.

This positive outlook is tempered in almost every case with an overwhelming concern that the students skill and the type of problem be carefully matched in order to realize the positive results (1). Today's technology is not automatic nor as easy to master as word processors. Computer aided design is not an easy medium to just pick up and use without training or experience. A consensus exists that if one wants to avoid spending 50% or more of the time in a studio devoted to training activity then one needs to carefully prepare incoming students. McCullough (McCullough et al. 1990) cautions that when the threshold for adapting to computers is too high for students, particularly weak students, they may be overwhelmed by it.

A student's skill level is possibly the most profound variable when trying to use today's technology in a design studio. Rubinger (1988) believes that "To derive the benefits of CAD, it is necessary to be fluent in its use. But if design studios are about learning to
design, it is not productive to try to learn computer applications at the same time. CAD applications must be learned, and learned thoroughly."

The analysis in these papers and most other papers is directed towards the issue of getting students to a level of achievement with the tools that permits them to master the medium enough to use it for creative expression. Zdepski & Goldman (1986) identify several issues they believe must be addressed. Two of the questions they believe must be asked are;

"what is the start-up time for students to use CAD usefully?"
"what are pedagogical implications?"

Jordan (1988) feels that a subtle obstacle to the deployment of computers has been methodological uncertainty. Should one look at the use of computers in terms of "tool-building" or "tool-using". The issue of literacy extends to the wise or appropriate use of a tool in design not just the technical proficiency of the student. Brown (1987) is concerned that pedagogical objectives are too often lost to an apparent lack of fit between the tool and its proposed use. Steinfeld (1988) ran an, "... experimental studio designed to explore how the act of learning the CAD tool could also be educationally valuable. To compensate for the expected decrease in productivity, design studio projects of limited scope can be offered." He established a pedagogical strategy to compensate for the productivity loss.

It also seems that critiques at the computer terminal or at final reviews spend an inordinate amount of time consumed by technical issues rather than the design objectives of the students work (Fox 1990 & Harfmann, Swerdloff, Kalay 1986). Omar Akin (1990) asks us to look at how the tool changes the way we design. He also feels the computer has the potential to change the student, instruction and the instructor. Discussion about the role of the professor as an active user of the technology in interactive visual debate is largely absent from current papers.

This paper originally set out to review the roles described in recent CAD papers of the studio critic and the critic's skill level. I was unable to find enough to discuss. I noticed that the vocabulary used in the papers is centred on phrases such as; 'the system does ....', 'the student can ...', or 'it allows the student to ...'. I never found the words - "the professor showed ..." or "the professor did".

It seems that most of us (including the author's previous articles) are writing about the mechanics of our systems and the syllabi of our courses. There is an amazing lack of discussion about the professors and their activity on computers. We are not looking at our own ability to use the computer to preform our role as studio critic and coach. Based on verbal discussions I have had with these and many other attendees to these conferences and visits to various schools I know that some of the authors are trying to use computers in this way. However, we are not writing about or debating this point formally in the literature on computer-aided design.

**A Role Model for Using Computers in Studio Teaching**

The following is an attempt to define an alternative role model for computer-aided design teachers that addresses this deficiency.
In conventional teaching practice students are the initiators of most if not all of the visual material used in discussion. Verbiage is the primary representation used to express spatial ideas by reviewers in final presentations. Visual material is often limited to occassional gestures made toward drawings on a wall. Even in desk critiques, verbiage is often the primary medium used to discuss designs. Pencil and paper is used less frequently for very schematic drawing and occasionally a wall or a tree on a working model may be manipulated by the professor to convey an idea to a student. I contend that this normative lack of emphasis on visual language can be ameliorated through the use of computers capable of supporting visual communication as a dialogue.

Computers should add the capability for two way visual dialogue to the review process. We should begin to use computers to foster the use of visual representations as not simply passive devices intended for the delivery of a message. It is time that we use visual representations as a more important part of the professor's language. Computers should be able to provide the capacity to generate pictures as a form of visual "discussion". Desk crits and even final reviews should become two way visual discussions rather than one way visual propositions followed by only talk on the part of the professor.

If as the literature contends, well trained students are able to use computers to improve geometric precision and the turn-around-time necessary to include perspective images or other forms of analysis in their work, then well trained professors should be able to employ computers to be more effective in their role as critics. If a studio teacher is proficient and literate in the use of this medium, why should the professor not bring serious professional tools into their work with students.

This approach seeks to make it possible for the professor to directly communicate and explore a student's design visually. In this model visual material moves from being a passive medium (controlled by the student) to an active participatory medium. If the professor can have active control of what we see and parametric control over some of the critical dimensional factors of the design, the professor should be able to work directly with the student to expose a whole series of design decisions the student has made but does not yet implicitly understand how her or his abstractions are manifested in the design. The balance of this paper will focus on the pedagogical role of professor as computer-aided critic rather than as an instructor of CAD.

The paper traces an experiment in which the author used his own computer tools in a junior design studio he teaches. The author became the computer-aided design critic for a week in the fall of 1990. The success of this test lead to a decision this year to change our curriculum and strategy for computing in Landscape Architecture. The next section will outline the experience in studio teaching at Toronto that lead to this experiment.

The Tools We Use in Studio at Toronto: Seeing & Intuition

We believe that the advances we have been making in research at Toronto are too valuable to be left only to the end of the educational cycle in our senior design studio. We now have a generation of tools that are extremely useful in making three dimensional ideas explicit and understandable to graphically inexperienced people. It is my contention that our research tools may be more profoundly useful in accelerating spatial literacy among our students than they have been in the professional environments where the spatial perception of professional users may be more developed.
The Programme has been fortunate to have a limited number of Silicon Graphics workstations that are made available for teaching during studio hours and off hours by the Centre for Landscape Research. Research funding has completely underwritten the efforts to use computers in studio over the last several years. The Centre has one silicon graphics 4D-310 VGX workstation capable of drawing 500,000 lit polygons per second, one 4D-70 GT workstation capable of drawing 40,000 lit polygons per second, one 4D-25TG and two 4D-20TG personal irises capable of drawing approximately 20,000 lit polygons per second. We also have a fairly comprehensive set of software tools that we have built to undertake a series of professional projects and previous senior design studios in the Centre for Landscape Research.

Our first paper in the ACADIA 89 Workshop identified our premise regarding representational speed and interaction. The goal being to engage a users intuition. We discovered that the optimum threshold for the response of graphics to a users actions was 1/4 to 1/2 second refresh rate and that one could tolerate up to a 1 second refresh rate before the act of exploring a line of thinking in front of the computer had to be preconceived before undertaking an action. At that time, we had to limit the representational budget to 1000 facets or polygons in an integer right rectangular coordinate space. The modeler we developed represented our hypothesis (a 4 dimensional hypothesis that can only be adequately captured on video as an expression for communication). Then in 1989 we began using the Silicon Graphics 4D series workstations. The advent of faster geometry engines and a hardware z-buffer permitted us to transfer our experience with shaded lighting representations of design ideas into an arbitrary polygonal (boundary representation) floating point coordinate space. This technology began with a $40,000 price tag and is now (3 years later) available as a plug-in graphics board for 386 DOS computers in the $3,000 to $6,000 range. We have found that one can effectively represent a massing model or a part of a building design such as a lobby using a representational budget of 5000 polygons. It is very important that one adapt the level of abstraction to fit with the computational budget if one wants to employ the technology for the kind of intuitively driven design exploration we have posited.

The fourth year studio in Landscape Architecture at our School uses computers to help students see their work in a manner that allows students to discover for themselves the merit of a design. This is accomplished through direct observation of the design in perspective. We believe that if students can learn from mistakes that they can compress the amount of time necessary for them to develop an adequate level of experience with a problem. We have successfully applied computer graphics to the problem of improving our students perception of their work. The time it takes a student to achieve this state stands as a major impediment to introducing these very useful tools to students in the early years (Danahy 1988).

It takes fourth year students 3 to 6 weeks of introductory exercises in studio to achieve this level of proficiency. This technical skill in the operation of a computer is not the same as being literate in its application. I find it very difficult to get students to make wise judgements about the abstraction of design ideas so that the representations are useful and also computable in real-time. This skill takes experience and more than 3 weeks introduction to such a totally new medium. I have found that even when I carefully monitor the progress of students, they have a compelling desire to push whatever level of computer they are using past its useful function in the pursuit of more detail. This will often occur
even when they have not firmly defined the spatial concept of a scheme. By the end of the
term last year, over half of the students were able to develop designs using 3 days of
computer time that external reviewers thought represented the work of a 4 to 6 week
problem.

I have speculated for some time that this kind of learning about scale and dimension in
visual perception would greatly benefit first or second year students. It is the author's
feeling that these tools may be even more useful in accelerating the spatial literacy skills of
first and second year students.

Learning computer-aided design tools to a level of mastery that permits a user to
develop ideas as a direct result of using the computer as a representational medium is a very
time consuming process. Papers addressing the subject of developing computer literacy
generally present a pedagogical sequence taking from between two and three preparation
courses before students are well enough prepared to be able to enter a computer-aided design
studio and not have students spend 50 to 100% of their time devoted to learning the tool
being used in that studio.

A question raised by this paper is that it may be a better use of resources and professors' time
to lead by example. A conclusion could be to put a high-end system in the hands of an
expert critic than a few less capable systems in the hands of students.

Teaching Landscape Architecture at Toronto : The Role of Second Year Design

The School of Architecture and Landscape Architecture at the University of Toronto offers
Bachelor of Architecture and Bachelor of Landscape Architecture degrees. The first year
design studios at the School are intended as a general introduction to design. Architecture
and Landscape Architecture attempt to make the first year studios as interconnected as
possible. The School has had a mandatory introductory computing course in the third year
for several years. Its usefulness in preparing students for senior design studios has been
largely non-existent.

In 1990, the School's curriculum committee decided to move the computer course into
the first year with the drawing and visual literacy sequence. In the past, the course tried to
be all things to all interests and seldom satisfied any one interest's needs. It is generally felt
that at least three preparatory courses would be required to cover the range of material that
had been given as a mandate for that course. Instead, the time allocated for computers is
being incorporated with the first year skills course. This course is related to drawing and
visual literacy. The focus of the computer component is on two and three dimensional
modelling. This content parallels the principles being addressed in the drawing, physical
model making and photography workshops of the course. The School's overall strategy to
computing is to use computers anywhere that staff are willing and able to bring it into core
courses and selected studios. Landscape Architecture has had the benefit of significant
research resources and full-time professors capable of integrating computers in subsequent
courses.

Second Year Landscape Architecture Design Studio introduces students to the
fundamental types of comprehensive landscape architectural problems. It is also a year that
is focused on teaching design process and graphic expression in a variety of mediums. The
year is divided into problems characterized by either natural systems or social / human use
determinants. Landscape architecture draws a significant percentage if its students from non
design areas. Many students are prepared for the natural sciences. Architecture on the other
hand, tends to attract a majority of people with strong interests in drawing. Since natural
systems are a part of the design / planning palette of the landscape architectural profession,
there is a tendency to find a stronger emphasis on design procedures and technique than is
found in the pedagogical approaches used in architecture at Toronto. The course aims to
develop visual literacy in the use of plan, section, and model-making unique to the
development of landscape design ideas. We try to develop the students' capacity to "see" the
implications of their designs. The starting point in this process is to help students
understand how their 2-dimensional representations translate into experienced 3-dimensional
form.

An Experiment with the Computer-Aided Desk Critique

The paper traces an experiment in which the authour used his own computer tools in a
junior design studio he teaches. The authour became the computer-aided design critic for a
week in the spring of 1990. The authour met with each student for a one hour review. The
design concept of each student was digitized and modelled by the professor during the first
half of the session from a plan drawing (usually pencil on trace paper, see figure 1 )
prepared by the student. This proved to be a very efficient use of both the professor's and the
student's time. The second half of the time was spent examining and walking through the
scheme.

The students developed a better capacity to "see" the implications of their designs. They
were able to see in an unambiguous way how their 2-dimensional representations translated
into experienced 3-dimensional form. Students were able to see for themselves if a given
parti translated effectively. Staff and a student's peers were able to more freely challenge and
discuss the effect of one party in the space over another because of the comparative and
accurate nature of the computer images. We feel this is a powerful form of learning.
Students were much less likely to seize upon a party based solely on conventional wisdom.
And students that could not see problems with an unconventional party could sometimes
see past the bias of their own drawing since they had not crafted it.

The success of this test lead to a decision this year to integrate computer based
critiquing as an integral part of second year design for the two problems described
previously. These problems are now offered in the spring term after students have had a
series of comprehensive site planning problems and greater experience with model making,
and plan, section, and perspective drawing. The spring term now adds the use of panorama
drawing and computer visualization as described next.

Studio Problem Description

In 1990, the Programme has strengthened the visualization and visual thinking aspects of
the course by teaming the authour (the computer "expert") and the drawing professor ( a
proponent of panoramic 360 degree perspective as a design procedure) together as the studio
critics. In addition to computing, the authour is the faculty member charged with the
person-environment relations component of the curriculum. The studio is run parallel to the
Social Factors in Landscape Architecture course. Issues of programming for social
interaction and visual perception are part of the studio objectives.
The studio uses three problems beginning with a design in panorama exercise lasting two weeks. This is followed by a four week courtyard problem and a seven week urban plaza design problem. The last two problems are the ones where the author has used the computer as a tool for use in desk critiques.

**Problem II: Designing an Exterior Space Delimited By Built Form**

The aim of this project is to give the student the opportunity to learn about traditional design procedure and media. This is accomplished through the solution of a landscape design problem that is focused on concern for the human use of a strongly defined, simple urban space already familiar to the student. This project is focused on the design of an exterior space that is primarily delimited by built form. The edges of the space that the student designs in this problem are defined by the walls of the architecture found on the site. The student selects a quadangle or courtyard in the Earth Sciences Complex of the University of Toronto to design. Students are divided into groups to prepare base material for drawing, physical and computer models during the first week of the problem.(footnote)

**Problem III: Designing an Exterior Space Formed by Landscape Elements**

The aim of this project is to further refine and demonstrate the student's understanding of traditional design procedure and media. This is accomplished through the solution of a landscape design problem that is focused on concern for the human use of an ill defined, complex urban space already familiar to the student. This project is focused on the design of an exterior space that is *not* primarily delimited by built form. The edges of the spaces that the student designs in this problem are not clearly defined by the walls of the architecture found on the site. A goal is to immerse our students (especially the non design background students) in an extremely rich array of visual representations of their design ideas. We want them to develop and calibrate their capacity to judge scale and perceived composition of design spaces through disciplined procedure. The hypothesis of the approach is that we will be able to accelerate the time frame in which students begin to accurately translate two dimensional diagrams in plan into perceived experience and vise versa in their mind's eye.

**Using the Computer to Develop a Visual Dialogue**

The same model for critiques that was used in 1990 was followed this year. A base model was prepared for the courtyard problem by three students with previous experience in autocad and the base model from last year's problem was used for the third problem. The students not involved in this activity prepared base drawings and physical models during this period of time. A typical session with the computer began by examining a sketch plan brought to the critique by the student. I would take the base model available in the system and quickly digitize or position (by eye) a schematic placement of vegetation, terrain changes and built elements such as stairs, ramps or buildings to complete a representation of the concept that was sufficient to permit us to discuss the student's ideas.

Once this task was complete, I would meet with the student and spend at least a half hour discussing the project. I would also continue to modify the model as the discussion progressed to address the analytical concerns defined below. This time period often extended to one or two hours if we could afford the time. I would also set up the model for them on
one of the Iris computers and show them the basic moves necessary to continue examining the model on their own while I met with another student. We would meet again briefly and make modifications to the scheme. Images were then saved and printed on an 11x17 inch Seiko Colour Printer. These images were used for further sketching or directly in the final presentation.

**Figure 1.** the drawing on the right is a scanned image of a student’s concept plan. The perspective images from the computer above showed the student that the textural quality of the plan drawing had nothing to do how the space would appear to users.
Figure 2. In this scheme the student wished to deal with grade change by rising one half of the space and planting trees in the lower half. What was not understood until the computer desk crit was that the branching point for the trees during the first twenty years on the scheme would totally obscure the formal composition of 'hard' elements that the student tried to achieve.
Figure 3. This illustrates the software interface used to parametrically apply leaves in the canopy zone of each tree. This also permitted us to evaluate degrees of transparency and variations in containment that would occur as the season changes.
Figure 4. this scheme is a study in the use of a row of columnar trees with two large specimen trees to organize the space.
The educational objectives for the exercise were:

- to bring the power of our visualization tools to studio and better support a heuristic approach to discussion and design development.
- to engage the curiosity of our students for computing in a fun and powerful way so that they can better understand why they need to prepare themselves for its use in the upper years.
- for them to observe an experienced user as a role model and see how to abstract ideas and establish an efficient, computable vocabulary of representations in this medium.

The model I used for these sessions involved two fundamental activities.

The first was a review of the student's concept in terms of the following concerns that I wanted every student to address in their design:

1. Spatial Containment - landscape edge as degrees of containment using semi transparency or filtering one's vision to symbolically create the illusion or feeling of containment.
2. Translation of the design idea from plan into perspective eye-level experience. - analyze the percentage of a viewer's cone of vision actually occupied by the geometry of the design elements important to the overall composition of the space.
3. Movement through the space - analyzing the scheme from multiple vantage points to determine if it works from all locations.
4. Scale of the Spaces for Social Interaction - placement of representations of people into a scene - to populate it, furnish it and then ask the student whether they think the design will be used according to the stated design objectives.
5. Scale of Plant material over time - analyze whether the design achieves an adequate degree of containment at various years in the maturation of a landscape.

The second activity was to open-endedly explore the model with the student to determine if the students ideas had been met. During a typical session the student and I would explore an aspect of geometric dimension until one of the two of us found a problem or opportunity. Since the student could not explore the scheme through modelling, I was careful to not completely direct the course of the session. I would try to communicate to the student through the evolution of the images or by varying a critical parameter until the student said something. If they liked or disliked the effect we would try to analyze their reaction and the parameters producing their response. In this way, I was attempting to make the student more sensitive to things they had been defining in the design that had remained at a largely unconscious level.

I was able to reach my half of the students in the studio for the second problem and most of the students in the whole class for the first problem effectively within the time limitations for desk critiques. I had hoped that the tools might be fast enough to permit me to have a desk crit with all 20 students in the studio. This limitation implies that as with all other one-to-one teaching methods this techniques can only be employed if the staff have the requisite skills to rapidly model on the computer being used. The problem centred more on the entry of the basic design concept. This model cannot become central to a curriculum until a significant percentage of the professors have developed the skill of using this technology.
The most vexing problem I encountered was trying to keep the complete time to enter an idea and discuss it to within the one hour limit we had set. If a scheme involves complex ground plane geometry it can take more than the half hour allocated to enter the scheme. If the time becomes greater than that it becomes impossible to deal with a whole class and therefore, not viable as general technique in design teaching. Most professors would not be willing or able to spend the extra time necessary to do this work. An alternative would be to hire a graduate student to assist in the process.

**Results / Observations**

The computer was most useful for those aspects of a design that could be played with in a dynamic manner. Since the model for teaching is concerned primarily with the strategic dimensions in a design that influence visual perception of the intended concept it became very apparent that the requirement for a real-time system extended not just to the representation but also the act of modelling.

Since I was in control of both what we looked at and what we modelled, I was able to control the abstraction of a design in order to focus attention on the organizing principles of the proposed scheme for discussion with the student. In those cases where a scheme was represented simply or with parametric objects we could propose changes to a scheme in seconds. It turned out that sometimes even when a student was able to generate a model on their own prior to the desk critique the way they constructed the model had a great influence on whether we could exploit the computational speed of the machines to engage in visual dialogue.

If one was evaluating the dimensional workability of a concept, I found that it was sometimes better to position design elements on a students plan by "eye" rather than use the digitizing tablet. This task would usually allow the model building phase to stay well within the 1/2 hour allotted and proved to be sufficiently accurate if done while the existing conditions layer of information was turned on for reference. It also showed students the value of very simple abstract visual representations. Many times after digitizing accurate representations of a complex of stairs to determine how altering the number of stairs would influence the look of a space we would find that the basic positioning of the stairs has not yet been resolved. Hence, the time required to digitize the precision of the stairs was wasted.

I also found we could simply place elements such as trees into the model until the desired visual effect was achieved. We would then go into the 2-dimensional view of the system and analyze what spacing dimension created the desired impression. This approach allowed students to more directly understand the role physical dimensions play in design.

**Results From the Final Review**

At the end of term reviews a personal iris computer was set up in the room during the presentations. I was able to enter the concepts of three students that I had not had an opportunity to work with previously in the project. Their schemes were modelled while the students presented their work. I was able to listen to the presentation, identify a key element or strategic idea in the scheme that was dependent on geometric properties (dimensions) and model a representation of the geometric idea. The representation was then used to confirm the degree to which the design worked in terms of dynamic movement and the growth of vegetation over time. In all three cases, it became clear that the planting strategy that
appeared to work in the plan did not in fact produce the desired effect when viewed with the perspective accuracy of the computer. These were students that had not had the benefit of a previous desk critique at the computer (refer to figure 5).

In the final reviews, it turned out that a great many students misrepresented important dimensional aspects of their designs in the hand drawings that were not based on computer printouts. They successfully conveyed intentions for the textural qualities of their proposed spaces with drawings. However, dimensional accuracy was another matter all together. When the actual number of trees proposed were placed into the computer model and given realistic size and age parameters, most schemes failed to achieve the intentions expressed in the plans for creating a strong sense of visual enclosure and containment. The most fascinating thing that became apparent during the use of the computer during the final reviews was that the other professors and guest critics did not notice these problems when all that they had to refer too were the plans, sections, hand drawn perspectives, and the physical models (refer to figure 6).

References


Figure 5. This scheme was modelled while the student presented and was used to provide comment on the planting strategy employed. The scheme did not provide any significant degree of spatial containment for the space for the first 40 years. If a tree were to die then the degree of containment implied by the hand drawn plan would never be achieved.
Figure 6. This is another scheme modelled while the student presented and was used to provide comments on the planting strategy employed. The scheme also had problems providing spatial containment for the space for the first 40 years.
Figure 7. The top image shows a template of social fields of view defined by Jan Gehl applied to a student’s design below.
Figure 8. The top and bottom schemes are based on strong circular geometries in the plan view. The strength of the idea is not as apparent when viewed in perspective. Vertical elements that do not figure prominently in plan become the dominant spatial geometry.